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Air Pollution. Air Pollution
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AIR POLLUTION FOUNDATION

1956

AN INDEPENDENT SCIENTIFIC ORGANIZATION
SUPPORTED BY PUBLIC-SPIRITED CITIZENS—
TO HELP DETERMINE THE CAUSES OF SMOG
AND IMPLEMENT ITS ELIMINATION.

704 SOUTH SPRING STREET - LOS ANGELES 14, CALIFORNIA - TELEPHONE: MAdison 6-9441

Our air resources, like water resources, must be protected. Expanding cities are producing excessive concentrations of air pollution from the sum total of man's activities.

The costs to our economy and health are fast becoming intolerable.

Practical remedies can and must be developed.

HERE ARE THE ANSWERS

to questions about the

AIR POLLUTION FOUNDATION

What has the Foundation accomplished?

Why the Foundation?

What is the Foundation?

What does the Foundation do?

How long will the Foundation exist?

Who finances the Foundation?

Who directs the Foundation?

WHAT HAS THE FOUNDATION ACCOMPLISHED?

1) By development of new and continuous measuring tools for smog, the Foundation in its first year increased man's knowledge of the problem and sound methods of attack.

2) By cooperation with government and private agencies, it has made apparent the need for constant measuring of pollutants.

3) Through a fact-finding program extending across the nation, it has evaluated the feasibility of proposed controls.

4) It has published as of November, 1955, twelve technical reports on basic aspects of the air pollution problem.

5) It has emphasized public service and information through all media including the press, radio, television, speakers' bureau, and addresses before leading civic organizations.

6) By exchange of information and literature, it is helping to unite efforts of industry, government, and the public here and elsewhere in striving for cleaner air essential to urban living. This serves to increase the manpower fighting a common, but still elusive enemy.

7) It has sponsored technical conferences bringing the help of national authorities to bear on important phases of the air pollution problem.

8) The Foundation has substantially advanced our understanding and diagnosis of the problem and is actively participating in the development and evaluation of workable remedies.

WHY THE FOUNDATION?

The Air Pollution Foundation was created specifically to shorten the time it will take to eliminate smog. By "smog" is meant the atmospheric condition defined so far only by identifiable effects such as eye irritation, reduced visibility, oxidant formation, and plant damage. While the Foundation works to reduce all air pollution, its immediate target is the alleviation of smog.

Scientific research is the key to the Foundation's activities. The Foundation will study every phase of air pollution and recommend constructive, remedial action. It will inform the public concerning progress. It cooperates with and aids in coordinating the work of all accredited fact-finding agencies.

WHAT IS THE FOUNDATION?

It is a non-profit organization, incorporated November 18, 1953, under the laws of the State of California.

As provided in its By-Laws, the Foundation is operated by a Board of Trustees, who serve without compensation.

It is committed to impartial fact finding—without fear or favor—through scientific research.

It is prohibited from using any of its money for the benefit of any individual, or from carrying on lobbying activities.

Contributions to the Foundation are deductible for income tax purposes.

WHAT DOES THE FOUNDATION DO?

It evaluates existing research and conducts new research projects, seeking answers to the unknown.

Investigation is done, at the request of the Foundation, in *existing laboratories*—both public and private. The Foundation does not spend time and money building its own laboratories. It encourages other institutions and agencies to continue their useful research programs.

Findings of the Foundation are turned over to constituted authorities to bring about the control and elimination of smog. We rely upon these authorities to work for effective legislation—to enforce the rules and regulations.

HOW LONG WILL THE FOUNDATION EXIST?

Until smog is conquered.

The smog-free skies of an earlier day in California cannot be brought back immediately through any quick expenditure of funds or energy; they can be restored only over a reasonable time by diligent and honest fact-finding and by wise and effective action.

Current research plans are on a five-year basis. When the answers have been found, the Foundation will close shop—because it is self-liquidating.

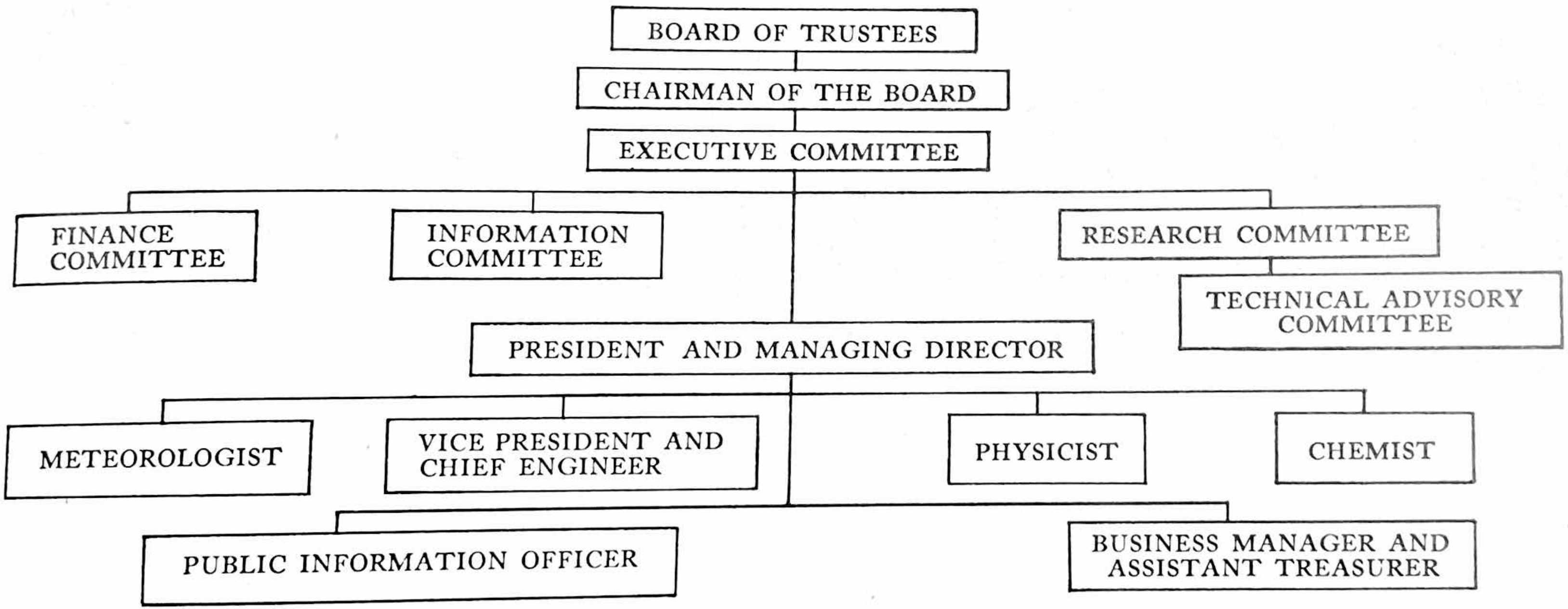
WHO FINANCES THE FOUNDATION?

Individuals, organizations, and corporations who are interested in the economic well-being and physical health of this community are asked to contribute to the Foundation as a public service.

Contributions are accepted on the basis that no donor will be permitted to exercise control over the Foundation's policies or program.

Because of the magnitude of the problem of *restoring cleaner air for the benefit of all segments of the community,* a concerted and united effort is required. On this basis the Foundation's officers and trustees request your support in this most important community endeaver.

THE ORGANIZATION



WHO DIRECTS THE FOUNDATION?

DR. LAUREN B. HITCHCOCK

Dr. Lauren B. Hitchcock is President and Managing Director . . . Has more than thirty years' experience as a chemical engineer, professor, research administrator, and business executive . . . Received his Doctor of Science degree at Massachusetts Institute of Technology. . . . Developed one of today's leading sources of nylon raw material . . . Is the author of twenty-two technical publications, including important work in hydrocarbon chemistry . . . Was Vice-President, Chemicals Department, Quaker Oats Co., and President of National Dairy Research Laboratories, Inc. . . . Was engaged in industrial research and development management in New York City when he became the unanimous choice of the Trustees to lead the Air Pollution Foundation.

FOUNDATION TEAM

Left to right: *DRS.* MORRIS NEIBURGER, *Senior Meteorologist;* NICHOLAS A. RENZETTI, *Senior Physicist;* W. L. FAITH, *Vice-President and Chief Engineer;* L. H. ROGERS, *Senior Chemist.*

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THE BOARD OF TRUSTEES

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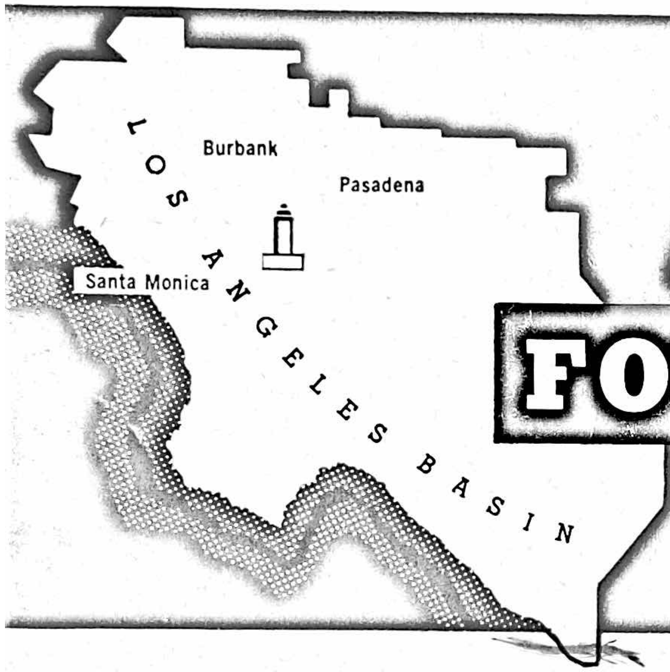
Assoc. Prof., Mech. Eng., Calif. Inst. of Tech.

John T. Middleton
Prof. of Plant Pathology, U. of Calif. at Riverside

Lawrence M. Richards
Asst. Mgr., Research and Devel't, Richfield Oil Corp

President's Report



Air Pollution FOUNDATION

704 SOUTH SPRING STREET
LOS ANGELES 14, CALIFORNIA

1955

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Professor of Plant Pathology
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Engineering

W. L. Faith, Vice President & Chief Engineer
B.S. (1928), U. of Maryland; M.S. (1929), Ph.D. (1932), U. of Illinois. Prof. of Chem. Eng., Kansas State Coll. and State U. of Iowa; Deputy Director, Office of Production Res. & Dev., War Production Board, Washington, D. C.; Dir. of Eng., Corn Products Refining Co., Argo, Ill. Member, Am. Chem. Soc., Am. Inst. Chem. Engrs. (director 1954-56).

Chemistry

Lewis H. Rogers, Senior Chemist
B.S. Ch.E. (1932), M.S. (1934), U. of Florida; Ph.D. (1941), Cornell U. Chemist, U. of Fla. Exp. Sta., Gainesville, Fla.; Supervisor, Anal. Res., Carbide & Carbon Chemicals Co., Oak Ridge, Tenn.; Leader, Anal. Div., National Dairy Res. Labs., Oakdale, N. Y. Member, Am. Chem. Soc., Opt. Soc. of America, Am. Assoc. Adv. Science, Am. Soc. Testing Materials.

Meteorology

M. Neiburger, Senior Meteorologist
S.B. (1936), U. of Chicago; grad. studies, U. of Chicago and Mass. Inst. Technology (1936-39); Ph.D. (1945), U. of Chicago. Observer to Asst. Meteorologist, U. S. Weather Bureau, Chicago, Ill. and Washington, D. C.; Instructor, Mass. Inst. Technology, Cambridge, Mass.; Prof. of Meteorology, U. of Calif. at Los Angeles; Consultant, L. A. County Air Pollution Control Distr. Member, Am. Meteorological Soc., Am. Geophysical Union, Am. Assoc. Adv. Science; foreign member, Royal Meteorological Soc.; assoc. editor, Jour. of Meteorology.

Physics

N. A. Renzetti, Senior Physicist
A.B. (1935), A.M. (1936), Ph.D. (1940), Columbia U. Res. Assoc., Columbia U., New York, N. Y.; Physicist, U. S. Navy Bureau Ord., Washington, D. C.; Chief Physicist, Twelfth Naval Distr., Mare Island Naval Shipyard, San Francisco, Calif. Physicist, Head, Exterior Ballistics, Aviation Ord. & Test, U.S.N.O.T.S., Inyokern, Calif.; Head, Underwater Ord., U.S.N.O.T.S., Pasadena, Calif.; Consultant, L. A. County Air Pollution Control Distr.; Physics Consultant, U.S.N.O.T.S., Pasadena, Calif. Member, Am. Phys. Soc., Am. Assoc. Adv. Science, Am. Math. Soc.

Research Assistants

Edward M. Liston
B.E. Chem. Eng. (1954), U. of So. Calif.; 1st Lt. USAF (R) 1954-55.

Rita Tice
B.A. Meteorology (1954), U. of Calif. at Los Angeles.

Public Information Department

J. B. Leiper, Public Information Officer

Fresno State Coll. (1928-32). Newspaperman for Fresno Morning Republican, Fresno Bee, S. F. Call-Bulletin, S. F. Chronicle; writer and newscaster for KMJ, KPO, NBC, New York and Hollywood; director, news film syndicate, NBC, Washington, D. C.; editor, Today, Esso News, NBC, New York. Member, Public Rel. Soc. of Am.; past member, Am. News Guild, Radio News Guild, TV Writers Guild, S. F. and L. A. Press Clubs, Radio News Club.

Donald L. Kirby, Assistant Information Officer

Los Angeles newspaperman 1936-54: advertising, six years, editorial, twelve years. Member, Greater Los Angeles Press Club.

Mackenzie Wasson, Public Information Assistant

A.B. (1952), U. of Calif., Berkeley. Gen. Electric Co. Advertising and Public Relations Training Program at Apparatus Div., Los Angeles, and News Bureau, New York.

Nancy J. Druley, Secretary

Dorothy V. Egan, Secretary

B.A. (1939), M.A. (1940), Psychology, Colby College.

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Mary E. Keeler, Executive Secretary and Office Manager

B.A. Journalism (1938), U. of So. Calif.

Anne Gyemant, Secretary, Vice President's Office

Mary H. Althoff, Secretary, President's Office

B.S. Speech (1954), Northwestern U.

Research Department

Mary Ann Jordan, Librarian

B.S. Chemistry (1943), Duke U.

Lee Kern, Secretary

Business Department

R. S. Weatherly, Business Manager and Assistant Treasurer

Robert C. Brooks, Secretary

Caroline Greer

Warren Young

President's Report
1955

Delivered to the Trustees and Supporters of the Foundation at the Second Annual Meeting, Hotel Ambassador, November 10, 1955, held jointly with the Southern California Conference on Elimination of Air Pollution arranged by the California State Chamber of Commerce.

by Lauren B. Hitchcock

WHAT THE AIR POLLUTION FOUNDATION IS DOING

One year ago, at our first annual meeting here, I told you of the formation of this Foundation as an independent, nonpolitical, nonprofit, fact-finding organization dedicated to establishing clearly the nature and causes of smog, thereupon to develop or encourage others to develop appropriate and workable remedies. Since at that time our staff had been organized and at work only a few months, my report was necessarily limited to a statement of what we were doing and what our plans were. Today we can report what we have done. I wish to acknowledge the help of my associates in preparing this report.

In the Statement of Policy adopted by the Board of Trustees of the Air Pollution Foundation there are eight objectives. One of these is to assemble a competent technical staff to organize and direct a broad program of cooperation, research, and public information. A second is to maintain a library of materials pertinent to the subject of air pollution. The accomplishment of both objectives was reported to you last year.

On the other six objectives we can report very substantial progress, primarily because of the hard and able work of the Foundation's scientific team and public service staff, as well as the help we have received from industry, business, government, and university leaders in air pollution work. It is from the very fact that all these men are joining in the attack, that the community is giving increasing support to this cause, that we know the job will be done.

The first of these remaining objectives is "*to determine, record, and publish what has been accomplished to date by all agencies dealing with air pollution.*" The significance of our results can only be brought into proper focus by concurrent consideration of the work of many other agencies dedicated to the solution of the air pollution problem. Accordingly, we take into account the progress of others in this report and evaluate the Foundation's results in the light of the other findings. Both the progress attained in the last year and the questions remaining to be answered are presented under four headings in our Second Technical Progress Report, No. 12 in our series of technical reports on air pollution. This report is just off the press and copies are available at this conference.

The four basic questions discussed in this report are:

1. What is smog?
2. How is smog formed?
3. What are the sources?
4. How may smog be abated?

In Report No. 12 we summarize in 143 pages all information available at the end of September, 1955 which bears on these questions. Since we are communicating with other air pollution workers on a scientific subject, much of this report is technical. However, our findings in each chapter are set forth in what seems to me to be plain English. In my report here to you today I shall only give you the high spots of this and other progress.

A second objective: *"To determine what remains to be done and to employ experts through the device of research or service contracts, who will provide information and advice for the shaping of future policies and action."* First of all we have conducted a fact-finding program consisting of crucial research investigations through contracts placed with leading research centers extending across the nation (Figure 1). Out of these has already come important evaluation of the feasibility

SMOG RESEARCH PROGRAM OF AIR POLLUTION FOUNDATION

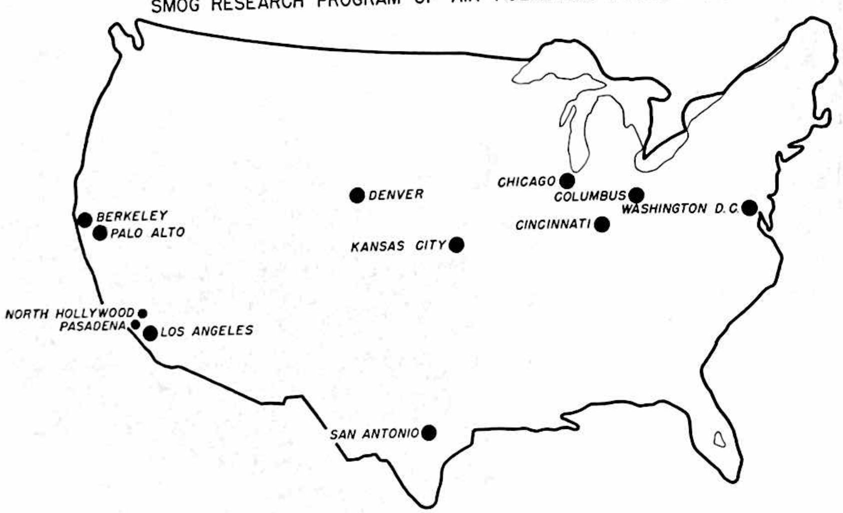

Fig. 1

Projects have been placed at Battelle Memorial Institute, (Columbus, Ohio); Armour Research Foundation, (Chicago, Illinois); Bureau of Standards, (Washington, D. C.); Midwest Research Institute, (Kansas City, Missouri); University of Denver, (Denver, Colorado); Stanford Research Institute, (Palo Alto and Pasadena, California); Berkeley Research Products, (Berkeley, California); Borman Engineering Company, (North Hollywood, California); Southwest Research Institute, (San Antonio, Texas); California Institute of Technology, (Pasadena, California) and others.

of proposed air pollution remedies. For example, we have investigated alternate motor fuels not containing tetraethyl lead, as well as alcohol-gasoline blends; the former, because it was thought that a catalytic muffler using nonleaded gasoline might be easier to perfect; the latter, because of persistent reports that alcohol blends might reduce motor vehicle exhaust pollution. For reasons set forth in Report No. 12, neither offers promise.

Devices have been evaluated for the control in automobile exhaust of unburned motor fuel, broadly known to the chemist as hydrocarbons and their derivatives. These devices seek to reduce such emissions or to treat the exhaust gases after they have left the engine. We find that some of these look very hopeful.

Burning of rubbish has been identified as an important source of pollution, and the economic, workable, and nonpolluting method of collection and sanitary landfill is recommended. I believe the Foundation's clear-cut recommendations have materially advanced the program of action now underway. It cannot for practical reasons be done overnight. The Air Pollution Control District is doing everything possible to press forward on this campaign.

By development of new and continuous measuring tools for smog, the Foundation in its first year has increased man's knowledge of the problem and developed sound methods of attack.

Out of this first year of fact finding the Foundation has substantially advanced understanding and diagnosis of the air pollution problem and is now actively participating in the development and evaluation of workable remedies. Valuable suggestions are being received from some of the best minds in industrial, governmental, and university laboratories.

A third objective: *"To collect information as to what other municipal areas have done and are doing under similar circumstances; to consult with, exchange information with, and to suggest to governmental and private agencies those research activities, enforcement methods, or other matters, which have not yet been conducted or tried and which seem to offer promise of air pollution abatement, so that the efforts of all groups and individuals may be coordinated properly."* By frequent meetings with these agencies and by exchange of information and literature, the Foundation is helping to unite efforts of industry, government, and the public here and elsewhere in the struggle for cleaner air. This increases the manpower on our problem, a problem we are sharing with a growing list of cities, a problem which is still elusive. One important conclusion is the need for constant measuring of pollutants in metropolitan areas, in order that we may know definitely with what we have to contend.

A fourth objective: *"To hold technical conferences with experts and specialists working in this country or abroad on selected phases of the air pollution problem in order to facilitate and accelerate the process of finding solutions."* The Foundation has sponsored technical conferences here in Los Angeles, which has brought the help of national authorities to bear on important phases of our air pollution problem. These include conferences on motor vehicle exhaust, sanitary rubbish disposal, formation and analysis of aerosols, smog-forming chemical reactions, and relation of our weather to smog. The Foundation has accepted invitations from leading scientific societies to conduct conferences at their meetings, at which our problem could be described and discussed. Out of such meetings comes greater help from others in this country and abroad.

The large-scale entry of the automobile industry into our problem, with all its resources of laboratories and engineering and scientific experts, is one of the most encouraging developments I can report. The decision of this great industry to come to our help was perhaps influenced to some small extent by the efforts of the Foundation to present the problem to it.

Other critical phases continue to be pushed forward by the oil industry and the steel industry. The cooperation we are receiving from these groups and their technical leaders is invaluable.

This summer, at the request of the Board of Trustees, seven authorities on various aspects of the Los Angeles smog problem agreed to serve as a Technical Advisory Committee on the Foundation's research program. The assistance of these outstanding scientists and engineers is very welcome. A list of members of this committee appears on p. 4.

Another important objective is *"to publish current information by the most appropriate means on all phases of air pollution and its abatement."* The twelve technical reports published to date constitute in total 1,120 pages of basic information dealing with primary aspects of modern urban air pollution in the Los Angeles area. Many of the findings will inevitably have application in other communities. Copies of all reports have been furnished not only to you, our trustees and contributors, but to all leading air pollution workers in this country and abroad, to scientific societies, and to the principal libraries in this country. These reports have been favorably reviewed in national magazines. Requests for them are being received not only from people in Los Angeles County but from municipal and state officials in California and from others over the country. Over 8,000 copies of these reports have been printed.

At the same time the Foundation has been aware of its obligation to accurately inform the public. Valid information has been supplied through all media, including the press, radio, and television. We publish a monthly newsletter. We have sound motion pictures and color slide collections as visual aids. In response to invitations from many civic and neighborhood organizations in Los Angeles County, we set up a speakers' bureau to provide competent speakers. Trustees and supporters of the Foundation have been most cooperative in providing able men from their own organizations for this bureau.

At the request of the local Public Affairs Committee of Kiwanis International with 110 clubs in the Los Angeles Basin, the Foundation has cooperated in their public-spirited effort to inform the public accurately and impartially about the nature and causes of smog and the progress which is being made in developing remedies. We stand ready to assist other groups if called upon. We are cooperating with the Air Pollution Control District and the State Chamber of Commerce in this meeting today.

Purposes to Which Funds Have Been Allocated

Despite the generosity of the contributors who are supporting us in this pioneering attack, the magnitude of the problem has required severe rationing of funds among a few of the most urgent projects, particularly those not being done elsewhere or done adequately. Figure 2 shows where our dollar went. Note that 74 cents goes for direct research expenses. General and administrative expenses amount to only 16 cents or 22 per cent of direct research as compared with 80 to 120 per cent typical of most industrial research.

Our Finance Committee, assisted by many civic leaders, serve without compensation in voluntary fund raising for the Foundation.

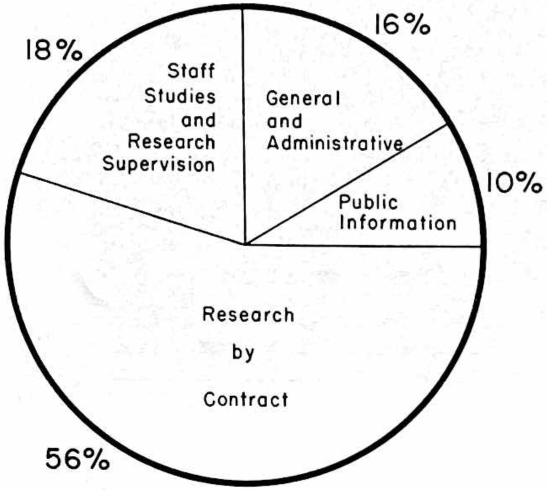

Fig. 2
Allocation of the Budget

Our research dollar has been divided among the main purposes shown in Figure 3. These subjects are most closely concerned with our smog problem and we believe the way in which our research dollar is divided among these purposes is roughly equivalent to their relative importance. Our 1956 goal is $750,000. Many of our contributors have already renewed their annual subscriptions. Remaining renewals are anticipated, based on the experience of last year. Even so, $200,000 of new money must be raised, primarily from sources which have not yet contributed. Favorable consideration is now being given by some of these groups. It is most important that our goal be reached.

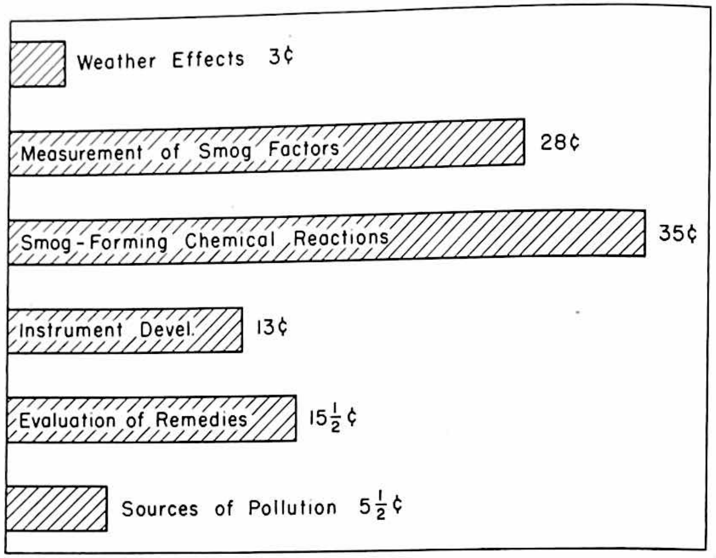

Fig. 3
Where our Research Dollar Goes

Summary of the Los Angeles Smog Problem

I have touched on some of our principal accomplishments and cited a very few examples. I know that you want to hear answers to such questions as "'What have we found out?" and "Are we any nearer to solving the smog problem?" The answer to the second question is "yes" and I shall do my best in this brief report to tell you why.

First, I will tell you what we have found out as a result of the work described above; second, why we are nearer to a solution; and third, the nature of the solution as it is now taking shape.

It is inevitable that in bringing the definition of the Los Angeles smog problem up to date some of the conclusions will seem familiar, particularly to those who have followed air pollution work in Los Angeles for several years. Many of these conclusions derive from the work of the Air Pollution Control District, Professor Haagen-Smit at California Institute of Technology, Stanford Research Institute, and others. This definition is the result of critical selection of facts and evaluation of many differing theories which characterized the vague understanding of the problem as of two years ago. Those of you who have followed this battle more closely may recognize a firming up of certain points, and the absence of other theories and supposed remedies.

The Los Angeles smog problem is a direct consequence of air pollutants arising from man's activities. Operation of motor vehicles, factories, and rubbish burners,

to name three principal categories, contribute a great variety of pollutants in gas, liquid, or solid form. Some of these are visible at the point of origin, and some are not. None of these pollutants at the point of origin possess the characteristics of smog, which we will define shortly.

While our smog problem is a direct consequence of man-made pollution, meteorological and topographical influences contribute to the undesirable effects, although they do not of themselves cause these effects. Los Angeles did not have a smog problem of any moment prior to around 1940, yet the meteorology and topography of this area have undergone no significant change as far back as there is any record. The quantity and variety of pollutants, being a direct consequence of man's activities, increase with the number of motor vehicles, factories, and tonnage of refuse burned.

About the beginning of World War II man's activities in the Los Angeles Basin resulted in a daily production of pollution which began to exceed the natural dissipating capacity of the environment, particularly on those days when the inversion was low and the winds were low. Man's activities had always produced pollution, but up until then, while we had had the same cycles of low inversions and low winds, objectionable concentrations did not arise because the emissions were not excessive. The same opportunities for escape of pollution exist today as existed then, no worse or no better, but the daily production of pollutants has increased enormously so that their concentrations are much higher than they used to be.

Methods of Attack

Two obvious approaches to the problem have received a vast amount of speculative consideration by both scientists and laymen. The first approach is to find some way of changing our meteorological or topographical features. The second is to reduce our pollutants at their points of origin. Another way is treatment of the atmosphere, as by neutralization or dilution.

Profound studies by properly qualified meteorologists and physicists have failed thus far to reveal any likelihood that man can economically change either meteorological or topographical features sufficiently to have any significant effect on our air pollution problem. The quantities of energy associated with these natural influences appear to be far beyond any resources of man of which we have knowledge at present.

The second approach, to reduce pollutants at their sources, is the only approach which has resulted in any progress in abating air pollution here or elsewhere. Beginning about eight years ago, various control devices were installed. These controls include, for example, sulfur recovery systems, electrostatic precipitators, bag filters and other devices for collecting some of the dusts, floating roofs on gasoline storage tanks, closed recovery systems in oil refineries, and many others. These installations have been made either voluntarily by the parties concerned or as a direct consequence of regulations of the Air Pollution Control District, which estimates that in total these devices are keeping out of our air today about 1,100 tons per day of pollutants.

In metropolitan areas with better natural ventilation, this achievement would undoubtedly have been far more significant. One can only speculate on what our smog problem here would be like today if this progress had not been made. That it is inadequate is due to the tremendous continuing growth here in man's activities, a growth unequalled elsewhere in this country. The continuation of severe smog attacks shows that either the pollutants which have been controlled are not the ones which contribute substantially to our smog effects, or if they are, that they have not been reduced sufficiently.

Are Some Pollutants More Harmful?

This brings up a third approach to a solution of our smog problem, which is really a special case under the second method of reducing pollutants at their points of origin. In this third approach it is assumed that some pollutants are much worse than others. By the same token it is assumed that there are some pollutants which are relatively innocuous. This, of course, has been the traditional approach to development of our sanitary water supplies, which contain innocuous contaminants but in which the harmful agents are controlled to levels which have been carefully determined to be tolerable.

This third approach has in its favor the possibility that the control of only harmful air pollutants would be considerably less expensive to the community; for to attempt to solve our problem by reducing *all* pollutants to, let us say, 1940 levels would require the development and installation of a vastly greater amount of equipment, hence take more time and money. The third approach assumes that the harmful pollutants can be identified and that devices can be developed and installed specifically for these pollutants in less time and at less expense.

There is evidence that some of our numerous pollutants here are more harmful than others. It therefore becomes apparent upon brief reflection that we must have some yardstick of harmfulness. We know of no single pollutant entering our atmosphere which is known to be harmful to man at the highest concentrations found here. Ozone, which has come to be the index of our smog intensity, does not originate in any of man's activities but forms in our atmosphere as a consequence of complex photochemical reactions involving certain of our pollutants. Neither has anyone been able to find among our myriad pollution sources any compounds which, as emitted, produce the specific forms of eye irritation or plant damage characteristic of Los Angeles smog in the concentrations measured in the atmosphere. Again, therefore, these agents are formed in our atmosphere subsequent to the point of escape.

Pursuing this third approach then, one wishes to know which pollutants take part in the reactions which produce the harmful or undesirable effects.

Let us at this point offer a definition of Los Angeles smog: it is an atmospheric condition which can be defined so far only in terms of its identifiable effects. These are (1) eye irritation; (2) reduced visibility; (3) oxidant formation, including ozone; and (4) plant damage. This is admittedly a loose and arbitrary definition, but we know of no better one at present. It distinguishes between gross air pollution

on the one hand and the condition which develops objectionable effects. It is useful only to the extent that it provides some basis for selecting harmful or undesirable pollutants from the great variety we have. To put it another way, if by removing certain pollutants we could prevent the above-named effects, we would say that we had found the smog formers.

Principal Pollutants

In pursuing the third approach, it seems logical to begin with an inventory of our atmosphere. An inventory of pollutants at their points of origin is also pertinent. Both inventories are needed in taking either the second or third approach. Much work has been done in an effort to develop these data. While much more remains to be done, estimates of the composition and quantities of sources, reinforced by extensive air sampling, indicate that the principal initial pollutants arising from man's activities include these:

- Carbon monoxide
- Organic Compounds
  - Hydrocarbons
  - Partially oxidized hydrocarbons
  - Miscellaneous organics from partial combustion of rubbish
  - Miscellaneous solvents (dry cleaning, paint thinners)
- Oxides of nitrogen
- Oxides of sulfur
- Particulate matter
  - Carbon (soot)
  - Dust (silicates, carbonates, sulfates, etc.)
  - Ash (great variety of metallic oxides)
  - High molecular weight organic polymers, tars, finely divided particles from the abrasion of tires, etc.
- Water vapor
- Carbon dioxide

In some of these categories there are a great variety of compounds. Water and carbon dioxide are considered to be innocuous. Carbon monoxide is not found in our atmosphere at concentrations remotely approaching toxic levels published by public health authorities, nor has it been shown yet to take part in atmospheric reactions. Accordingly, it is set aside tentatively as harmless under presently known conditions prevailing here.

Particulate Matter

Particulate matter is suspect not only because of its more obvious role in forming aerosols and reducing visibility, but because of the growing evidence that submicron* particles may collect gaseous and liquid pollutants existing at nontoxic

*A micron is about 1/25,000 of an inch; the average human hair is about 70 microns thick.

levels, concentrate them, and transport them into the deeper portions of the respiratory system. Some metallic oxides existing normally in our particulate matter are also capable of catalyzing oxidation reactions, including the oxidation of sulfur dioxide to sulfur trioxide.

Analyses of our particulate matter by the U. S. Public Health Service, as reported by Chambers, are preliminary but indicate that the sulfate and nitrate content here is higher than in any of thirty other American cities sampled. Because of the obvious contribution to grime and smoke, let alone the unproven but suspected effects, it is generally conceded that particulate matter should be the object of more complete control. Despite the efforts of the Air Pollution Control District (APCD) and others, one important source of particulate matter, namely the burning of rubbish, remains largely uncontrolled mainly because of political factors. APCD regulations exist, the purpose of which is to limit the rate at which the particulate matter may be emitted as defined either by grains per cubic foot of stack gases or by opacity as estimated by the Ringelmann chart. Burning of refuse has been estimated by APCD to account for as much as 65 per cent of the "smoke" in Los Angeles.

The control of particulate matter is subject to the same approach as air pollution in general, in that one may strive to control *all* particulate matter at the source, or to identify harmful particulates and seek to control these selectively. Again, we are in need of much more information. Except for the reduction of visibility, there is inadequate evidence so far that particulate matter contributes to smog as defined by its manifestations.

Sulfur

Sulfur dioxide itself is found in our atmosphere normally at lower levels than found in some other large cities. Plant damage due to smog is definitely distinguishable from that due to oxides of sulfur and sulfuric acid. Data on the concentration of sulfur trioxide and sulfuric acid in our atmosphere are virtually nonexistent. There is no evidence that sulfur dioxide in the maximum concentrations ever reported here causes any eye irritation. There is no evidence that oxides of sulfur or sulfuric acid increase measurements of oxidants or ozone. Sulfur dioxide reduces the oxidant reading by potassium iodide. In short, at the concentrations found in our atmosphere in Los Angeles, there is no evidence that sulfur dioxide exerts any harmful effects despite the popular impression that "sulfur is a culprit," a view traceable to incidents in other cities where at times sulfur oxides or hydrogen sulfide have been found at higher concentrations and associated with acute air pollution effects. The extent to which sulfur compounds in the Los Angeles atmosphere are harmful is yet to be established.

Organic Compounds

Among the so-called principal pollutants listed above, there remain organic compounds and oxides of nitrogen. These include all the hydrocarbons* found in natural

*Hydrocarbons are compounds of hydrogen and carbon and are the principal substances in petroleum and petroleum products, such as gasoline and oil.

gas, and petroleum and petroleum products, beginning with methane. Such compounds and their derivatives enter our atmosphere from gas distribution systems; from the production, refining, and marketing of petroleum products; and from the incomplete combustion of these products; also, from the vaporization and/or atomization of heavier products such as lubricating oils; and by evaporation from carburetors and motor vehicle fuel tanks. Depending upon air-fuel ratios and upon normal operating temperatures and design characteristics of the great multitude of combustion devices which man operates today, both unburned and partially oxidized fuel escapes to the atmosphere.

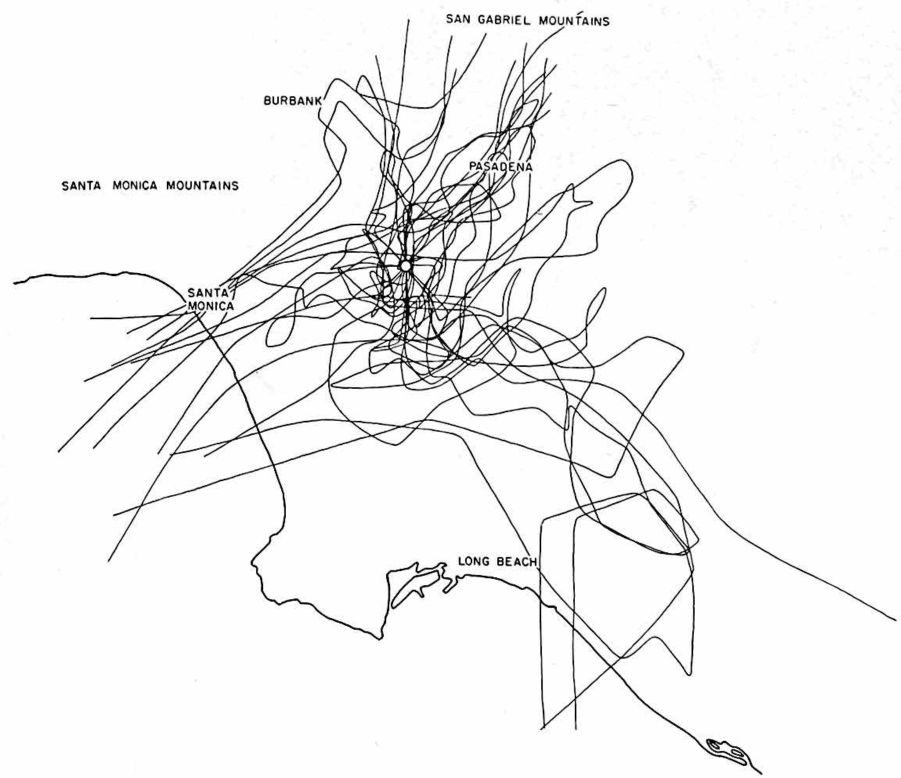

Fig. 4

Paths taken by polluted air to downtown Los Angeles on thirty-two smoggy days when hydrocarbon concentrations downtown exceeded 0.5 parts per million of air. This confused jumble of "spaghetti" is clarified by the schematic representation in Figure 5.

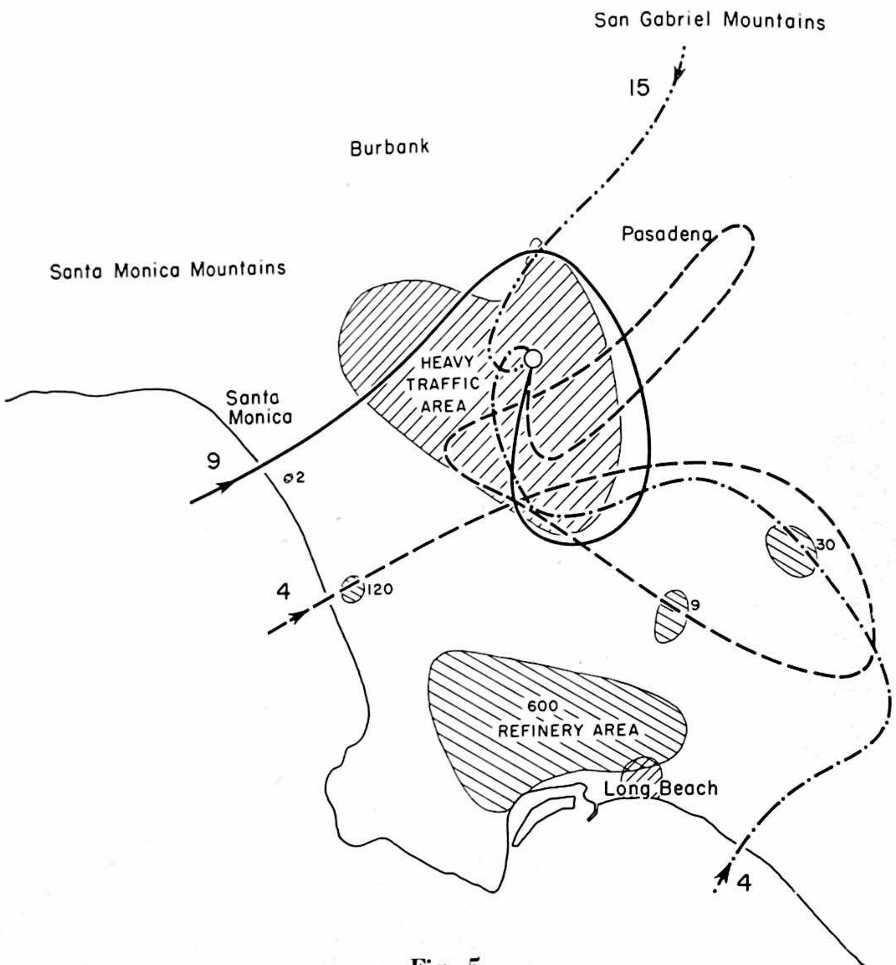

Fig. 5

Schematic summary of thirty-two wind paths from Figure 4, with number of individual trajectories represented shown by a numeral near beginning of each of the four representative paths shown. Note that on fifteen days hydrocarbons in downtown Los Angeles were picked up by air moving in from the San Gabriel Mountains and on nine other days from the coast near Santa Monica, a total of twenty-four, or 75 per cent of the thirty-two smog days when the air traversed heavy traffic areas and no refinery areas; on the other eight days the paths led near enough to refineries to be influenced by them, although none passed directly over the area of concentrated refineries in the south. In all thirty-two cases wind paths traversed heavy traffic areas in arriving at the downtown test station at Fifth and Spring Streets. Details of these findings are included in Report No. 13 now in preparation.

In addition to the galaxy of hydrocarbons and hydrocarbon derivatives connected with the production and use of commercial fuels, there are organic compounds resulting from the incomplete combustion of miscellaneous refuse. While but a few of these organic compounds have been identified, it is known that they include phenols, acetone, methanol, organic acids and tars, somewhat analogous to the products of wood distillation.

The consumption of miscellaneous solvents, as in dry cleaning or in paint thinners in the Los Angeles area, must closely approximate the input of these compounds to our atmosphere. Among such solvents would be found carbon tetrachloride, trichloroethylene, tetrachloroethylene, benzene, monochloro benzene, solvent naphthas, and turpentine.

Haagen-Smit originally, and now several other workers, have produced oxidant and/or ozone by irradiating mixtures of single organic compounds with nitrogen dioxide and oxygen, in which the organic compound has been any one of a number of different saturated hydrocarbons, olefins, diolefins, straight chain or branched molecules, aldehydes, alcohols, ketones, and complex mixtures of organic compounds such as commercial gasoline as well as auto exhaust. The capacity for oxidant or ozone formation may vary widely from one organic molecule to another. The amount of oxidant and/or ozone formed is also dependent upon the starting concentration of nitrogen dioxide and upon the intensity and time of radiation.

Reduction of Selected Organic Compounds

In the light of these experiments and others carried out along similar lines, observed oxidant and ozone values in the Los Angeles atmosphere can be accounted for qualitatively in terms of observed concentrations of organic compounds and nitrogen dioxide, even though we do not yet understand the complex reaction mechanisms. We cannot yet say that the reduction or the elimination of certain classes of organic compounds, such as gasoline hydrocarbons, would cause a proportionate, or any, reduction in ozone, because it is entirely possible in our present state of knowledge that the remaining organic matter plus the unchanged nitrogen dioxide would still produce as much ozone as before. Conceivably, reduction of nitrogen oxides might have a more significant effect in reducing smog than reduction of organic compounds, particularly if the latter reduction were confined to certain classes of compounds.

So far we have been discussing one smog effect, namely oxidant-ozone. The experimental production of eye irritation, plant damage, and reduced visibility by irradiation of organic compounds and nitrogen oxides at experienced concentrations is far less extensively reported in the literature.

There are indications that auto exhaust blended from all four operating cycles, and hydrocarbons at concentrations close to those estimated for the Los Angeles atmosphere during heavy smog periods, when irradiated, will produce both eye irritation and plant damage. There are indications that the same may be true of gasoline vapors themselves. We do not know what the compounds are which irritate eyes or damage plants, nor do we know from which hydrocarbons or other organic compounds they are formed. Ozonated olefins produce typical smog damage to plants in controlled laboratory tests. Consequently, we cannot say that reducing the hydrocarbon content of auto exhaust by 50 per cent or any other fraction will or will not reduce eye irritation and plant damage. If what might be termed "gasoline-economizer" devices are developed, which would reduce the hydrocarbon content in auto exhaust on an over-all average by 50 per cent for example, at the present time we can only say that this would effect fuel savings of about 3 per cent, based on the total fuel consumption of the average motor vehicle. Based on an average consumption of two gallons per day, this should represent a savings of about 20 gallons per car per year, or about $6. Some people feel that the cost of a control device would be justified by fuel economy alone. Multiplied by over two million vehicles, this would amount to keeping out of our air something like 500 tons of gasoline vapors per day. With respect to smog effects, however, without control of oxides of nitrogen at the same time and without control of the very substantial remainder of the organic compounds, we can see little basis at present for the conclusion that a significant reduction in smog is to be expected by the use of a device which will reduce hydrocarbons from automobile exhaust by 50 per cent.

This statement will doubtless seem unreasonable to some people and disappointing to a great many. It is a statement based on lack of data rather than on the basis of facts in hand. This is why we feel that "chamber" experiments (see page 22) are urgently needed in order that the smog-forming potential of actual sources, singly and in combination, may be tested, as well as the effects of proposed control devices for these sources. Experimentation in this way could forestall the premature adoption of devices which might cost the community many millions of dollars without commensurate gains.

Other Data Needed

We believe that additional information is essential as to the variation of various pollutants with respect to both time and place. We have no data showing the concentrations of organic compounds and oxides of nitrogen, for example, in the immediate proximity of heavy traffic arteries. Our data so far are limited to a few scattered monitoring stations where in all likelihood we have measured residual values after both chemical reaction and dispersion have taken place. Similar comments may be made with respect to composition and concentrations of other pollution sources, such as industrial stacks. Considerable progress has been made in developing methods of analysis, particularly in the direction which will permit continuous automatic recording for monitoring purposes. Much, however, remains to be done. Without sufficiently accurate and dependable methods of analysis and monitoring, we cannot know with what we have to contend.

The many uncertainties on what seem to us crucial questions, indicated throughout the foregoing discussion, are the basis of the numerous research projects we propose. Any practical estimate of the cost of such research now in sight far exceeds our own financial resources. We hope that other agencies will recognize the importance of these research projects so that more rapid progress may be made.

How Much Progress Has Been Made?

Because the nature and causes of smog are now more clearly understood and more generally agreed to, and because, therefore, the types of remedies are beginning to take shape at least in a general way, important progress has been made and is being made despite the fact that smog is still with us and may be getting worse. We know now what our principal targets are. We are building an arsenal of weapons in the form of scientific instruments and methods of analysis. We can begin to call our shots. Those of you who were close to the situation two years ago I think will agree that progress has been made. The Foundation has been a part, but only a part, of this progress.

What is the Shape of Remedies to Come?

Recognizing that predictions are hazardous, certain probabilities stand out with respect to the types of remedies likely to prove successful. These are:

1. There is little likelihood that any practical changes in the meteorology or topography of the Los Angeles Basin would be effective in reducing smog. The quantities of energy required to transform or modify these natural influences appear to be far beyond any resources of man of which we have knowledge at present.
2. Control of the effluents from the burning of rubbish can well be accomplished by banning this archaic practice. Cut-and-fill disposal may offer effective relief for some years, but eventually improved designs for municipal large-scale incinerators will probably have to be developed. Adequate designs await further research.
3. The reduction of air-borne particles from industrial stacks will have to be attacked from two different standpoints. Improved efficiency of combustion could eliminate organic aerosols, but inorganic materials will have to be removed from the stack gases by physical or chemical means. Both approaches require further research.
4. If sulfur dioxide emissions are found to require further reduction, the most effective attack may well be elimination of sulfur from the fuel. Suitable methods, particularly for residual fuel oil, are not currently available.
5. Further abatement of hydrocarbon and solvent losses by evaporation means an extension of vapor recovery or combustion systems. More engineering research will be required to develop economic equipment for this purpose.
6. Reduction of the hydrocarbon emissions from the exhaust of internal-combustion engines awaits an effective method. In the case of spark-ignited engines, four areas show promise: fuel cutoff devices operating during deceleration, exhaust converters (either catalytic or noncatalytic), fuel injection, and improved maintenance. It may well be that ultimately some combination of the above may be most suitable. In the first three areas adequate devices are not yet developed, although automobiles using fuel injection could well appear in 1957. Such designs would obviate the need for a fuel cutoff device. Even so, exhaust converters would still be needed.

The quantitative value of improved maintenance has not yet been determined. Whether governmental action in this regard will be desirable depends on the magnitude of hydrocarbon reduction that could be achieved and the nature of other devices to be used.

Slightly different problems are presented by the diesel engine, but these should be amenable to further research. Such work should be initiated at once. If the gas turbine engine becomes a reality for automobiles, other problems may develop. It is assumed that the automobile manufacturers will anticipate this possibility.

7. The one area in which it is difficult to envision an effective reduction device is for oxides of nitrogen, whether they are emitted from automobiles, diesels, or industrial stacks. Obviously, a concerted research study is badly needed.

Implicit in this picture of remedies to come is the need for stepped-up engineering and development. Above all, Los Angeles needs an air resource test facility. Plans are now being drawn up by the Department of Engineering at the University of California at Los Angeles with the cooperation of the Air Pollution Control District and the Air Pollution Foundation. Such a facility is intended to provide accurate and reliable information as to the importance of various atmospheric pollutants and the consequences of reducing or eliminating any one or more of them. Of great importance to us would be our ability to test in this facility the various remedies that have been and will be suggested. In this way the public would be assured that any remedy recommended to it or required of it was workable, worthwhile, and economical. **Among all the jobs that lie ahead of us on the road toward victory over smog, the construction of this air resource facility we consider foremost.**

Can the Smog Problem be Solved?

We are asked many times by our friends, by the Foundation's supporters, and the public in general if we really believe that the smog problem can and will be solved. If the staff of the Air Pollution Foundation believed that the answer to this question were anything but "Yes!" they would shut up shop and change jobs. No reputable scientist willingly associates himself with any project that he believes will result in failure.

But to say that the solution will be easy and quick is another matter. There are two technical factors involved in solving the Los Angeles smog problem. These are (1) lack of information, and (2) lack of adequate abatement methods. To solve these problems, we must (1) establish limits for the important pollutants and (2) develop control mechanisms based on these facts. We are currently engaged in finding and assembling the necessary factual information. With this as a base, we can develop abatement procedures just as surely as scientific men can develop jet aircraft or man-made satellites.

But there is a third problem — one not under the control of the scientists. This is the willingness of the community — which includes business, industry, the public, and government — to spend the necessary money and to accept the necessary controls. Nothing worthwhile is ever free.

Now let's get specific! Evidence is piling up that two major smog sources not now controlled are incinerator effluents and the hydrocarbons from automobile exhaust. We, along with others, are developing solutions. We *know* what to do about the incinerator problem; now it is up to the community to accept the solution.

Work on the development of a device to reduce hydrocarbons in automobile exhaust is underway in many laboratories. A device to reduce oxides of nitrogen may also have to be developed. Industry will have to tool up to manufacture these. But, will industry supply the money if it is not certain that the products will be effective and will sell? We are developing the means to test these devices so that we can assure industry and the public that they will be effective.

Let us assume these tests are affirmative. Then comes community action. The devices will cost money—perhaps $15, perhaps $150, for each car owner. The devices may have to be inspected twice a year. This means an inspection system, which means higher taxes and further inconvenience to the motorist. So, in this hypothetical but highly probable case, the alleviation of smog will mean that the community must accept direct costs for installation and maintenance, the indirect cost of inspection, and a measure of inconvenience. But again, if we did not believe the community wants to get rid of smog badly enough to do these things, we wouldn't be here.

Likewise, industry may have to develop and install additional devices for the reduction of hydrocarbons, nitrogen oxides, and possibly other pollutants. We think the willingness of this part of our community to spend the necessary money and to accept the necessary procedures has been demonstrated and may be relied upon in the future.

But even if remedies which have been suggested do not completely solve the problem, the remaining difficulties are amenable to the same tactics:

Get the facts.
Develop and test abatement devices and methods.
Get public acceptance.

This is the Foundation's program; we believe it will be effective.

"The scientist should be a man willing to listen to every suggestion, but determined to judge for himself. He should not be biased by appearances; have no favorite hypothesis; be of no school; in doctrine have no master. He should not be a respecter of persons, but of things. Truth should be his primary object. If to these qualities be added industry, he may indeed hope to walk within the veil of the temple of nature." ... *Michael Faraday*

Statement of Policy

Purpose of the Foundation

An independent, nonprofit corporation has been established for the following purposes:

1. To cooperate with and to assist in coordinating the efforts of governmental agencies, educational institutions, specialized research groups, and medical, legal, and other technologists, so that every phase of air pollution shall be the object of careful study and constructive, remedial action.
2. To provide for research on those phases of the problem not already undertaken or completed by other agencies.
3. To inform the public periodically concerning the nature and extent of air pollution, progress made in its elimination, and obstacles to such elimination.

Organization of the Foundation

The Board of Trustees of the Foundation is composed of business, professional, and industrial leaders with records of conspicuous public service. About one-third are representatives of industrial enterprises which are or may be contributors in some degree to air pollution. The principal reason for their membership on the Board, in addition to their recognized standing in the community, is to make certain that they will be parties to all facts and evidence brought to light on the problem, so that they and their colleagues in like enterprises can continue to devote their best efforts toward the abatement of air pollution.

As a matter of policy, not more than one representative of a given industry serves on the Board at a time. Trustees serve without compensation, nor do they contribute financially to the Foundation. Less than half of the Trustees represent companies or organizations which are providing financial support, and most of these do not contribute to air pollution.

The funds of the Foundation are donated by about 150 different enterprises, trade associations, banks, insurance companies, and industries, representing a cross section of the community. Few of the donors are or may be contributing to air pollution, and less than one-half of total funds received come from all such sources combined.

Financial contributions are unrestricted as to purpose and convey no rights to the donors other than to receive copies of reports, findings, and recommendations. Neither membership on the Board of Trustees nor donation of funds can in any way obtain privileged treatment in connection with responsibility for air pollution or its abatement. The work of the Foundation will be conducted with complete objectivity at all times and its findings are made impartially.

A Managing Director and a limited staff of experts will conduct the day-to-day activities of the Foundation under the general supervision of the Board of Trustees.

What the Foundation Proposes to Do

1. To assemble a competent technical staff to organize and direct a broad program of cooperation, research, and public information.
2. To determine, record, and publish what has been accomplished to date by all agencies dealing with air pollution.
3. To determine what remains to be done and to employ experts through the device of research or service contracts, who will provide information and advice for the shaping of future policies and action.
4. To collect information as to what other municipal areas have done and are doing under similar circumstances.
5. To maintain a library of materials pertinent to the subject of air pollution.
6. To consult with, exchange information with, and to suggest to governmental and private agencies those research activities, enforcement methods, or other matters, which have not yet been conducted or tried and which seem to offer promise of air pollution abatement, so that the efforts of all groups and individuals may be coordinated properly.
7. To hold technical conferences with experts and specialists working in this country or abroad on selected phases of the air pollution problem in order to facilitate and accelerate the process of finding solutions.
8. To publish current information by the most appropriate means on all phases of air pollution and its abatement.

What the Foundation Does Not Propose to Do

1. It will not duplicate services already rendered by governmental or private agencies.
2. It will not conduct research activities directly, unless it appears clear that no existing agency can conduct them as advantageously.
3. It will not expend funds entrusted to it for the construction or equipping of Foundation laboratories that will duplicate facilities already available.
4. It will not hold public hearings for the purpose of receiving complaints, or in any way substitute for governmental agencies now charged with responsibility for certain phases of the air pollution problem.
5. It will not offer any immediate or ready solution for a very complicated, long-range problem.

How the Work of the Foundation May Be Assisted

Those who believe that the proposed activities of this independent Foundation can be of help may assist in this work by making contributions payable to the AIR POLLUTION FOUNDATION, addressed to its headquarters at 704 South Spring Street, Los Angeles 14, California.

Contributions from governmental organizations, business or industrial enterprises, and from private citizens will be welcomed by those in charge of its program.

A Word of Caution . . . and an Invitation

The smog-free skies of an earlier day in California cannot be brought back immediately by any endeavor, however resolute the attempt, or through any quick expenditure of funds; they can be restored over a reasonable time by diligent and honest fact finding, by wise and effective action.

Air pollution is now recognized as a national problem. The fundamental contributions which the Foundation is making toward the solution of urban air pollution are attracting increasing national attention.

Assumptions Made by the Foundation

1. That the problem of air pollution is one of the most serious confronting urban areas in California and elsewhere; that it is worthy of the best efforts of everyone concerned; and that it calls for the expenditure of whatever funds are needed for its solution.
2. That the air pollution problem is not new and is generally increasing.
3. That geographical and meteorological features often contribute materially to the air pollution problem, especially in the Southern California area.
4. That every additional person or industrial enterprise locating in this area potentially adds to the problem.
5. That much excellent work has been done by governmental and private agencies to reduce air pollution, and by the press to keep the public informed; that the public should be informed of all significant phases of the problem.
6. That further information must be obtained and additional action taken before the air pollution problem can be brought under proper control.
7. That there is no quick or easy solution to the problem, no matter what funds should be spent immediately or what laws should be invoked. There is an understandable tendency to oversimplify this problem and to insist that its obvious seriousness and urgency somehow must expedite its solution.
8. That the control of emission of particular gases, fumes, or dusts may not alone solve the problem. (Some of these pollutants, believed to be harmless or of minor importance individually, may in combination undergo photochemical reactions in a manner not completely understood at present.)
9. That while the solution of the urban air pollution problem is long range, short-range steps should be taken to alleviate it further, as soon as reliable facts are available and policy decisions have been made.
10. That many of the findings of the Foundation, including methods of attacking the air pollution problem as well as remedies, are applicable to all metropolitan areas and should be widely disseminated.

TECHNICAL REPORTS
published by the
AIR POLLUTION FOUNDATION

Report No. 1 "Meteorology of the Los Angeles Basin"
M. Neiburger and J. C. Edinger, 99 pp., April, 1954............$ 3.00

Report No. 2 "Combustion and Smog"
W. L. Faith, 63 pp., September, 1954............$ 3.00*

Report No. 3 "Conference on Incineration, Rubbish Disposal, and Air Pollution"
Francis R. Bowerman, Editor, 52 pp., January, 1955............$ 3.00

Report No. 4 "First Technical Progress Report"
W. L. Faith, L. B. Hitchcock, M. Neiburger, N. A. Renzetti, L. H. Rogers, 89 pp., March, 1955............$ 4.00

Report No. 5 "Hydrocarbon Losses from the Petroleum Industry in Los Angeles County"
Southwest Research Institute, 22 pp., November, 1954............$ 1.50

Report No. 6 "Basic Statistics of the Los Angeles Area"
Neil Goedhard, 74 pp., January, 1955............$ 3.50

Report No. 7 "Tracer Tests of Trajectories Computed from Observed Winds"
M. Neiburger, 59 pp., April, 1955............$ 3.00

Report No. 8 "Field Evaluation of Houdry Catalytic Exhaust Converters"
Southwest Research Institute, 77 pp., June, 1955............$ 3.00

Report No. 9 "An Aerometric Survey of the Los Angeles Basin, August-November, 1954"
N. A. Renzetti, Editor, 334 pp., July, 1955............$10.00

Report No. 10 "Feasibility of Control Methods for Automobile Exhaust"
Southwest Research Institute, 63 pp., August, 1955............$ 2.50

Report No. 11 "Visibility Trend in Los Angeles"
M. Neiburger, 45 pp., September, 1955............$ 1.50

Report No. 12 "Second Technical Progress Report"
W. L. Faith, L. B. Hitchcock, M. Neiburger, N. A. Renzetti, L. H. Rogers, 143 pp., November, 1955............$ 3.00

Report No. 13 "Wind Trajectory Studies of the Movement of Pollutants in the Los Angeles Basin"
M. Neiburger, N. A. Renzetti, R. Tice............in preparation

Report No. 14 "Photochemical Processes in Polluted Air"
P. A. Leighton and W. A. Perkins............in preparation

*Out of print. Essential information of Report No. 2 now brought up to date and included in Report No. 12.

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The Board of Trustees at its Annual Meeting requested that copies of this report be sent to all friends and supporters of the Foundation. Additional copies are available free upon request.

2072 W.W. Robinson Papers
Box 93 Research material
f.24 Los Angeles. City services.
Air pollution. General. 1950
- 1967. Magazine clippings.

LOOK - 6-20-50

That EVIL Los Angeles SMOG

The acrid, yellow-gray pall blots out the sun, produces swollen eyes, rasping throats, stinging nostrils—and some of the rawest tempers west of the Mississippi

BY LEWIS W. GILLENSON
LOOK Staff Writer

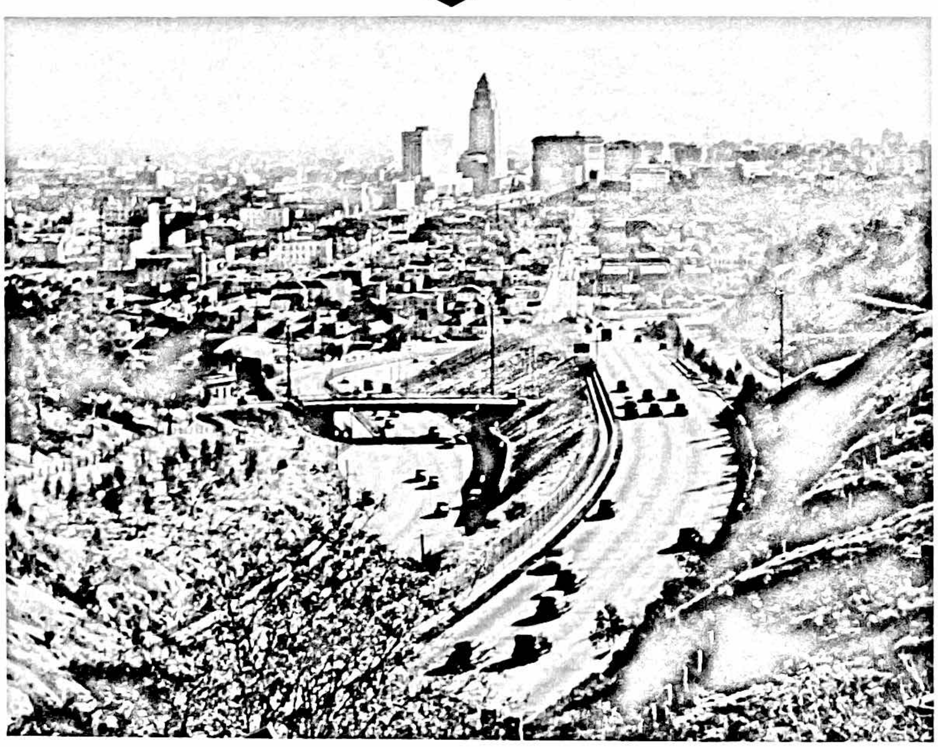
In Los Angeles not long ago, a prominent attorney gulped his breakfast coffee, kissed his wife and children and started to drive to his downtown office. Half way in, the skies changed from bright blue to dirty gray. A moment later, his eyes started itching and tearing. With difficulty, he made it to his office, picked up some briefs and headed for court. When he got there, the clerk, alternately sneezing and sniffing, announced that the judge had closed court. Los Angeles smog was too much for Los Angeles justice.

On that same day, school children who normally spent their gym periods outdoors were hustled inside when the raw, chlorine-like odors brought on mass coughing spasms.

In a downtown hospital, a surgeon felt his eyes tear and ceased operating till blowers

(Continued on page 40)

BELOW, CLEAR DAY ↓ RIGHT, SMOG →



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MEET THE PEOPLE

How Do You Amuse Yourself on Long Train Trips?

***Bob Elson, on the Century* (WJJD, Chicago) queries some well-known train travelers**

Patricia Neal, screen actress, to Bob Elson: "I read and read and read—and love every minute of it. I never have time to get caught up on all the books I'm interested in—and save them up especially for long train trips."

Vice-President Alben Barkley: "I have no set way to spend my time on a train. Usually, I like to talk and relax with friends I see or with some person who recognizes me."

Joe E. Brown, actor: "You notice I have two radios? On a train, I'm forever trying to get stations wherever the train is at the moment. It's my main entertainment."

Jo Stafford, singer: "On a train or anywhere else right now, I'm trying to become a bridge player. If I meet people, I play with them. If I don't, I use my Autobridge."

Jack Gregson, Television's *Auction-Aire:* "I'm a mystery fan and a Perry Mason addict. On my recent travels, I've completed Perry and now I'm with Ellery Queen."

through the state legislature which created the authority to deal with the problem. The Los Angeles Air Pollution Control District was formed with power to operate across municipal boundaries—but not on the matter of rubbish collection—the politicians saw to that.

The District is charged with licensing factory operations. No new factory may start producing unless it has the equipment to eat up its smoke wastes. Operating industry is given time to clean up or shut up. And Gordon P. Larson, ex-Army engineer who heads the District, can't be pushed around.

Periodically, certain industry associations try roughing up Larson by slamming a couple of crippling amendments on the law. That's tantamount to telling Angelenos that they are going to get more smog and like it. The public is in no mood for such nonsense and says so. Perhaps that's why no group has come out openly against the law.

In the two years the District has functioned, its results must be considered impressive. The refineries are now pumping 78 per cent of their sulphur gases into chemical plants which produce sulphuric acid and raw sulphur —at a neat profit to the refineries. They have also spent more than two million dollars in equipment to capture their other stack gases.

Control District Produces Results

New-type furnaces in two big steel mills of the area have reduced their atmospheric pollutants markedly. Forty-two evil-smelling garbage dumps have been closed. The lumber, asphalt, rock-crushing and metallurgical industries are installing filtering equipment.

Still, Los Angeles has its smog. After a serious attack, Larson's office is deluged with *threats, complaints and wails of anguish. The papers carry stories regularly of collapses in* the real estate and farm markets, of severe dents in the tourist trade. Recently a movie company waited three expensive weeks for the smog to lift, to shoot a special outdoor scene.

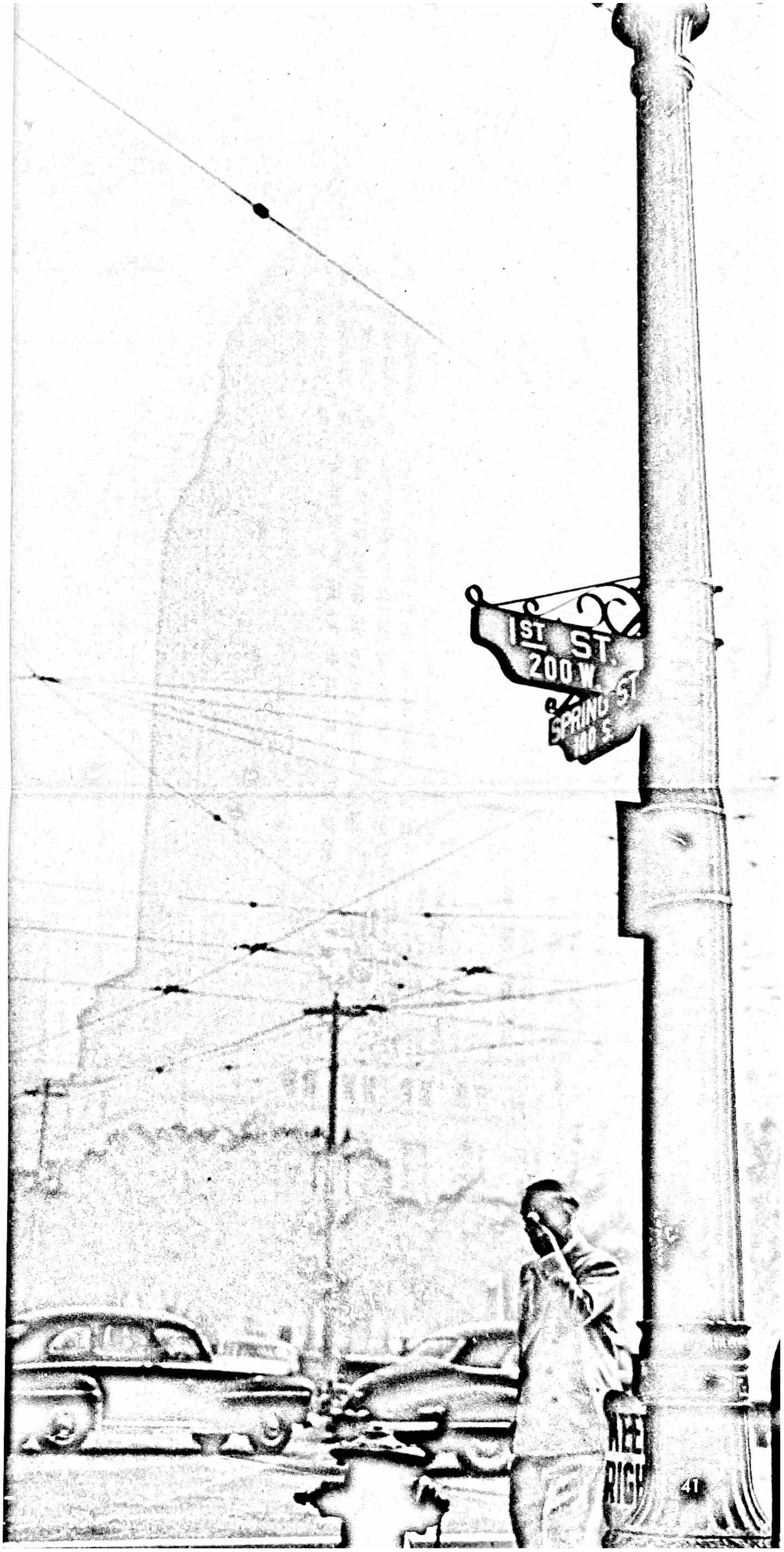
A patient, logical man, Larson knows enough to expect no miracles. Smoke control equipment is as tricky to design as it is expensive. Cleaning the air is a slow process.

While it waits, the city of Los Angeles might thank itself that it acted as soon as it did to control the air. Had it done nothing, there is scientific reason to believe that the area could have experienced another Donora. Scoffers answer that Donora was slumped in a narrow valley and was therefore more vulnerable than sprawling Los Angeles. But this answer is true and false: Los Angeles sprawls—but it has an infinitely greater industrial concentration. And its temperature inversions are far more chronic.

As in Donora, the chemicals causing the irritation in Los Angeles have yet to be isolated and dealt with. It will probably be at least two years before the air again approximates its prewar sweetness.

By that time, Angelenos should have learned the lesson Donora citizens had to learn the hard way; namely, that the air, like other natural resources, belongs to all the people who breathe it. To allow anyone to defile it can be terribly costly. END

In mid-morning, pedestrian walks dark, smog-filled streets of downtown area, daubing his stinging eyes.



Leaves of spinach plant day after smog are coated with hard crust, which ruined whole crop.

Unlike smog in other cities, the Los Angeles kind appears on sunny days

cleared the room.

Fifteen miles from the downtown area, in a sanatorium, a doctor watched patients wheeze and spit. Asthmatics coughed fitfully and gasped for breath. The patients' fingernails and lips had turned a bloodless blue. The symptoms added up to cyanosis—a condition where adequate oxygen is prevented from reaching the system.

The next day, complaints of farmers in the agricultural basin swelled to a roar. A brittle silver substance formed on the leaves of a spinach crop and in 12 hours destroyed $30,000 worth of it. Lettuce, beet and alfalfa growers were hit the same way. A honey producer reported that his entire swarm of bees lay dead in their hives.

It's ironical that such an atmospheric blight should hit Los Angeles of all places—the city for 50 years exploited as God's own solarium. An evangelist hinted darkly that The Maker had visited the stuff on the place for its iniquities. Angelenos, who have been suffering the nuisance an average of 90 days a year since 1943 felt little inclined to try sweeping away the smog with prayer. The ordinarily easy-going citizen was so worked up by this foul air that he'd rather use a gun than the gospel on any one responsible for it.

Before resorting to either, however, Los Angeles decided to find out what the fuss was all about. Citizens' "seeing-and-smelling-committees" broke out like freckles on a youngster. They sniffed and snooped, but did little else. They got their first big boost when Norman Chandler, publisher of the Los Angeles *Times*, put his powerful paper behind the drive. A new committee invited Prof. Raymond R. Tucker, the man who cleaned up a sooty St. Louis, to Los Angeles to take a look and a sniff. Chandler picked up the tab. Tucker got the reception of a tribal medicine man. In early 1947, he explained what the town's atmospheric halitosis was all about:

First, there was the industrial factor. Before the war, 1,500 factories were spewing smoke and gases into the air. Since the war that number has jumped to 10,000.

Then, there was the phenomenal growth of population; easily a million more people arrived in the last ten years. They brought with them their cars, trucks, private-home chimneys and did their part to pollute the skies.

No Collections of Aerial Garbage

The peculiar Los Angeles airshed just couldn't handle this aerial garbage. In most places, the higher you go the colder it gets. Usually, warm smoke is drawn upwards by the cold air until it disintegrates. But not so in the eccentric Los Angeles skies. The atmosphere there has what is known as an inversion layer. After about 1,500 feet the air starts getting warmer. That's simply wonderful for suntans and gardens, but awful for dispersing smoke and fumes. As the stuff hits the warm layer it bounces back. When the inversion layer drops, it pushes billows of foul air down with it.

Two other factors contribute to the raw tempers in the city of the Angels. One, the mountains which ring the city on three sides; the other, the casual breezes which blow no faster than an average of six miles an hour. The breezes nudge the polluted clouds to the mountains where they float around like dirty bedsheets in a tenement backyard. Below, the foothills residents choke in gray, greasy smog.

Unlike the sooty smog of Pittsburgh and St. Louis—caused by coal dust and fly ash—the Los Angeles brand is essentially gaseous. Particles in the smog clouds are usually smaller than 1/25,000th of an inch. Though they leave little dirt, they scatter light like dust in a light beam. This makes the skies hazy over Los Angeles all year round, unless there are winds or rains to scour them. Unlike other smogs, the Los Angeles product requires no fog. A dry, windless day brings out its worst.

The chemical origin of the smog begins with smoke from the combustion of organic materials such as rubbish, industrial wastes and fuel oil. More troublesome are the gases and fumes from factory stacks. Present in all smog are sulphur compounds. For a while, experts tried making them the black sheep of the chemical family. Since most of the sulphurs came from the stacks of the 16 refineries in the Los Angeles area, the oil industry came in for its share of public abuse—and still does.

Sulphur Dioxide Harmless Alone

This industry would have made a better whipping boy if anyone could have proved that the sulphur dioxide (SO_2), which becomes sulphuric acid mist when exposed to sunlight, caused all the irritation. Tests showed that in no one place was there enough of the stuff to make even one nostril twitch. With its back to the wall, the oil industry tried to capitalize on the public's concentrated hatred of the irritants; it agreed that the poor visibility came with the sulphur dioxide, but denied responsibility for the eye, nose and throat irritations.

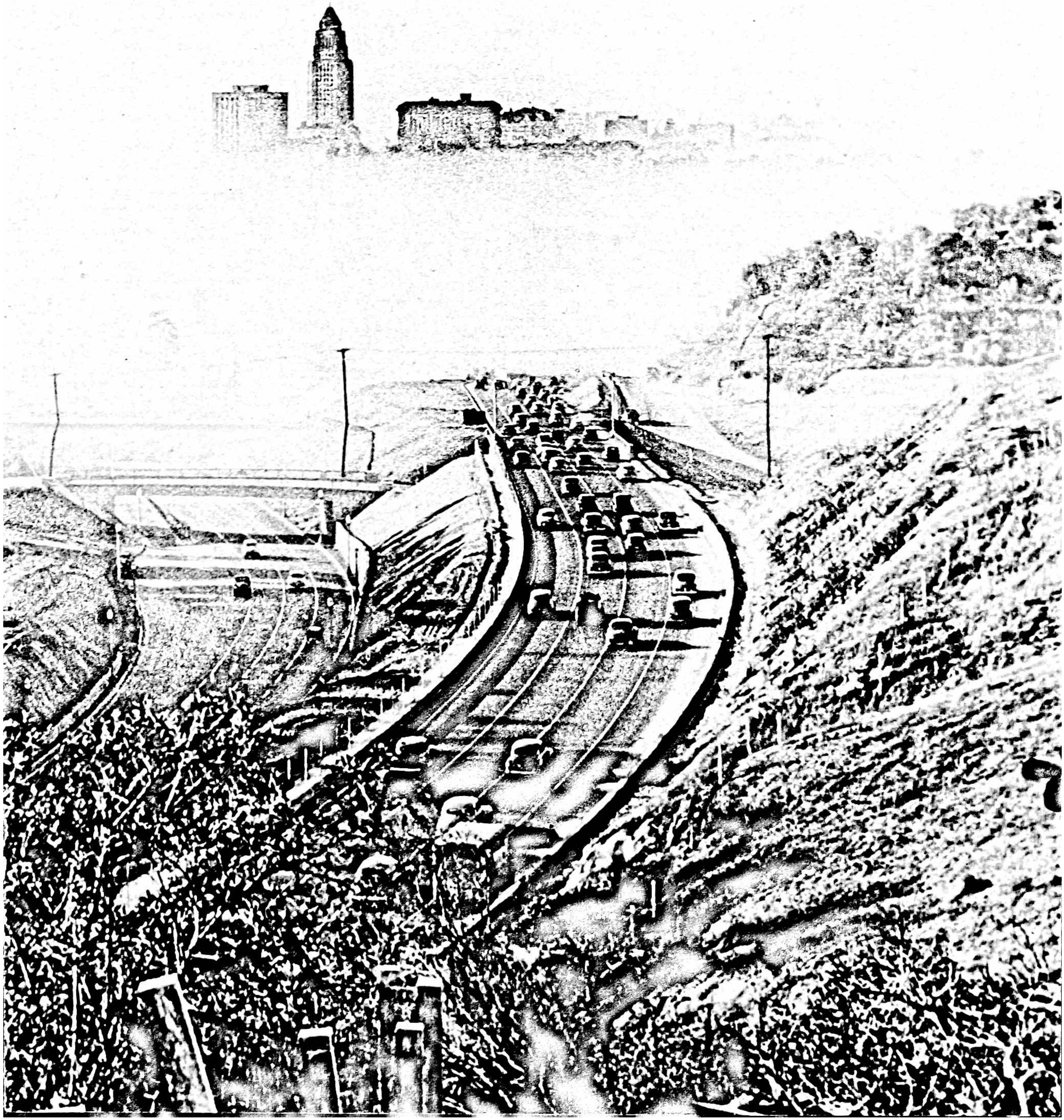
The argument sounded reasonable until people began reading U. S. reports on the Donora, Pa., disaster of 1948. The report showed that SO_2 was found in the Donora skies, but that the 20 deaths were not caused by it alone. It was concluded that the SO_2 could have acted as a carrier of particles or an agent which, when mixed with other gases, raised the devil with human tissue. The oil industry in L.A. was emitting about 400 tons of SO_2 per day.

The industry couldn't very well disregard the U. S. Public Health Service reports on Donora. Alarmed at the ferocity of public opinion, it retired to its private $350,000-a-year-research institute to try to isolate the different gases that pour from refinery stacks.

From the Tucker report came another poke at chromium-modern Los Angeles—this time, for its rusty-archaic handling of the area's rubbish. Most houses in the county are equipped with rubbish-burning incinerators which do their bit to make more smog.

Now that it has become clear to the politicians that Los Angeles hates smog more than Satan, most of them have courageously gone on record in their opposition to smog. But since the politician hasn't yet discovered whether his constituents hate it more than taxes, he's doing precious little to battle for a rubbish disposal program. That would take money—to get it would require taxes.

Tucker's study, general public irritation and a few strategic smog attacks did, however, push Los Angeles County into action. By late 1947, a law with teeth in it was jammed



Smog in the South Coastal Area

injury to herbaceous plants in the affected area found to be result of air pollution by gases and aerosols

John T. Middleton, J. B. Kendrick, Jr., and H. W. Schwalm

Smog injury to crops in Los Angeles County in 1949 amounted to an estimated loss of $479,495.00.

Crop damage by smog was first noted in 1944, when certain vegetables in Los Angeles County were observed to have leaf injury.

Subsequent study revealed the injury to be a problem of general air pollution with the area affected including important parts of Los Angeles, Riverside, and San Bernardino counties and nearly all of the agricultural sections of Orange County.

The term, smog, is widely used to describe a mixture of smoke and fog which is not unusual or confined to any particular region. It is more descriptive to refer to a similar condition in the south coastal area of California as air pollution. The condition in that area is unique and has developed with population and industrial expansion during and since the recent war years.

Causes of Air Pollution

Visible air pollution is formed by a peculiar set of air phenomena in the affected area which is bounded by mountain ranges to the north and northwest, and by low ranges of hills and mountains to the east and southeast. These barriers confine the air pollutants from a thickly populated, highly industrialized area within a rather restricted zone.

The primary phenomenon is a warm air stratum which is part of the Pacific inversion layer and frequently present in the area. This stratum acts as an invisible lid which prevents the smoke, fumes, dusts, and gases originating in the basin from dispersing into the upper atmosphere. The bottom of the inversion level usually exists at 1,000 to 3,000 feet above sea level.

The Pacific inversion layer rises and lowers according to the meteorological conditions affecting it. Occasionally the base of the inversion layer drops below 500 feet above sea level. When this lowered ceiling is accompanied by several days of low wind velocity, so that stagnant air accumulates beneath the lid, smog develops. During the daylight hours there is usually a westerly breeze of low velocity which moves the air mass eastward. This air mass must escape through three natural outlets—Mint Canyon, Cajon Pass, and San Gorgonio Pass—to desert areas where it is dispersed.

Injury to plants occurs only during periods of aggravated air pollution. This aggravation is brought about by the lowered ceiling and reduced wind velocity. Air pollutants during a smog are concentrated in a smaller volume of air than is normally available. Wind velocity at this same time is likewise less than its normal rate. This increased concentration of the pollutants generally causes susceptible plants to show symptoms of smog damage within one to three days.

Types of Air Pollutants

At least three types of air pollutants are known to occur in the Los Angeles area: gases; aerosols; and particulate matter.

The gas phase is the most common cause of plant damage. Occasionally, especially during periods of foggy weather, plant injury results from the deposition of an aerosol containing toxicants. There is evidence that particulate matter is released into the atmosphere, but no evidence that this material is responsible for plant injury. The liberation of particulate matter may, however, play an important part in the formation of aerosols which later become laden with toxicants. Minute dust particles are known to behave as condensation nuclei for various types of aerosols.

Actual analyses of the atmosphere in Los Angeles County during smog periods, by the Stanford Research Institute and the Los Angeles County Air Pollution Control District have shown that the following constituents are present: sulfur dioxide, ammonia, oxides of nitrogen, sulfur trioxide, aldehydes, filterable oils, soluble chlorides, carbon, ozone, hydrogen sulfide, traces of many minerals and elements, organic peroxides, acrolein, fluorides, methyl chloride, formic acid,

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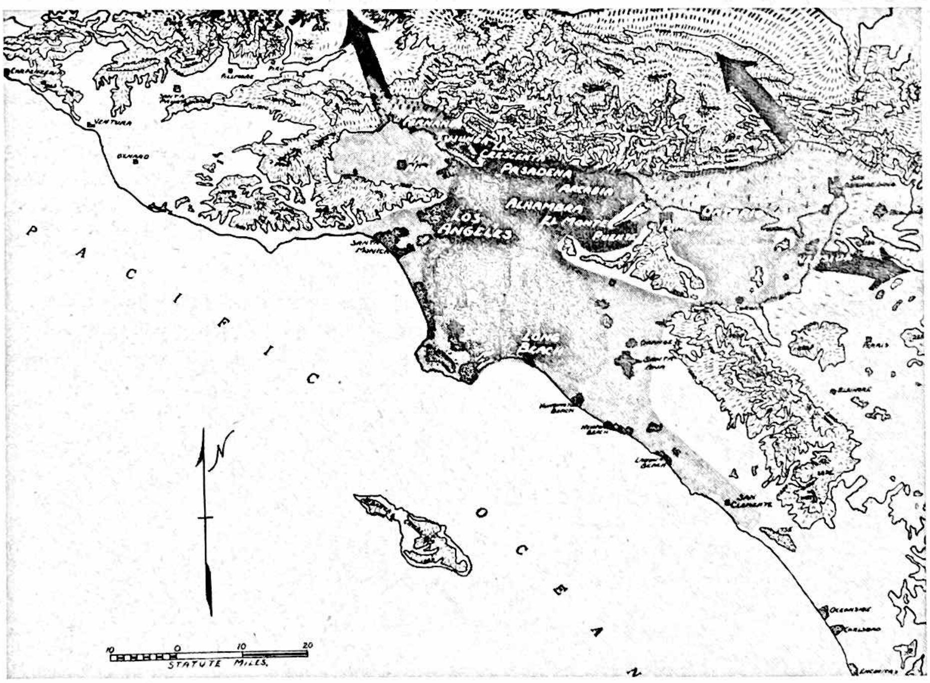


Topographical map of California's south coastal basin, showing the extent of air pollution—lightly shaded area—and the area of heaviest concentration of air pollution, where the greatest economic loss of vegetables occurs—darker shaded area. Stippled areas represent incorporated cities. Arrows indicate the direction of normal air flow out of the basin into the adjacent desert areas, the darker arrows signifying the main outlets.

sodium chloride, and gaseous hydrocarbons. Sulfur dioxide, a common air pollutant in several districts in the United States, is present in subtoxic concentrations in the Los Angeles area and is not considered to be the primary cause of plant damage in this area.

On the basis of symptom expression and of the existing concentration of hydrogen fluoride in the Los Angeles air pollution, there is no indication that this compound is responsible for plant damage.

Symptoms

The initial symptom of plant injury—which develops 24 to 72 hours after exposure to the gaseous component of air pollution—is a glazed appearance on the under surface of the affected leaves.

On crops such as spinach, garden beets, Romaine lettuce, and chard, the glazing is silvery like that due to freezing injury. Endive and turnips affected show initially a bleaching of the lower leaf surface rather than a glazing, which often develops into light-tan necrotic areas.

Microscopic examination of these affected areas shows that the protoplasts of the mesophyll layer of cells, especially in the region of the stomata, have collapsed, and that large air pockets have taken their place. These air-filled spaces are responsible for the glazed or bleached appearance of the leaves. The epidermal layer is not initially affected.

Under certain conditions, which may be due to low concentration of the air pollutants or a short exposure period, no further symptoms develop. Usually, however, there is progressive dehydration of leaf tissue in the affected region until scorched areas develop through the entire thickness of the leaf and leave brown necrotic spots with glazed margins.

The leaf scorching develops across veins and is not limited in area by any anatomical leaf structure. Under severe and prolonged attacks the entire leaf may be so affected.

The aerosol component of air pollution damages plants in a different manner. This type of damage is usually seen only during periods when heavy air pollution is accompanied by fog. The surface of a plant may be wet by the precipitation of fog particles, which presumably contain air pollutants of an as yet undetermined nature. Under these circumstances the sequence of symptom development is one in which the exposed surface, usually the upper surface, shows the initial necrosis. The pH—the measurable alkalinity and acidity—of the leaf-surface moisture, which is between three and four, indi-

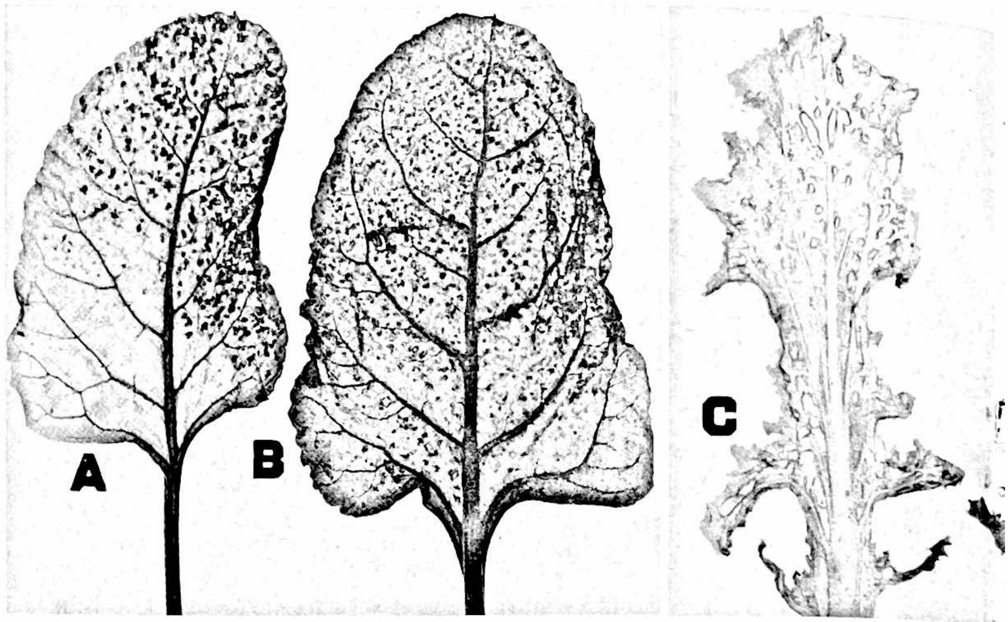


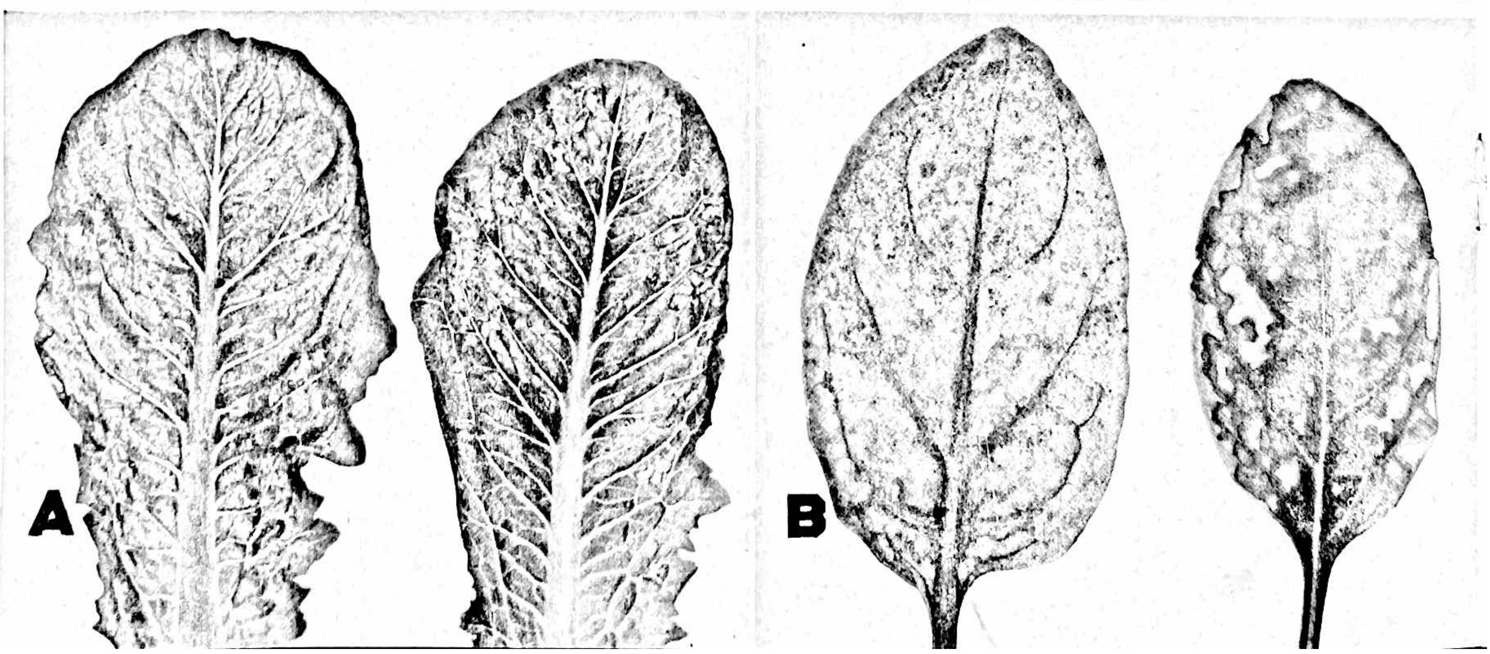
Table beet leaves *left*, showing aerosol injury on both top *A* and bottom *B* surfaces of leaf. leaf area. The lower left-hand area of leaf *A* was protected by a covering leaf. *Right*, le bleaching of lower leaf surfaces and a subsequent tan to bronze color of dried-out tissues. T

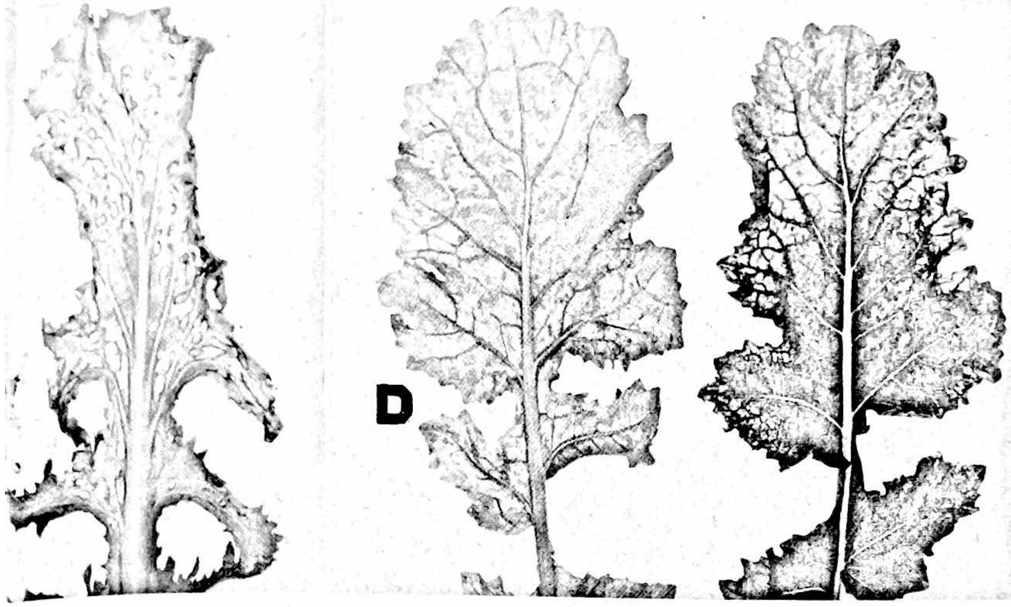
Economic Loss to Susceptible Crops Caused by Ai 1949, Showing Acreage Affected, Average Yields,

Crop	Total acres planted*	Acres affected	Per ce of tot affect
Alfalfa	53,400	9,000	17
Spinach	3,380	1,000	30
Parsley	300	300	100
Celery	2,300	100	4
Romaine	500	300	60
Endive	350	275	79
Radish	750	500	67
Turnip	750	300	40
Table beets	700	250	36
Mustard greens	600	200	33
Chard	50	40	80
Total			

* Information from Annual Crop Report of the Los Angele

Gaseous air pollution injury to leaves of *A*, Romaine lettuce; *B*, spinach; *C*, garden beet; and *D*, Swiss chard. The lower leaf surface is shown on the *left*, and the upper surface on the *right* in each case.





. The small punctuate spots characterize this type of injury, uniformly dispersed over the leaves of endive C and turnip D, showing gaseous air pollution injury manifested by initial The latter symptom is visible on both upper, left, and lower, right, surfaces of each group.

\ir-Pollution Damage in Los Angeles County in ;, Estimated Damage, Unit Value, and Dollar Loss.

cent otal cted	1949 average yield per acre*	Per cent loss	Dollar value per unit*	Total dollar loss
7	5.3 tons	15	$24.00	$171,720.00
0	5.1 tons	50	33.50	85,425.00
0	500 crates	25	1.50	56,250.00
4	950 crates	25	2.00	47,500.00
0	300 crates	25	1.50	33,750.00
9	300 crates	20	1.40	23,100.00
7	400 crates	10	1.10	23,000.00
0	500 crates	10	1.00	15,000.00
6	300 crates	10	1.50	11,250.00
3	400 crates	10	1.00	8,000.00
0	450 crates	25	1.00	4,500.00
....				$479,495.00

es County Agricultural Commissioner.

cates the presence of a relatively strong acid. Cellular collapse in many small spots develops progressively through the upper epidermis, mesophyll, and lower epidermis of the leaf, leaving scorched areas similar to those caused by the gaseous component.

No glazing or bleaching accompanies this injury. Leaf areas covered by exposed leaves show no markings and thus give further evidence that this type of injury is due to the precipitation of a phytotoxic agent from the atmosphere.

The gas-type injury may be confused with sulfur dioxide injury by an untrained observer. The distinct bleaching or loss in chlorophyll of the leaf in interveinal areas—and not across the veins—in sulfur-dioxide injured plants is not found with the gas-type of air-pollution marking. In addition, when lists of plants susceptible to injury by sulfur dioxide and gaseous smog are compared, it is evident that host susceptibility is distinct for each type.

Alfalfa is extremely susceptible to sulfur-dioxide injury, but only moderately so to gaseous air pollution.

Squash and cucumbers are easily injured by sulfur-dioxide, while apparently untouched by gaseous smog.

In general, most members of the mustard-type plants—the Cruciferae—are uninjured by gaseous air pollution but are marked by sulfur-dioxide. Controlled fumigation by sulfur-dioxide has in no instance given any sequence of symptom development such as that described above, and it has failed to produce the characteristic glazing of under surfaces of leaves. This latter symptom is the most reliable indication of gaseous smog damage to crops in the southern California area.

Economic Losses

The greatest economic losses due to air pollution are experienced in those crops in which the foliage is the salable portion of the plant, such as lettuce, alfalfa, and spinach.

During certain periods in 1949 entire fields of spinach were unharvested because severe leaf scorching made the crop unmarketable.

In some alfalfa fields in southeastern Los Angeles County, leaf drop reduced yields of fall cuttings by 50%. The market value of the damaged hay was greatly lowered because of the high proportion of stems to leaves. In a few fields the last cutting was sufficiently damaged to make it unprofitable to be cut for hay.

Other crops such as table beets, tur-

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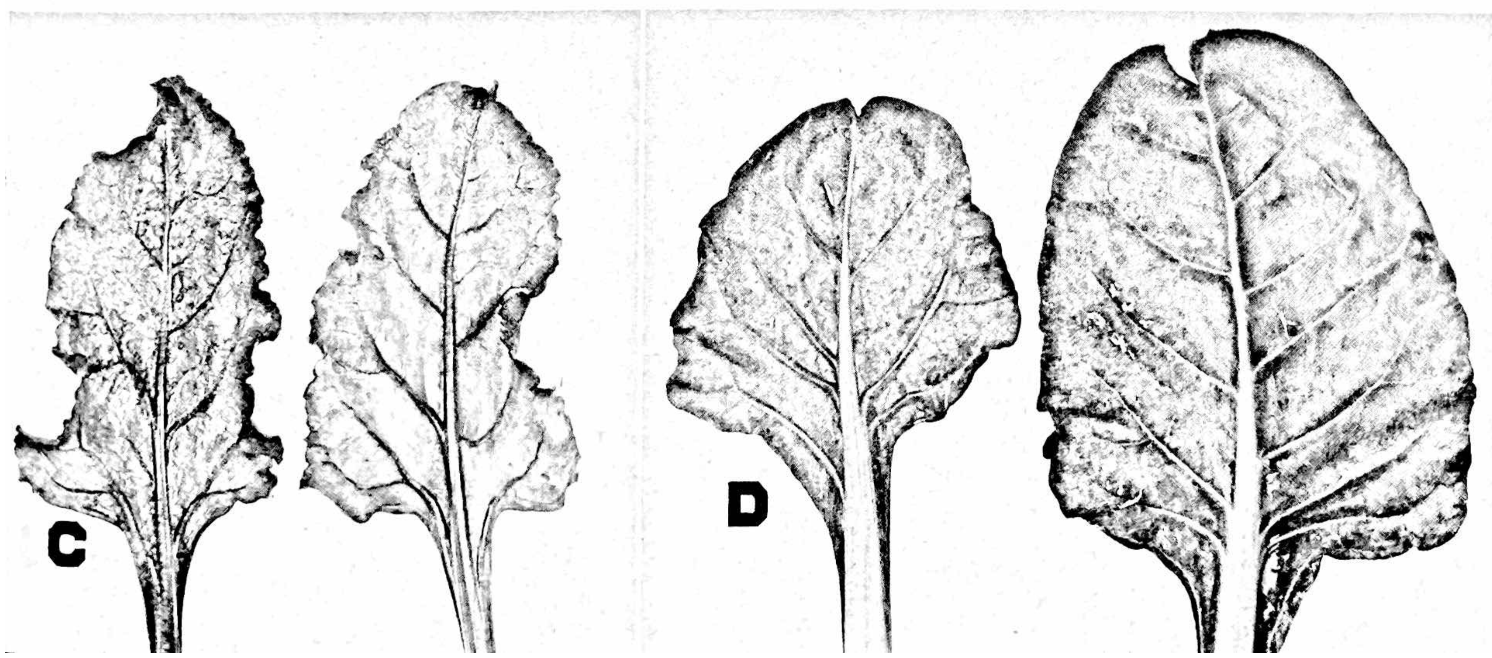
Note that the lower surface shows the initial stages of injury characterized by a glazed appearance; the upper surface shows injury when the tissues dry out further, as in Romaine and spinach.



SMOG

Continued from preceding page

nips, and radishes also were damaged by smog. The roots or edible portions of these crops were uninjured, but severe burning and spotting of the tops lowered market value because of poor appearance.

In the table on pages 8 and 9 crops are listed in the order of dollar-value loss due to smog damage.

In the case of alfalfa, only 17% of the Los Angeles County acreage is produced in the area seriously affected by air pollution. The greater portion of the acreage is north of the Sierra Madre Mountains in a desert area far removed from industrial and urban centers. In the case of other crops, such as spinach and parsley, 20% to 100% of the acreage is located in the area of heavy concentration shown in the dark-shaded portion of the map on page 7.

Estimates given in the table are for total 1949 production. Individual crops of spinach may have been a total loss at the particular time they were scheduled for harvest, whereas at other times during the year spinach was undamaged. The same is true of all other crops listed.

In addition to the listed crops there were others that showed damage but evaluation of dollar loss would be exceedingly difficult. For example, the leaf tips of young oats, barley, and onions were scorched. However, these crops overcame the injury sustained during early growth and eventually produced a near-normal yield. Destruction of leaf tissue resulted in delayed maturity in some instances. The longer growing period necessitated additional irrigation, fertilization, pest control, and weeding for crops such as beets and onions. No attempt was made to calculate these losses.

Many types of flowers and ornamental nursery stock—in greenhouses as well as out of doors—have at times had either leaves or flowers, or both, marked by concentrated air pollution. In most cases, the market value was lowered because of poor appearance, and estimates of loss by members of the flower industry ranged from one half to one million dollars. There are no surveys or other reliable data to substantiate these estimates.

The following cultivated plants are listed in order of decreasing susceptibility: *Extreme*—Romaine lettuce, endive, and spinach; *Moderate*—beet, celery, oats, Swiss chard, and alfalfa; *Slight*—barley, onion, parsley, radish, tomato, turnip, and rhubarb; *None*—cabbage, cantaloupe, carrot, cauliflower, cucumber, pumpkin, squash, and broccoli.

A number of weeds also have been damaged by air pollutants, namely: wild oats, *Avena* sp.; lambs quarters or pig weed, *Chenopodium album*, and *C. murale; Malva parviflora* and annual blue-grass, *Poa annua*. Weeds are used as an indication of the extent of air pollution injury because they are often found in zones not ordinarily cultivated. Annual blue-grass is the most susceptible plant observed to date.

Injury to herbaceous plants has been recorded in a triangular area delineated by the cities of Santa Monica, San Clemente, and Redlands. The agricultural districts most seriously affected are those south and east of Los Angeles.

Air pollution damage to susceptible crops is particularly devastating, and is comparable to such catastrophies as fires, frosts, and floods, because it can render a crop worthless almost overnight, with no previous warning. It is a direct function of the weather and of meteorological conditions of the southern California coastal plain. This fact alone makes the problem a difficult one to solve.

Since crops differ in degree of susceptibility to injury, it may be advisable for growers in this area to revise their crop schedules by eliminating the extremely sensitive plants. This will have to be done in order to stabilize their economy until such time as the phytotoxic agent or agents of air pollution are definitely identified and eliminated.

Elimination of the components of air pollution will require diligent research to solve the engineering problems involved, and also will require the establishment of new regulations governing air pollution and means for their enforcement.

John T. Middleton is Associate Plant Pathologist, University of California College of Agriculture, Riverside.

J. B. Kendrick, Jr., is Assistant Plant Pathologist, University of California College of Agriculture, Riverside.

H. W. Schwalm is Associate Agriculturist, University of California College of Agriculture, Los Angeles.

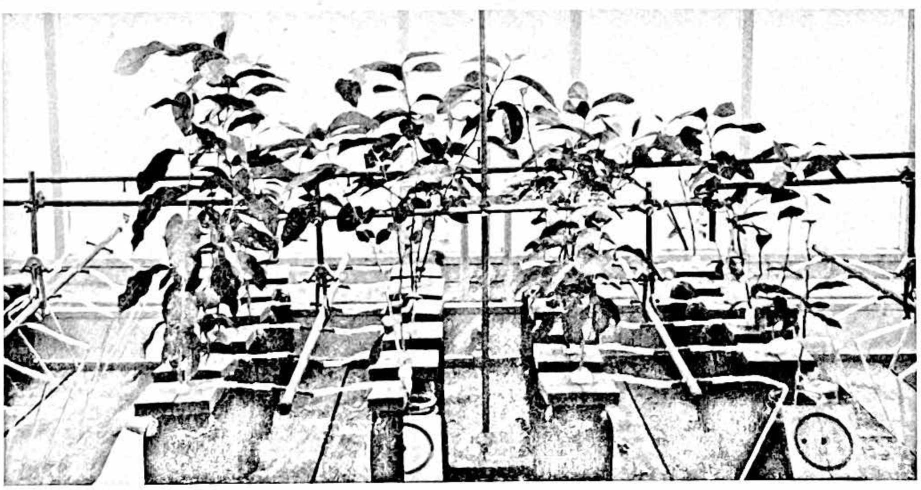
The above article is based on Paper No. 640, University of California Citrus Experiment Station, Riverside.

SYSTEMIC

Continued from page 3

Studies on systemic insecticides will require several years of experimentation—and the solution of many technical problems—before any practical use can be anticipated. Among the many questions to be answered, the following are readily apparent: *1*, duration of effectiveness at various concentrations to a variety of citrus pests; *2*, most suitable methods for application—whether by foliage spray, irrigation, pressure injection, or soil treatment; *3*, distribution of compounds in citrus plants and possible toxicity of treated fruit to consumer; *4*, distribution of soil applications through the root zone of citrus trees and its effects on soil fertility and possible deleterious effects on citrus or other crops.

Because the answers to many of these questions are difficult to obtain—due to the extremely small amounts of compound present—it is planned to use radioactive molecules as tracers. Such studies should increase current knowledge of insect and mammalian toxicology. They should be valuable also in elucidating the principles governing the translocation and distribution of organic molecules in plant tissues.



Experimental set-up for growing lemon seedlings in water cultures containing systemic insecticides.

Robert L. Metcalf is Associate Entomologist, University of California College of Agriculture, Riverside.

Robert B. Carlson is Laboratory Technician, University of California College of Agriculture, Riverside.

The above progress report is based on Research Projects Nos. 1078 and 1415.

Fortnight

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VOLUME 17, NO. 11 CALIFORNIA'S OWN NEWSMAGAZINE December 1, 1954

THE BLEWETT REPORT

SMOG

What Is It? Why Is It? A Scientific Analysis of One of California's Most Serious Problems

FORTNIGHT in this issue drops its regular news columns in order to bring its readers the most comprehensive, scientific and unbiased theory ever published on the causes of California's greatest curse—smog.

If you don't breathe, this article won't interest you. If you do breathe (and live under the pall which embraces millions of Californians) you will find in this report no easy-to-read, ready and optimistic conclusions. It is hard reading on a hard, baffling and widely misrepresented problem. From a journalistic standpoint—aside from the fact that it taxes the intellect and reasoning powers of its readers, it has one cardinal fault: It is an expose without a villain.

From the great automobile and oil industries to the man burning yesterday's newspaper in his backyard, no scapegoat will emerge to be banished, and hence bring back the good old days when "you could see Catalina on a clear day."

From the hallowed halls of Caltech to the political forums of Los Angeles, the search for a villain will continue. Many more millions will be spent, vilification will run rampant, and elections may turn on the outcome of these charges and countercharges.

FORTNIGHT editors were told they were hopelessly visionary to run this piece, that nobody would read it, that nobody outside of scientific circles could understand it if they did. But nonetheless here it is.

We believe you *will* read it and understand it. We ask you to file this copy. From time to time as the months pass along and the smog—attacked along political lines—does not become less noxious, turn to it and read it again.

THE EDITORS

"The poison in smog is a mixture of ozone and nitrogen dioxide . . . Its source is not factories or incinerators or auto exhausts, but the stratosphere over the Pacific . . ."

A TREMENDOUS amount of research has been done on the Southern California air pollution problem by numerous agencies. Millions of dollars have been spent on research during the last seven years and many more millions on corrective devices to remove dust, fumes and gases from the effluent of industrial plants. No improvement in the smog condition has resulted. The failure of all efforts to date has been blamed on various factors such as increase in automobiles, oil refineries, backyard incinerators, lack of enforcement of present laws, and politics. The reason for the widespread confusion as to source, cause and increase of smog in Southern California will be evident from the content of this report.

The word "smog" which originally meant the combination of smoke and fog has been so continually and widely applied to the type of air pollution prevailing in Southern California that it has come to mean the acrid, respiratory irritating and sometimes eye-smarting mass of pollution that frequently invades the area. Some refer to the typical odor of smog as musty or acrid, and some, as ozone-like or a combination. All are describing the same thing. The variation in odor is due principally to variation in moisture content of the air.

We have found the principal and only important harmful constituent of Southern California smog to be a mixture of nitrogen oxides and ozone. The report will discuss only the source, concentration and effects of the mixture of nitrogen oxides and ozone. Other impurities in the atmosphere have been treated at great length by other research organizations and will be touched on here only where they are important to better understanding of this discussion.

The concentrations of the mixture of ozone and nitrogen dioxide in smog as measured by the Los Angeles County Air Pollution Control District (1), Stanford Research Institute (2) and others, often exceeds the maximum allowable concentration set by the US Public Health Service, the National Bureau of Standards and most states. Maximum Allowable Concentration (M.A.C.) is that concentration in a working atmosphere of a dust, fume or vapor such that if exceeded for appreciable periods can cause damage to the health of exposed individuals. It is general knowledge in the field of industrial hygiene that a mixture of ozone and nitrogen dioxide is extremely toxic in concentrations as low as .1 to 1 part of the gas mixture per million parts of air by volume (ppm) (3)(4). All the health damaging aspects of smog can be directly attributed to this mixture of nitrogen dioxide and ozone, and therefore, it is difficult to understand why researchers have continually sought after some vague, mysterious, unidentified compound.

The first section of this report concerns the chemistry of the smog problem; the second, the meteorology; the third is a combination of chemistry and meteorology and describes the role automobiles, industry and the public play in the total smog picture; the fourth contains the outlook for alleviation and conclusions.

I. CHEMISTRY

BROWNISH, yellowish and whitish hazes have been observed in California and over the adjacent Pacific Ocean as far back as recorded history. Early in 1954, the author found there was a direct correlation between the presence of these haze clouds at the surface and smog. Since the initial announcement of the discovery, the press and others have referred to the phenomenon as the "Blewett Cloud."

The color of these hazes in dry air suggested the presence of nitrogen dioxide as the transition from chocolate brown to reddish brown to yellow with decreasing temperatures following the well known physical chemical properties of NO_2 (nitrogen dioxide) and N_2O_4 (nitrogen tetraoxide) (3).

Francis S. Stewart (5) of F. S. Stewart Associates undertook an extensive chemical sampling program in March of 1954, in cooperation with Air Research Associates. The presence of nitrogen oxides in the haze clouds was immediately established and a continuing test program has revealed the concentration reported as nitrogen dioxide ranges from less than .1 to several parts per million.

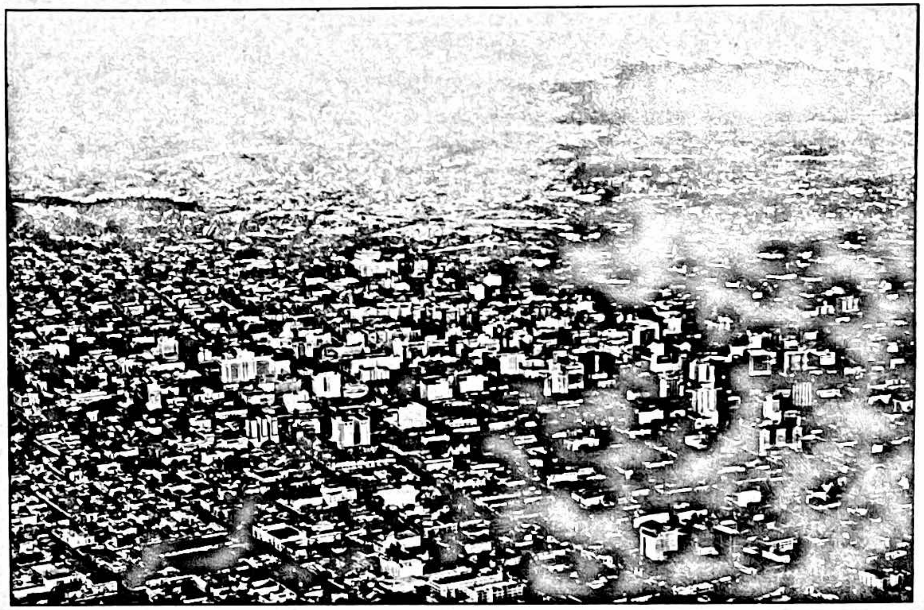
Tests were made by sucking polluted air through fifty cubic centimeters of one percent potassium hydroxide and one half percent hydrogen peroxide dissolved in distilled water. The sample was then analyzed by the standard phenol di-sulfonic acid method. Great care was taken to avoid contamination throughout the analyses. Regardless of the type of nitrogen oxide captured in the potassium hydroxide solution of the sample, it was reported as nitrogen dioxide.

The sampling program showed that there was little connection between the general level of nitrogen oxide in the air and engine exhaust. Measurable amounts of nitrogen dioxide often could not be found a short distance from busy freeways, even with stagnant conditions

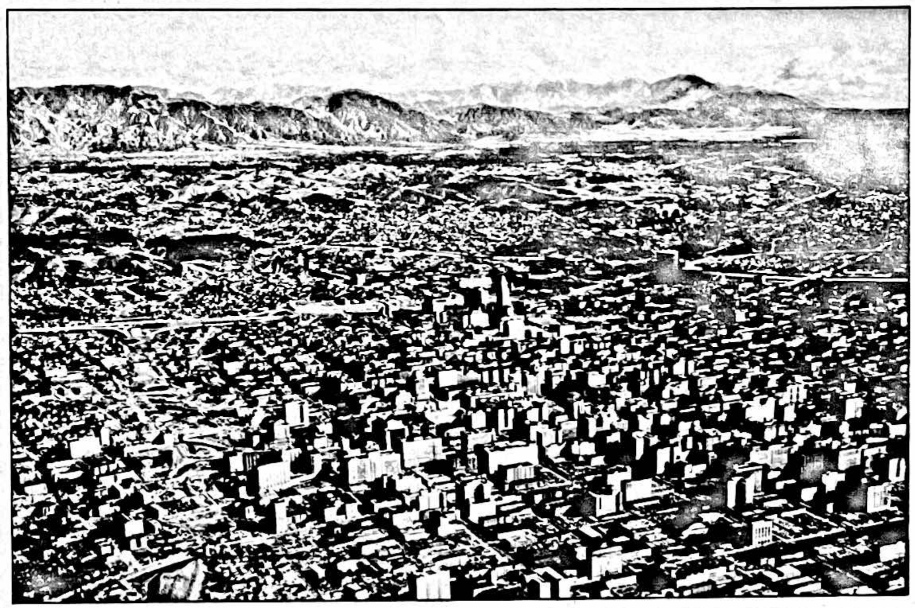
ABOUT THE AUTHOR

STEPHEN E. BLEWETT, the author of this report, majored at the College of the Pacific in Chemistry and Physics, in Chemistry and Engineering at Stanford. He received a B.A. from Stanford in 1939. At California Institute of Technology he studied the physics of air gases and meteorology, and took a B.S. there in 1940. In 1942 Blewett took his Master's Degree from Caltech in Meteorology. As a teacher, researcher, meteorologist and inventor of the Automatic Weather Map he has had wide experience and now heads his own company, Air Research Associates.

His exhaustive research into the problems of smog was triggered by a poignant personal problem. His boy suffers from asthma. Several years ago he moved to what he hoped would be the pure, smogless air of Altadena. He was sadly disillusioned, and is now preparing to move even further afield.



A SMOGGY DAY IN 1926:
If you think smog is new to Los Angeles take a look at the photo. That ain't fog, brother. That's good old smog!



A SMOGLESS DAY IN 1951:
Getting rarer all the time, too. But—just in case you've forgotten, this is how a really good day in Los Angeles used to look.

THE BLEWETT REPORT:

"There are no man-made sources of ozone sufficiently large to account for more than traces of this gas in the atmosphere. . . ."

and a temperature inversion. During one series of tests a nitrogen dioxide cloud hung over the entire Los Angeles area and impinged on the hills in Altadena where the concentration was 1.4 ppm. This cloud had not mixed down to surface in Los Angeles as evidenced by tests along the freeways that disclosed no measurable NO_2 from Pasadena to Eighth and Harbor; the amount of NO_2 produced by the automobile traffic was too small and diffuse to measure.

Concentrations of NO_2 equal to those found in the Los Angeles basin during smog have been found over two hundred miles away in the foothills of the Sierra Nevadas and desert regions. The NO_2 hazes were usually accompanied by the odor of ozone; the characteristic effect on the respiratory system was the same as in Los Angeles. Some of these tests were over two hundred miles from either Los Angeles or San Francisco industrial sections and far from any concentrations of auto exhaust. Near Mariposa, California, at 1300 feet elevation, .8 ppm NO_2 was found at 7:12 p.m. on August 17, 1954. At Red Rock Canyon on the northern edge of the Mojave Desert at 7:45 a.m. on June 21, 1954, a vast brown haze covered hundreds of square miles. When the boundary of the "cloud" was entered, the unmistakable odor of smog was immediately evident. An air sample disclosed the NO_2 concentration as .5 ppm which is similar to that found on a smoggy day in downtown Los Angeles; yet, it was physically impossible that this smog had come from Los Angeles.

Due to dry air aloft on deserts and in the Sierra Nevadas in summer, the NO_2 hazes do not restrict visibility as much as they do at surface in coastal areas where the combination of moisture and nitrogen oxides often forms a thick haze. At times along the coast fog is predominant over the haze but when the fog clears and the air dries out a whitish haze is present. The whitish nitrogen oxide haze is composed of small acid droplets and possibly the pentoxide which is white.

Ozone has a bearing on the kind of nitrogen oxides in haze, for ozone can assist in the conversion of the lower to the higher oxides. Ozone is in excess in the dry air on top of the principal temperature inversion and appears in marked quantities in the inversion layer. Moisture, exhaust gases and other impurities are capable of removing ozone from the air. According to Volz (6) clouds and combustion gases dissociate ozone. Zimmerman (7) says ozone content sharply decreases with an increasing concentration of exhaust gases and decreases with relative humidity. Regener (8) pointed out that as ozone is destroyed in one to three hours in dusty surface air, it must be brought from above.

That ozone is formed in the stratosphere and brought to the earth by vertical exchange of air is well known and has been the subject of many technical papers as well as being treated in most elementary texts. (This is treated in detail in the meteorological section.) There are no man-made sources of ozone sufficiently large to account for more than traces of this gas in the atmosphere. The fact that the highest concentrations are persistently found in dry air stratas in the warm or hot air in the inversion layer or above is further proof that the source is aloft. During a very low inversion the warm inversion layer will be at surface over vast areas of Southern California and at this time the odor of ozone is widespread.

II. METEOROLOGY

WEATHER is the key to all air pollution problems. It determines the path and concentration of all contaminants. The two greatest local influences on the climate of Southern California are the form of the land mass and the proximity of the Pacific Ocean. Examination of a topographical map will show that the Los Angeles basin is ringed in with mountains except to the seaward where no important rise in elevation breaks the coastal plain from Santa Monica to Newport Beach. To the northwest and the southeast of the coastal plain the coast range mountains are very close to and parallel the Pacific Coast shoreline. There are occasional breaks in these ranges where valleys open back to the interior but they are all minor in size as compared to the Los Angeles basin. The topography, nearness to the ocean, and the latitude all combine to give Southern California coastal areas a "Mediterranean type" climate.

The mountain range known as the San Gabriels lying to the north of the Los Angeles basin which is blamed by many for the pollution problem acts as a barrier to the cold blasts of air coming down over the interior of the Western United States in winter and thus provides a mild winter climate. The marine layer of air which invades the coastal plains throughout the summer and which is largely responsible for the much talked about inversion, keeps the coastal areas relatively cool in summer and prevents high, desert-like temperatures from scorching the land. Without the summer inversion the temperatures at surface in the Los Angeles area would be over 100° Fahrenheit daily and would match those of the Imperial and Coachella Valleys.

Temperature Inversion

In a temperature inversion the air temperature is warmer above than below (see diagrams A and B). The inversion has been talked about so much in regard to smog that many think it occurs only in this area. This is an example of the widely publicized misinformation concerning inversions and wind patterns given utterance by too many self-styled authorities on California weather. Actually the same type of inversions prevail all over the world, particularly wherever the ocean is cooler than the adjacent land.

Temperature inversions of the radiation or land type occur all over the world on every clear, wind-free night; the inversion forms whether it be in Europe, Asia, Africa, Australia, South America or Los Angeles. A discussion of this can be found in any good elementary text on meteorology (9) (10). Whenever the sun goes down cooling begins immediately at the surface of the earth with the most marked effect within the first few feet above the ground. If temperatures are taken on clear, cloudless and wind-free nights at fixed intervals from surface to twenty feet or more, it will be found that the temperature rises with elevation. Increases in temperature on the order of a degree a foot for the first fifteen feet are common and rises of twenty-five degrees between the ground level and the top of a building have been observed many times.

Unless a pollutant is discharged above the top of this inversion or charged with sufficient heat to pass through this inversion, it will be held beneath it. This condition holds all over the world and it *not* unique to Los Angeles.

The sea air inversion, which is also not limited to Los Angeles, forms in the following fashion. During all except the coldest time of the year the water along the immediate coast of Southern California is colder than the daytime temperature of the surrounding land; further, the air immediately over the

THE BLEWETT REPORT:

"The smog is found at sea and blows inland along the coast of Southern California. . . . It is entirely natural in its origin. . . ."

ocean is colder at nearly all times of the year except during storms or high winds than the sinking or subsiding air from aloft. This warm or hot air aloft dominates the entire region in late spring, summer and fall. This condition exists over the entire Pacific Coast at times and for most of the year over the Pacific Ocean south and west of San Francisco to low latitudes.

The warm air on top of the cool sea air subsides from aloft. When air sinks rapidly it heats up adiabatically at the rate of 5.6°F. per thousand feet (9) (10) and slightly less due to mixing, with slow subsidence; this accounts for temperatures of 80°F and 90°F and more aloft over the Pacific Ocean where there are no land masses to heat.

The sea air subsidence inversion is the strongest in summer and early fall and the weakest in winter. It occurs to some degree in the Los Angeles area on almost every day that it does not rain or the wind blow strongly. It is also important to note that there are often subsidence inversions in the upper air above the principal inversions.

The difference in temperature in the main sea air inversion will amount to from ten to over thirty degrees in summer and five to ten degrees or more in winter. The fact that the air under the base of an inversion is more dense due to lower temperature than the air on top prevents much interchange between the lower stratas and those above, particularly at night.

During the daylight hours turbulence caused by heating plus the increased motion of air over rough ground provides more interchange of air, particularly between the surface strata and the inversion layer. Those who fly over the Los Angeles basin know that during the daylight hours turbulence caused by superheating of the ground may be felt above the base of the inversion. Thus it can be seen that although local contaminants are almost 100% held down at night in a well defined strata, in the daylight heating may cause a dispersion through a thicker layer.

During the daytime with the onshore sea air moving all across the coastal plain some pollution is discharged through such passes as Newhall and Mint Canyon to the north, Beaumont to the east, and to the south through the coastal valleys, and some pollution rises aloft and is carried away by the upper wind. It would seem then that smog should be much worse at night before the gentle land breezes set in, and most certainly should be very bad along the coast at night. This is not a fact. Smog in general is worse during the daylight hours.

Winds

The coastal plain of the Los Angeles basin has a marine climate. That is, the influx of cool, marine air far exceeds the outpush of hot, desert or subsiding air. On the rare occasions when hot, dry, interior winds blow out to sea, temperatures of 90°F to 100°F and more are found along the immediate shore. This is certainly the exception as official United States climatological data shows the average maximum temperatures for July near the coast to be in the 70's. It is well known also that fog occurs along the shore line at night throughout a large part of the year and often moves many miles inland. These are all manifestations of a marine climate; a climate where the incoming, onshore wind far exceeds the outgoing, offshore wind.

Table I shows the average wind velocity by the hour throughout the year in downtown Los Angeles. From this table it is obvious that during only four months of the year, November, December, January and February, does the offshore wind equal or exceed the onshore. The remainder of the year it will be seen that the onshore gradient of wind far exceeds the offshore; for instance, in downtown Los Angeles during May, June, July, August and September there is no prevailing offshore flow during any hour of the day or night. What this essentially means is that the net air movement across Southern California is from west to east near the surface. If a neutral, or constant altitude balloon were released off the shore of Southern California during April, May, June, July, August or September, it would pass across the coast line and then if it were overtaken by night in Los Angeles, it would hesitate, change its course to parallel the coast temporarily, and then the next day blow well inland and eventually continue across the United States. During October, the balloon would move a short distance to sea before continuing

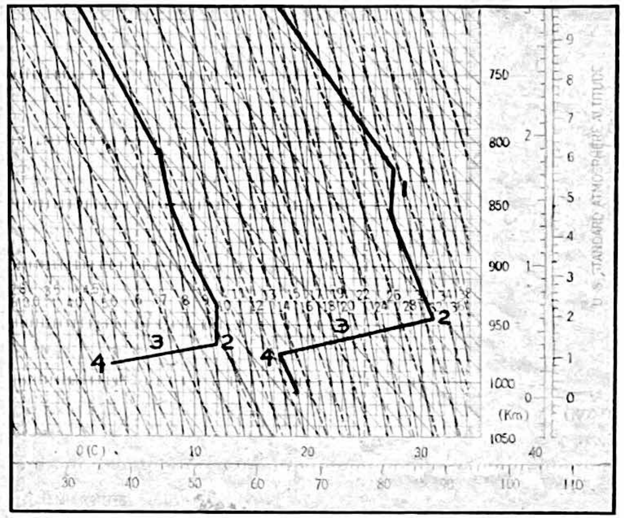


DIAGRAM A

Temperature-Altitude graph of ground inversion, Pasadena, Jan. 1, 1954 (0700 PST).

DIAGRAM B

Temperature-Altitude graph of typical sea-air subsidence inversion, Southern California.

(1) subsidence inversion layer; (2) top of main inversion; (3) main inversion layer; (4) base main inversion.

THE BLEWETT REPORT:

"The great error is . . . thinking that the smog crossing the coastline during the day is the same air pollution that was blown out to sea the night before. . . ."

inland if it arrived over Los Angeles between 1 a.m. and 6 a.m.; during the other nineteen hours it would also move inland. It is generally known that during the war the Japanese released many balloons from their Islands and that these balloons crossed the coastline of California and the Pacific Northwest only a few days after their release.

During the mid-winter months the upper winds over Southern California are from northwest to northeast aloft between storms, and from southwest to west before and during storms; in the summer months upper winds come from the southeast to southwest as well as westerly (11). It is the winds from the westerly directions that bring in the great percentage of the naturally formed ozone and nitrogen oxides throughout the year. The easterly winds in mid-winter may keep the city and interior free of smog for days at a time.

At times, particularly in winter, there is a wind discontinuity along the coast with light easterly winds aloft and inland and light westerlies over the ocean and out to sea. Under such conditions very high concentrations of nitrogen oxides can be seen along the coast or just offshore. The vast reddish brown haze cloud will appear as though there were a great fire at sea. When these clouds are wafted in to impinge on the coast range hills the highest concentrations of nitrogen dioxide are found.

Lack of knowledge of the surface winds over Southern California has caused one of the great errors in smog research to date. The error: It has been often repeated in print, and now it seems to be firmly imbedded in the minds of many of those working on the smog problem, as well as the lay public, that air pollution crossing the coastline throughout the day during a smog siege is the same air pollution that was blown out to sea the night before. It is, of course, true that the offshore breezes will carry a certain amount of air pollution out to sea; however, an examination of the wind table shows that from April through October if any offshore component prevails, the velocities are so light that the pollution could not even reach the Channel Islands. It will be seen from the velocity of the onshore flow that in only a matter of hours this pollution will again pass inland and there will be nothing but clear air the remainder of the day if the source is pollutants blown off at night. However, smog can be observed blowing inland throughout the daylight hours during a heavy smog spell.

There are times when a particularly strong onshore surge of sea air will increase the visibility markedly in coastal areas. At these times a careful observation of the air just on top of the inrushing sea breeze will show a yellowish or brownish haze present moving in from the sea. Airplane pilots have noted that with good visibility along the coast during strong onshore flow, they will often run into layers or stratas of brownish air pollution at upper levels. During the severe smog attack of October, 1954, smog was observed blowing inland across the coastline on many days from early morning until dark.

In summation: Smog and brownish, yellowish and whitish haze clouds that blew in over the Southern California coastline during most of the last spring, summer and fall are *not* pollution that has blown out to sea and returned during the day; nor are they pollution that has moved inland, penetrated the inversion, blown out to sea aloft, dropped to the ocean again and blown back in. Such theories are absolutely unsound meteorologically and are in complete conflict with the known circulation patterns over Southern California.

We have also proved chemically that the smog blowing inland over the Southern California coastline does not originate in Los Angeles. The tests are described in section III.

Subsidence

The greatest subsidence in the Pacific High Pressure Belt seems to take place off and over California and Northern Mexico with a marked increase in subsidence over Southern California as compared with extreme Northern California. This is borne out by a study of official United States Weather Bureau radiosonde data, and also the study of temperatures on knife ridges in Southern California. Night temperatures in the mountains in Southern California areas are often phenomenally high due to the great subsidence of air. Night temperatures in mountain valleys, of course, do not always show this effect since radiation cooling will form strong ground inversions giving much lower temperatures. The dewpoints are also another evidence of extreme subsidence. It is not unusual for dewpoints to be many degrees below zero when the temperature is 50° or more above zero on mountain ridges in Southern California. A study of the weather data from the United States Civil Aeronautics station at Mt. Wilson confirms this. Such a condition can occur only from the subsidence of extremely dry air from aloft. There can be no other source of this dry air.

Airplane passengers are often startled after landing at Los Angeles airport, when a few minutes before at 2,000 feet the temperature was near 100°F, to find the temperature is only 65°F. The 65° is easily explained by the influx of air off the cool Pacific but the extreme hot air which extends well out over the Pacific cannot be so easily accounted for. There are no land masses at sea to heat up and, further, since this air stays hot day or night, the only explanation is that it has descended from aloft and been heated by compression. This is the universally accepted meteorological theory for the presence of this hot air aloft. Practical tests of temperature and lapse rates bear out the theory 100%. These illustrations have been discussed to point up the fact that the air over Southern California descends from great heights as it also does over the Pacific to the west of California, and occasionally, over a large portion of the Pacific.

Source of Nitrogen Oxides and Ozone

In the preceding we have given details of the finding of nitrogen dioxide throughout Central and Southern California. At an early stage in our research we noted that the clouds of nitrogen oxides move in over the California coastline during and following days of uninterrupted westerly winds. The unmistakable odor of ozone often accompanies these clouds.

It has long been known that ultra violet rays of certain wave length will convert oxygen into ozone. Electric lamp bulbs which put out controlled amounts of radiation of 1,850 angstroms are sold commercially to produce ozone for odor killing and as a bacteriacidal and fungicidal aid. In the stratosphere where the air is almost entirely free of moisture or airborne contaminants from the earth's surface, the rays of the sun are unusually active and convert oxygen to ozone. There is hardly a meteorological text that does not treat in some detail the formation of ozone in the stratosphere. Ozone in the stratosphere and its appearance at the surface of the earth is the subject of many meteorological and chemical papers. Many European researchers have correlated the various weather pressure fields causing

THE BLEWETT REPORT:

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the increase or decrease of ozone at the surface of the earth. Paneth and Gluckauf (12) observed that the average ozone content of the air over Oxford, England, varied widely with the direction and velocity of the wind. They found the variation closely followed the variation of ozone in the stratosphere. Zimmerman (7) says that ozone is transported down from the stratosphere. Busse (13) states that in general high pressure areas are associated with high ozone concentrations. According to Bowen and Regener (14) it has been established that ozone forms in the stratosphere and is brought downward by subsidence in anticyclones.

It is almost unbelievable that the high concentration of ozone in the Los Angeles basin should have been considered such a mystery. Southern California lies in an area of great atmospheric subsidence. The Pacific Ocean west of California is one of the great "weather sinks" of the world. That is, it is one of the areas where air is predominantly descending rather than rising. That ozone should be found in high concentrations in California is to be expected.

The presence of naturally formed oxides of nitrogen at the surface in California, however, is a startling meteorological as well as chemical discovery. The fixation of nitrogen by electrical discharge in the air has been studied and reported in the literature; the formation of vast quantities of nitrogen oxide by photochemical processes has received very little consideration but is reported in the scientific literature. Virtanen (15) states that it is quite possible that most of the nitrogen fixation in the atmosphere is photochemical. Conditions for this fixation probably exist in the ozonosphere. Massey *et al* (16) reported nitric oxide in the upper atmosphere. They attribute the "D" layer to ionized nitric oxide. Bates and Seaton (17) write of the photo-ionization of nitrogen oxide. The further oxidation of nitric oxide to nitrogen dioxide is a simple chemical reaction involving oxygen. Referring to the lower atmosphere, Henderson and Haggard (3) state that nitric oxide does not exist in atmospheric air, for in the presence of moisture and oxygen it is converted into dioxide.

Many times the sky in California has been observed to contain nitrogen oxides which were visible from above the cirrus deck down almost to ocean level off the California coast. Henderson and Haggard (3) write that nitrogen dioxide in the form of NO_2 is a dark brown gas. The molecular form of the oxide is determined by temperature. On heating the colorless N_2O_4 is first changed to a pale yellow; this color becomes deeper until at 59°F it is orange, and at 68°F, a reddish brown vapor. The color of this vapor deepens until at 104°F it is a chocolate brown. The change of state consists in the relative preponderance of either of the two forms of the dioxide. This is exactly what is observed in the atmosphere. Numerous tests and observations have shown that when the temperature is below 68°F in the free air, the oxides of nitrogen are most apt to have a yellowish color; above this temperature, a reddish brown color; and near the ground when the temperatures are high, a chocolate brown appearance. The fact that the haze clouds of nitrogen oxides in dry air are always brown near the surface on a warm day and yellow aloft, or yellowish throughout on a cold day, and that they follow the laws of color observed by chemists for many years is further substantiating evidence of their composition.

It is a generally accepted fact among meteorologists that there is a certain amount of subsidence in high pressure areas of any size (9) (10). This subsidence accounts for clear, very dry weather aloft unless over-running moist air is present. Now, observation has shown that the nitrogen oxide clouds move in principally from the Pacific Ocean where subsidence is at a maximum. (These haze clouds have been observed to descend over the desert regions and the mountain regions of California under certain weather conditions.) The nitrogen oxide clouds have been observed many times moving inland when the source of wind for days was from off the ocean and far from any industrial region. (Japan and the Asiatic mainland, nearly 5,000 miles away, are the nearest source of industrial nitrogen oxide.) Therefore, the presence of nitrogen oxide clouds and hazes aloft over California must be a meteorological phenomenon.

GLOSSARY

ADVECTION: Horizontal motion of air.

CARBON MONOXIDE: An invisible gas formed in auto exhaust and other combustion processes.

DEWPOINT: Temperature of the air at which moisture condenses out as fog or dew.

HIGH PRESSURE BELT: Large area where air pressure is high and air is sinking.

INVERSION: Inverted temperature condition—Temperature rises with increase in elevation instead of falling.

MAC: Concentration of a gas which, if exceeded, will be detrimental to health. Definite figures set by US Public Health Service and various states.

METEOROLOGY: The study of the science of weather.

MICRO-WEATHER FRONT: Boundary between different types of air formed due to local conditions and not associated with a storm.

NITROGEN DIOXIDE: Irritant gas composed of one atom of nitrogen and two atoms of oxygen.

OZONE: Active form of oxygen composed of three oxygen atoms instead of two; a strong irritant.

PPM: Number of parts of gas per one million parts of air.

TRACER GAS: A stable and readily detected gas that is used to determine source path and dispersion of air contaminants.

TURBULENCE: Boiling, irregular motion of air, particularly vertical exchange of air.

VAPOR DENSITY: The density of a gas compared with the density of air.

WEATHER SINK: An area of marked and persistent sinking of air from aloft.

WIND DIRECTION: The direction from which air is moving.

WIND VELOCITY: Movement of air measured in miles per hour.

THE BLEWETT REPORT:

"Los Angeles does not have a unique temperature inversion condition. Similar and equally strong inversions are a daily occurrence throughout the world. . . ."

We do not know whether the oxides of nitrogen are formed in the same layer as the ozone or at different elevations (15) (16). It is known that the two gases reach the earth in varying mixtures. Sometimes the ozone odor predominates and sometimes the characteristic acrid or musty odor of the oxides of nitrogen predominates. Since moisture and ground level impurities are all a factor in the reduction of concentration of ozone (6) (7) (8) and to some extent, NO_2, it will require high elevation tests to determine the natural fluctuation in the ratio of the gases from their natural source region.

Concentration and Paths of Nitrogen Dioxide and Ozone

Some very interesting facts have already been determined concerning the concentration of nitrogen dioxide as it subsides earthward. The heaviest concentrations occur in strata or striations between one and three thousand feet. This has been chemically proved and visually observed. It would be predicted, of course, that the concentration would increase as the air sinks into areas of higher pressures. The reasons for the striations or stratas is quite simple. As the air descends and approaches the earth, a divergence and flattening out effect takes place which causes the formation of inversions. It is within these upper inversion layers that concentrations appear to be the heaviest. Very heavy concentrations are also found in the main inversion layer; that is, between the top and the base of the inversion layer caused by the meeting of the hot air aloft and the cool sea air below. It could be argued that some of the nitrogen dioxide would enter this layer from sources below as well as from meteorological sources above. This could be true over the Los Angeles section but since the nitrogen dioxide striations have been observed all over Southern and Central California and at sea at times when the wind has been onshore for days, industry cannot account for them. Further, nitrogen dioxide has often been observed and measured in the higher subsidence inversion layers in the warm dry air aloft.

During fall when the inversion is extremely low, a very interesting phenomenon takes place. Vast stratas of air covering tens of thousands of square miles sink down to the ocean surface where they are modified by contact with the water. When this takes place, the sea air which blows in over the California coastline contains the oxides of nitrogen in heavy concentration. For instance, on September 22, 1954, a large bank of smog was observed off San Diego in the afternoon. This bank extended as far north and south as the eye could see and appeared to be about fifteen to twenty miles offshore. The winds had been onshore all day along the immediate coastline. Toward evening the smog bank moved onshore near Point Dana just south of Laguna Beach. At this time the winds were brisk, west-southwest, or onshore. As the writer drove into this bank he noted the unmistakable odor of smog. There was no fog present. The sun shone weakly through the smog bank in a manner that is typical of smog or haze and not of water clouds.

On other occasions when the temperature and dewpoint are coincident the oxides of nitrogen will be carried inland in a fog bank. When the sun warms the air and the fog clears, the smog will be left. Chemical analyses of this air have proved the presence of oxides of nitrogen which, of course, are largely in the form of nitrous and nitric acid. Henderson and Haggard (3) explain that nitrogen dioxide in the form of N_2O_4 reacts with water to form nitric and nitrous acids and in the form of NO_2 reacts with water and oxygen from the air to form nitric acid and nitric oxide. The nitric oxide is oxidized and converted into nitric acid.

Heavy dampness in the air or fog will mask some of the smog odor; as the same air becomes dried the odor of smog becomes more penetrating. The odor in the same air mass changes from musty to acrid with a drop in humidity. In the presence of an excess amount of moisture the NO_2 is almost all in the form of a weak nitrous or nitric acid solution; as the air dries out the nitrogen dioxide is gradually released.

Air Research Associates

TABLE I

U. S. Department of Commerce -- Weather Bureau

Climatological Record, Los Angeles, California

Hr	0-1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Jan	NE 5	NE 5	NE 5	NE 5	NE 5	NE 6	NE 6	NE 6	NE 6	NE 5	NE 5	SE 5	SE 5	SE 6	W 6	W 7	W 6	W 5	W 4	W 4	W 4	NE 4	NE 5	NE 5
Feb	NE 5	NE 5	NE 5	NE 5	NE 5	NE 5	NE 5	NE 5	NE 5	NE 5	SE 5	SE 6	SE 6	W 7	W 8	W 8	W 7	W 6	W 5	W 4	W 4	NW 4	NW 4	NW 5
Mar	NE 4	NE 4	NE 4	NE 4	NE 5	NE 5	NE 5	NE 5	E 5	SE 5	SE 5	SE 6	W 7	W 8	W 9	W 9	W 8	W 7	W 6	W 4	W 4	W 4	SE 4	NE 4
Apr	SE 4	SE 4	SE 4	SE 4	NE 4	NE 4	NE 4	SE 4	SE 4	SE 5	SE 5	W 7	W 8	W 9	W 10	W 9	W 9	W 8	W 6	W 5	W 4	W 4	W 4	W 4
May	SE 3	SE 3	SE 3	SE 3	SE 3	SE 3	SE 4	SE 4	SE 4	SE 4	SE 6	W 7	W 8	W 9	W 10	W 9	W 9	W 8	W 8	W 5	W 5	W 5	W 5	SE 3
Jun	SE 3	SE 3	SE 3	SE 3	SE 3	SE 3	SE 3	SE 3	SE 4	S 4	S 5	S 7	W 8	W 9	W 9	W 9	W 9	W 8	W 7	W 5	W 4	W 4	W 3	SE 3
Jul	SE 3	SE 3	SE 3	SE 3	SE 2	SE 2	SE 3	SE 3	SE 4	S 4	S 5	W 7	W 8	W 9	W 9	W 9	W 8	W 8	W 6	W 5	W 4	W 4	W 3	W 3
Aug	W 3	SE 2	SE 2	SE 2	SE 2	SE 2	SE 3	SE 3	S 4	S 4	S 5	W 6	W 8	W 9	W 9	W 9	W 8	W 8	W 6	W 5	W 4	W 3	W 3	W 3
Sep	SE 3	SE 3	SE 3	SE 3	SE 3	SE 3	SE 3	SE 3	SE 4	SE 4	W 5	W 6	W 8	W 8	W 9	W 9	W 8	W 7	W 5	W 4	W 3	W 3	W 3	W 3
Oct	SE 4	NE 4	NE 4	NE 4	NE 4	NE 4	NE 4	NE 4	NE 4	SE 4	SE 4	W 5	W 7	W 8	W 8	W 8	W 7	W 6	W 4	W 4	W 3	W 4	SE 4	SE 4
Nov	NE 5	NE 5	NE 5	NE 5	NE 5	NE 5	NE 5	NE 5	NE 5	E 4	SE 4	SE 5	W 6	W 7	W 7	W 6	W 5	W 4	W 4	W 4	W 4	NE 4	NE 4	NE 4
Dec	NE 5	NE 6	NE 6	NE 6	NE 6	NE 6	NE 6	NE 6	NE 6	NE 6	NE 5	SE 5	SE 6	SE 6	W 6	W 7	W 6	W 5	W 4	W 4	NW 4	NW 4	NE 5	NE 5

Summary of hourly prevailing wind directions and velocities

TABLE I

THE BLEWETT REPORT:

"Present smog control methods are now increasing smog by removal of contaminants that are harmless in the air, and which, if left, would actually help to destroy the ozone. . . ."

When the oxides have descended far at sea and mingled with the moisture from the ocean surface forming the sea air layer, the mixture has a whitish appearance. This is due to the moisture and acid droplets and also at times, due to the lower temperature near the ocean. Heretofore there has never been a reasonable explanation of this whitish haze that continues to move inland over the Southern California coast following the breaking of the fog. Some sought to attribute it to salt particles but salt has never been found in concentrations to account for the thick white layer.

Ozone is the most concentrated when in dry air aloft and is progressively less noticeable as the humidity increases. This decrease in ozone concentration with rising humidity is reported by Obenland (18), Zimmerman (7) and many others.

Often from late April until sometime in November no rain falls in Central and Southern California and winds are light. This allows uninterrupted subsidence and transport downward of NO_2.

The highest average concentrations of NO_2 to date have been found in stratas along the coast range mountains northwest of Los Angeles where land turbulence has not had the opportunity to disperse the gas through thicker layers.

The sea air temperature inversion over Los Angeles plays an unusual role in determining concentration of the nitrogen oxides at ground levels. Many times the inversion which has been blamed for a good part of the smog actually keeps the brownish oxides from reaching the ground except in the foothill sections where they are advected in and impinge directly on the surface. Of course, in late summer and fall when the inversion is very low and the great clouds of oxides settle at sea, this does not hold. During the spring months when the inversion is higher there is very often a strong odor of these gases in the foothills surrounding Los Angeles and none down in the industrial or downtown sections. Chemical tests have been made which confirm this.

Several times in spring with the brownish haze on top of the fog along the coast and with a westerly wind, it was found that the lower fog or sea air contained no measurable nitrogen oxides. However, two or three miles inland the brown haze surfaced due to turbulence. Observations were made to see if the point where the brownish oxide haze first impinged on the earth was the geographical start of the smog. In all cases the characteristic odor was met at this point.

The formation of a micro-weather front is a factor contributing to the concentration and retarding of the nitrogen dioxide clouds over downtown Los Angeles and Pasadena. In late summer, fall, winter and early spring a well defined micro-weather front forms in a northwest-southeast direction along the hills bordering the Los Angeles River and extending out through East Los Angeles to the Montebello Hills and southeastward at times to the Puente Hills. South and west of these low ranges the land slopes gently away to the sea with only a few unimportant hills. It is along this frontal line that the incoming westerly and southwesterly breezes are most often held by the southeast, east or occasionally, northeasterly breezes from the interior. The vertical extent of this micro-front is several hundred feet to several thousand feet. There is always a slight drop in temperature, increase in humidity and wind shift or change in velocity when this front passes a station. When the oxides of nitrogen and ozone are moving in from the ocean they will concentrate behind this front or weather barrier and often be held for a long period, sometimes over Los Angeles, very often over the foothills at Pasadena. Sometimes in fall this front will not get beyond Pasadena and, therefore, foothill areas 1,200 feet or more in elevation may be on the north or east side of the front all day.

In spring and summer nitrogen oxides and ozone are usually concentrated at higher levels than fall and winter and often will cross the coastline and Santa Monica Mountains into the San Fernando Valley and enter the foothill area back of Pasadena from the west northwest instead of coming across the coastal plain from the southwest. If a concentrated strata of nitrogen is over 2,500 feet in elevation it can top the Santa Monica Mountains in an unbroken cloud. Many times in the summer or spring season the acrid odor of the oxides of nitrogen or the odor of ozone will be in the foothill region well before the micro-front arrives and the concentration of these principal smog-forming gases will actually decrease when the micro-front passes. However, in fall and winter the heaviest concentration of these gases is often close to the ocean surface below the top of the coast range. Therefore, they will not be able to pass in any heavy quantity across the Santa Monica Mountains and directly into interior foothill regions but rather will have to take the path in across the coastal plain arriving in foothill sections by crossing Los Angeles behind the micro-front. Even under this last named condition, ozone and some of the nitrogen oxide haze will move in over the top of the front at 1,000 feet to 2,000 feet or more and can be readily detected well ahead of the arrival of the lower more concentrated stratas of gases behind the front.

Often the nitrogen dioxide and ozone mixture arrives at the surface by vertical turbulence rather than advection. In these cases the nitrogen dioxide is first visible all over the sky at several hundred or a thousand feet above the station and then, as the sun heats the ground, vertical turbulence begins to mix the gas downward. The first odor of smog will occur as the ground inversion is wiped out an hour or more after sun-up depending upon the thickness of the inversion. Then the gas will start reaching the surface in spots and so will envelop the whole foothill area. Therefore, the smog can reach any point by direct advection from the ocean or by vertical turbulence bringing it down from aloft. Vertical turbulence

"BAY OF SMOKES"

How the Smog Looked In 1868

In 1542 Juan Rodriguez Cabrillo sailed into the San Pedro Bay, took a long look and a hard sniff and named it "*Bahia de los Fumos*" (Bay of Smokes). In 1868 the editor of the *Alta*, the leading Los Angeles newspaper, wrote: "*It is now about six days that we have in this and the surrounding country been spectators of an unusual atmospherical phenomenon, which from its peculiarity, has given occasion to many manifold surmises, conjectures, speculations and rumors. The atmosphere has been so filled with smoke as to confine the vision within a small circumference. . . .*"

THE BLEWETT REPORT:

"Record of early explorers, aborigines and missions show smog has occurred in cycles throughout recorded history. . . ."

accounts for the gradual increase after sun-up of the oxidant content of the air. Many have sought to explain this phenomenon by the action of sunlight on the contaminants in the lower air but our tests and observations have shown that it is caused by the sun heating the ground and initiating vertical turbulence.

Smog at Night

There has long been a mystery about what happens to the smog at night. Occasionally very strong concentrations of smog do descend at night, particularly in the foothills when there is an outfall of wind from aloft; sometimes it remains until well after dark but generally two or three hours after sunset it is almost gone. The mechanism is now completely understood. Observations both chemical and visual indicate the nitrogen oxide and ozone clouds lay stratified all over the Los Angeles basin at night except during the colder half of the year when they may be pushed away from the immediate mountains and then lie over the coastal plain and ocean or in some cases, entirely off the coast.

It is known through a study of deposits on leaves and roofs and other subjects that nitrates do precipitate out of the air and deposits continually build up during dry periods (5). It is apparent that when the vertical turbulence gradually comes to a standstill at night no more oxides or ozone are transported downward. Since the shallow surface layer either moves slowly toward the coast or becomes quite stagnant there is no influx of nitrogen dioxide and ozone from low elevations at sea except under unusual conditions. With the source gone, the ozone and oxides near the surface are destroyed by moisture, combination with other pollutants in the air, and by the nitrates precipitating out on the leaves of plants and on other objects. Regener (8) found that there is a maximum of ozone about 3 p.m. at Friedrichshafen on quiet days and a minimum at night. Obenland (18) found that for the mountain as well as the valley observations, low ozone values were associated with high relative humidity and vice versa. Thus the air is gradually cleansed in the shallow surface layer. Night observations will disclose that stratas of nitrogen oxides and ozone lie from a few hundred to a few thousand feet above the earth. Next morning the gases are brought to the surface as vertical convection sets in.

Haze, Smog and Low Visibility in the Past

It is generally agreed that smog is increasing and has increased during the past ten years. However, those who say visibility was *always* good twenty to twenty-five years ago and that they could always see Catalina and other points are remembering only the good days and have a bad memory for the poor days. A check of visibility records and temperature and dewpoint records from Burbank Airport and other stations shows that low visibility is not new to this area. Low visibility was regularly reported in the past when no fog was present in the air and far too consistently to have been caused by some nearby fire or dust source.

For example, official US Department of Commerce Weather Bureau records (19) reveal that at Laguna Beach, California, from 1934 to 1938 43,794 observations of visibility were made. During the three summer months (June, July and August) fog was present 7.6% of the time but visibility was greater than twelve miles only 14.5%. Something in the air other than fog restricted the visibility about 78% of the time. Stratus clouds were present 46% of the time with the night hours accounting for the bulk of the percentage. These clouds are not a restriction to horizontal surface visibility and would exert an effect only when extremely low. Therefore, the only explanation for low visibility is that some substance caused a haze in the air throughout the summer months.

The official records at Oceanside, California (19), indicate the same condition during the same period of summary with fog present 8.5% of the summer but the visibility over twelve miles only 15.4% of the time.

At Burbank, California, the period of record summary is from October, 1931 — December, 1938, and includes 64,296 observations (19). During the three summer months (June, July, and August) fog was present 14.3% of the time but the visibility was over twelve miles only 23.2% of the time. Something restricted the visibility in summer 62.5% of the total time from 1932-1938 and was not fog.

The condition at Burbank can be partially attributed to man-made sources of pollution but Oceanside was and is still far from industrial sources.

There are reports of eyesmarting from atmospheric conditions as far back as 1912, and there are printed reports in the mid-1880's of strange hazes covering the region for days at a time when there was no fire or other local source (2). Records of early explorers, aborigines and missions show smog has occurred in cycles throughout recorded history. Further, California has had what is known as "heat haze" throughout its history. This haze is evident in old photographs. As far as we know, no one ever analyzed this heat haze to see what it contained prior to our work of this year. Our analysis of this haze wherever it appears in California has shown that it consists of nitrogen oxides. We have found that nitrogen dioxide in the air will form a definite light haze in amounts lower than one-tenth of a part per million parts of air.

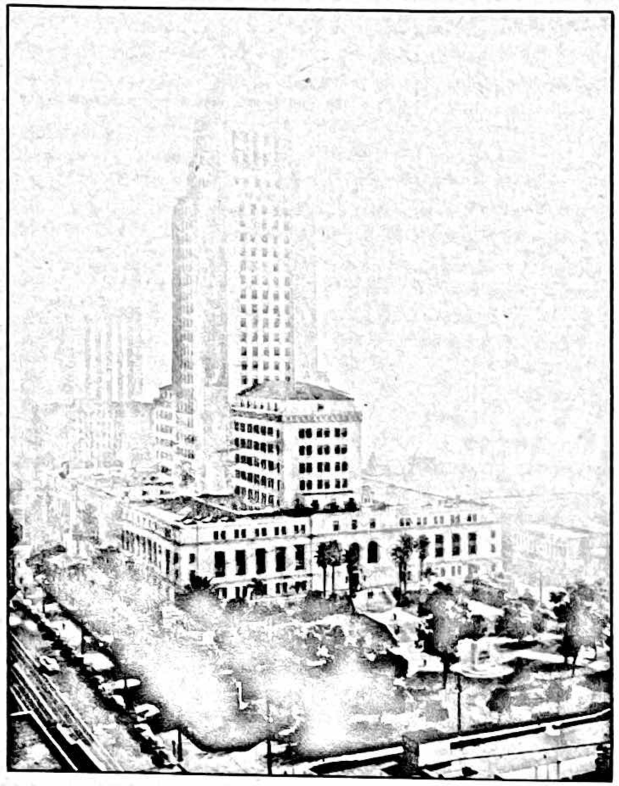
These hazes are of common occurrence a great distance from any industrial sections. As long as the concentration is low there is no smog effect. During tests in the lower elevations of the Sierra Nevadas in the summer of 1954 we found that hazes containing oxides of nitrogen and ozone occasionally would be strong enough to manifest the same irritating effects on the respiratory system as the smogs in Los Angeles. This is also true at times in the San Joaquin Valley.

It is our opinion that since the appearance of NO_2 and ozone is a weather phenomenon, it runs in cycles like other weather phenomena. There is always some present but there are times when it is much stronger than others. It is our opinion that there is now an increasing cycle of the formation of these gases or a weather cycle that is allowing more of the gases to reach the surface and, due to stagnant conditions, to concentrate more along the California coast line. Or, perhaps a combination of both weather phenomena is taking place. No attempt as yet has been made to correlate increased concentration with solar activity. A maximum in sun spots is expected in 1957 or 1958 and if there is any correlation with this type of activity, then there should be an increase in the amount of the nitrogen oxides formed until after the passage of the peak.

Naturally formed oxides of nitrogen must be present at other places in the world where climatic and meteorological conditions are similar to Southern California. Color photographs of brown striations over the Mediterranean have been examined. Pilots have reported the phenomenon is widespread but as yet we have made no chemical tests outside of the Pacific Southwest and off the Pacific Coast of California.

THE BLEWETT REPORT:

"The automobile exhaust has an unpleasant odor in a confined space but is not the cause of Southern California smog. It actually destroys ozone. . . ."



Los Angeles City Hall Smogged In

III.

AUTO, INDUSTRY AND PUBLIC

IT IS widely known that automobile exhaust contains a high concentration of carbon monoxide. Much testing and research has been done throughout the world on the concentrations of carbon monoxide reached in tunnels and over streets and in mines and factories (20). Because carbon monoxide is odorless and colorless and often encountered in factories and mines and wherever internal combustion engines are used, there has been a rapid development in the field of portable, sensitive quantitative analyzing instruments. The portable color indicating instrument developed by the National Bureau of Standards and manufactured by the Mine Safety Appliance Company can be used for making accurate tests in the field even where the concentrations of carbon monoxide are very low. Schnidman (20) says concentrations as low as 1 ppm or below can be easily detected.

Carbon monoxide makes an ideal mass tracer gas in the atmosphere. It is approximately the same density as air (.97 vapor density) and rapidly diffuses through and moves with an air stream. If the air the carbon monoxide is mixed with does not penetrate a temperature inversion, for example, neither will the carbon monoxide. Further, carbon monoxide is a very stable gas in the atmosphere and retains its identity for long periods at temperatures and conditions found in the free air over a city or open country. It, of course, can be burned at a high temperature to carbon dioxide and can enter into other chemical reactions.

It has been suggested that ozone may cause the further oxidation of carbon monoxide (CO). Ozone reacts with many components of exhaust gases but since the concentration of exhaust gases exceeds that of ozone by many times in downtown traffic areas there is no validity to the argument that carbon monoxide is eliminated in this fashion. Conversely, there is a definite reduction in the concentration of natural ozone crossing a city due to exhaust gases (6)(7)(21). Ehmert (21) made absolute measurements of ozone near the earth and found a rapid destruction of ozone by combustion gases.

There is very little reduction of airborne carbon monoxide from contact with surfaces, though certain soils and trees and plants can slowly remove some. Despite minor losses, it can be said that the bulk of the carbon monoxide that goes into the air will remain in the air.

A lot of work has been done on determining the composition of auto exhausts. The quantity of carbon monoxide, nitrogen dioxide, and hydrocarbons emitted has been calculated under various driving conditions (2)(22). The amount of CO escaping from automobiles each day in Los Angeles County is estimated at over 6,000 tons; hydrocarbons from 1,000 to 1,200 tons; nitrogen dioxide from less than 50 to over 150 tons. Our tests for NO_2 from automobiles indicate the lower estimate to be more nearly correct. From these tonnages a ratio of 100 to 20 to 1 (5,000 to 1,000 to 50) for carbon monoxide, hydrocarbons and nitrogen dioxide is reasonable. Even marked variations in this ratio would not affect the results disclosed in this section.

When these contaminants are released from the automobile they are rapidly diffused through the air due to natural air motion and air motion created by traffic itself, speed of the releasing automobile, and further turbulence caused by the heat of the gas released. Broboese *et al* (23) found a dilution of 100 times at a distance of one meter from outlet. It all adds up to a very rapid mixing of the exhaust into the atmosphere which quickly forms a rather uniform mixture over a large local area. The exceptions being, of course, in tunnels and spots on high-

THE BLEWETT REPORT:

"The backyard incinerator does not cause smog. Although the smoke does lower visibility it also aids in destroying smog by destroying ozone. . . ."

ways where a lack of ventilation will cause maximums greatly exceeding the general area level. These cases, however, are extremely few.

For example, on October 11th, 1954, a test was made just off San Pedro Boulevard between Sixth and Seventh Streets in downtown Los Angeles. The time was 4 p.m. and the wind was light west which brought it right across the area of heavy city traffic concentration and industrial section. Carbon monoxide concentration of 10 ppm was found. Half an hour later on the Arroyo Seco Freeway another test was made; there were three solid lanes of outbound traffic and considerable inbound traffic at the time. The test was made approximately 8′ from the outside lane. The wind was up the arroyo and slightly across the traffic toward the test station. There was little difference in the velocity of wind here and the San Pedro test spot. The Arroyo Seco Highway is made up of many curves and lies in the bottom of the Arroyo Seco Canyon. Conditions are ideal for the build-up of contaminants. It was smoggy both places. The carbon monoxide here was identical with that of San Pedro Boulevard, 10 ppm, which indicates the rapid diffusion of auto exhaust a short distance from the street, highway or freeway. Many tests have borne this out and have shown that if the carbon monoxide test is made off a highway or street so that no direct stream of exhaust from any vehicle is thrown into the testing equipment, the concentration level will be very constant throughout a local area with concentration dependent on the mass tonnage of carbon monoxide discharged into the air and wind currents.

Tests for carbon monoxide, therefore, present an ideal means for estimating the quantities of the various constituents of auto exhaust in the atmosphere and are a good index of the overall part the automobile may be playing in the smog. It is, of course, true that carbon monoxide is released from many other sources —industry, fuel gas, rubbish burning and wherever carbonaceous material is oxidized in incomplete combustion. It is also true that nitrogen dioxide and hydrocarbons are released from other sources. If tests are made in an area such as Beverly Hills or Santa Monica with the wind onshore, then the principal source of any carbon monoxide is the automobile. Further, it can be definitely stated that if no carbon monoxide is present in the air then the air has not come from either an automobile or an industrial source or from the home incinerator. Any air stream that has contacted the automobile traffic, the residential sections or the industrial sections of Los Angeles will contain carbon monoxide. If it does not contain carbon monoxide, it did not come from these sections.

A most interesting series of tests was made on Saturday, October 9th, 1954. This was a very smoggy day throughout most of Southern California. The testing area was from the coast near Malibu, west of Santa Monica, to the summit of Saddle Peak, 2,860 feet. Smog covered the entire Los Angeles basin and San Fernando Valley and extended out over the ocean as far as the eye could see. There had been an early morning fog along the immediate coast but by the time the sampling began the fog had dispersed and the sun was shining weakly through a thick layer of smog.

The first test was made at noon on the summit of Saddle Peak at 2,820 feet. The wind was variable from east to south, velocity approximately 4 to 5 mph; a light haze covered the peak and heavy brown clouds were visible on all horizons. Below the brownish haze clouds the smog took on a more whitish cast out toward the ocean and a light brown cast inland. Tests showed nitrogen dioxide .16 ppm; carbon monoxide, zero. Thus it was evident that although the air contained nitrogen oxides they did not come from any industrial or city areas and the air reaching the top of Saddle Peak had not come from Los Angeles but had subsided from aloft and moved in over the top of the Los Angeles basin. The proof of the subsidence of this air from aloft was the temperature of 80°F; the temperature on the Coast at the same time was in the middle 60's although the coast line was less than three airline miles away.

The second test was made forty-five minutes later at 2,500′ on the western slope of Saddle Peak. The temperature was 86°F; there was a definite heavy smog odor in the air and visibility was reduced. By smog odor is meant the characteristic odor attributed to smog in downtown Los Angeles, Pasadena and surrounding areas. The wind was west 5 mph. Oxides of nitrogen, expressed as nitrogen dioxide, were present in a concentration of .5 ppm; carbon monoxide tests revealed none present.

Considering the auto ratios given earlier in this paper—with smoggy air containing .5 ppm of nitrogen dioxide, 50 ppm of carbon monoxide would be expected. Yet none was found.

The third station at 2,000 feet was along Rambla Pacifico Highway leading from Saddle Peak down to the ocean at Malibu. Here the tests were run on the windward side of the road overlooking a canyon that extended down across Highway 101 about two airline miles to the south and then a short distance to the ocean front. Heavy smog was present with strong odor and poor visibility in all directions. The wind was south 5 to 6 mph up the canyon; temperature was 82°F. The nitrogen dioxide content was .28 ppm and a trace of carbon monoxide was picked up. This trace of carbon monoxide was anticipated since the up-canyon wind plus the sea air was coming across Highway 101 and mingling with the direct horizontal onshore flow of the mass of smog.

Test number four was made at 2 p.m. at 1,600 feet on Rambla Pacifico Highway overlooking the ocean. As before, it was very smoggy. The wind was south southwest 4 mph and although the ocean was only a little over a mile airline distance, it was not visible through the thick smog; temperature was 82°F. .22 ppm nitrogen dioxide was in the air; carbon monoxide present was zero.

It should be noted that all these tests were in the hot air above the base of the inversion and the wind below the summit of Saddle Peak was onshore at all times. The coastline in this area runs east and west. Cool ocean air was reached at about 1,000-foot elevation.

A test was made at 2:30 p.m. at 600 feet along the Rambla Pacifico Highway overlooking the coastline which was still not visible due to the heavy smog. The wind was south southwest 6 mph and the temperature at this point was 72°. .21 ppm of nitrogen dioxide was measured and also a trace of carbon monoxide. The small amount of carbon monoxide was expected from the airstream moving up the canyon across Highway 101.

It is interesting to note that no fog was present along the coast and yet the visibility was very poor; the sun shone only weakly through a yellowish-white smog bank that poured across the coastline between sea level and 2,500-foot elevation.

This series of tests shows that on this typical smoggy day on the coast the smog rolling across the coastline west of Santa Monica did not have as its

McCABE

LARSON

HAAGEN-SMIT

DAUGHERTY

WHAT SMOG'S BIG FOUR HAVE SAID:

LOUIS C. McCABE, first director of the Los Angeles Air Pollution Control District, and present head of the Smokes and Fumes Division of the US Bureau of Mines:

Summer 1949: "Within 18 months the smog situation will have been materially corrected. . . . The removal of sulphur compounds is the most important problem."

Winter 1949: "Los Angeles will never rid itself of smog, but improvements now under way should virtually eliminate days of eye-irritating smog by 1950. . . ."

Fall 1954: "Our report places major emphasis on exhausts. . . ."

GORDON LARSON, present Director of the Los Angeles Air Pollution Control District, and successor to McCabe:

Summer 1949: "I need greater authority to curb smudge pots. . . ."

Fall 1949: "The cause of the eye-smarting properties of smog remains a mystery. . . ."

Winter 1951: "We no longer have bad smog conditions except when the inversion layer is below 1,000 feet. . . ."

Spring 1951: "Smog is manufactured in the atmosphere as high as 1,500 feet up. . . . Hydrocarbon is the guilty party. . . ."

Spring 1954: "Smog rarely comes from industrial sections. . . . It originates mostly from traffic. . . ."

DR. ARIE HAAGEN-SMIT, California Institute of Technology, chemical consultant to the LA Smog Control District, and originator of the hydrocarbon theory:

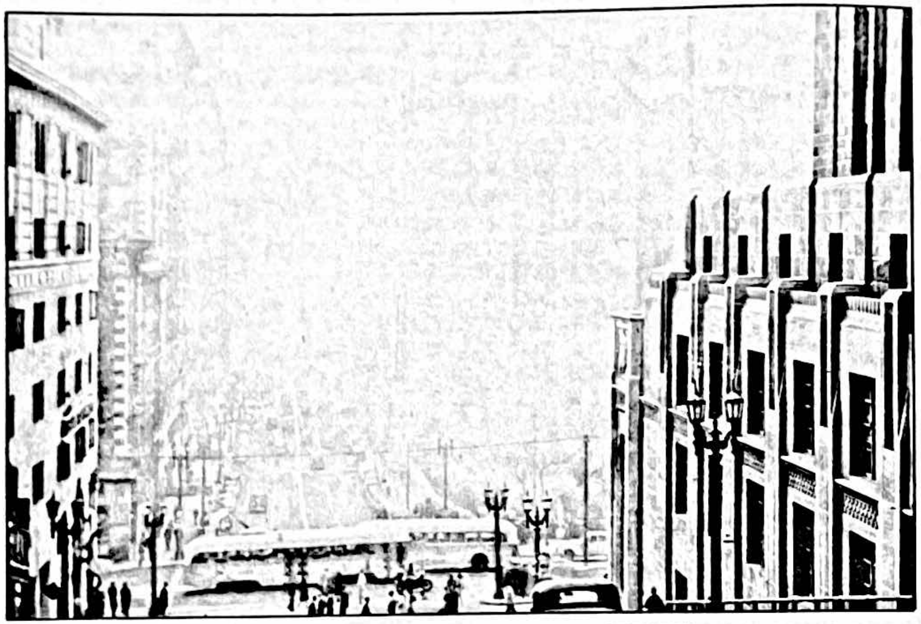
Spring 1951: "Gasoline is the source of eye-irritation and crop damage. . . ."

News item from Pasadena *Star-News*, Jan. 14, 1954: "The theory that automobiles are a major smog contributor was dealt a severe blow here New Year's Day, Dr. A. J. Haagen-Smit reported today. With an estimated 300,000 vehicles jamming into town for the Rose Parade . . . no smog whatever was encountered. . . ."

ROBERT L. DAUGHERTY, Professor of Mechanical Engineering at the California Institute of Technology, and chairman of the now-defunct Committee to the Board of Supervisors of Los Angeles County:

Summer 1949: "Southern California will see cleaner air one year hence. At that time $6 million in anti-smog tooling of the oil companies will be at work. . . . Sulphuric acid mist . . . causes citizens to shed tears."

Fall 1954: "Auto exhausts acted upon by the sun is the main cause of irritation. . . ."



TYPICAL SMOGGY DAY IN DOWNTOWN LOS ANGELES

source any industrial or residential section of Los Angeles or any other city. It showed the automobile had nothing to do with the smog. The smog had the same odor and irritating effect on the respiratory system as the smog in downtown Los Angeles. It rolled across the coastline in a 2,500 foot thick deck unceasingly throughout the daylight hours of observation.

The testing program proves:

Whereas carbon monoxide always has a gradient decreasing from the city to the suburb and then rapidly aloft, the nitrogen dioxide often does just the opposite—increases away from the center of town reaching a maximum in the foothill region and being found in heavy concentration on top of the inversion. Carbon monoxide follows exactly the course that would be predicted for the dispersion and dilution of a gas from any given source. For instance, during a smoggy period the amount of carbon monoxide in downtown Los Angeles was measured as 10 ppm, whereas the suburbs had 2 to 5 ppm. In rural sections and in foothills and mountains and along the coast, carbon monoxide concentration was from zero in the same heavy smog.

The smog, of course, takes no such pattern as the carbon monoxide. As an average it is stronger in the foothill sections and the frequency is much higher in the foothill and elevated sections than sections from downtown Los Angeles westward. During a heavy smog siege such as has occurred during September and October, 1954, and has occurred many times during the past, the smog covers thousands of square miles of Southern California with no decrease of concentration away from each highway and away from the center of each town or city. If the smog concentration followed the automobile exhaust pattern there would be little smog in the country or outlying foothill communities; also, there would be no smog blowing in over the coastline and into the coast range mountains.

Contamination by Auto

Much of the confusion in the public's mind has been brought about by the publishing of tonnage of contaminants. For instance, the estimation that 1,200 tons of hydrocarbons are discharged daily by automobiles has alarmed the public which does not appreciate that the 1,200 tons are dispersed over 4,071 square miles of Los Angeles. Further, the word hydrocarbons refers to all compounds of hydrogen and carbon, all of which are absolutely harmless in the amounts found in the Los Angeles atmosphere. Henderson and Haggard (3) state, "The idea that the toxicity of motor exhausts is due to unburned gasoline is entirely fallacious, for the gasoline concentrations in the exhaust gas, even at the highest point attainable, never approaches in toxicity the carbon monoxide present, even when this substance is at the lowest amount." . . . "The unburned gasoline in exhaust gas is neither the cause nor even a reliable index of its poisonous character. Neither is the amount of smoke, for it is usually due to the partial volatilization and partial combustion of an excessive supply of the lubricating oil."

In regard to the unsaturated hydrocarbons, the same authority (3) says they are simple asphyxiants and anaesthetics and require tremendous concentrations, such as over 60% (600,000 ppm) for ethylene and propylene to reach an anaesthetic level. Of course, the lack of oxygen would cause suffocation long before such a concentration was reached. County-wide levels of the unsaturated hydrocarbons are considerably less than 1 ppm.

Supposing all the hydrocarbons discharged from automobiles in Los Angeles County were put into a one cubic mile box instead of diffusing through hundreds or thousands. For illustration the cubic mile could be in the form of a box 3¼ x 3¼ miles x 500 feet (approximate) to simulate low inversion conditions. One cubic mile contains approximately 147,000,000,000 cubic

SMOG PICKETS PICKET A LOS ANGELES PAINT COMPANY

feet of air and weighs over 10,000,000,000 pounds or 5,000,000 tons. If, for illustration, we assume an average molecular weight of 50 for the hydrocarbons, their concentration in the cubic mile will be approximately 120 ppm. According to Sax (4) the maximum allowable concentration for gasoline vapors is 500 to 1,000 ppm. Sax (4) says, "The vapors are not considered to be very poisonous unless its concentration in air is sufficiently high to reduce the oxygen content below that needed to maintain life, in which case it acts as a simple asphyxiant." Therefore, the 120 ppm is only 12 to 24% of the MAC for gasoline (hydrocarbons) and presents no problem whatsoever, even in the one cubic mile+. Or, with a 1,300′ inversion over the entire county, assuming no diffusion out or up and the entire twenty-four hours to be contained at one time (fantastically impossible situation) the concentration would average .12 ppm, which is only .012 to .024% of maximum allowable concentration.

Now, the proponents of the hydrocarbon theory say the ozone or nitrogen dioxide unite with the hydrocarbons forming an organic peroxide which they blame for smog. Let us take another cubic mile of air and add ozone and nitrogen dioxide until a combined concentration of 120 ppm is reached. This according to Sax (4) and others, is from 120 to 1,200 times greated than MAC. "Ozone is a gas of low solubility but of intensely irritating action. The upper respiratory tract is affected, but the main focus of action appears to be in the lungs," state Henderson and Haggard (3). Sax (4) and all authorities agree that nitrogen dioxide is one of the most insidious of all the irritant gases. Its damaging action on lung tissue is described at length by these authorities. It is further pointed out that continued exposure does not build up a tolerance to the irritating effects. Unfortunately, nitrogen dioxide and ozone when mixed form a more poisonous gas than either does separately.

It is readily evident that the presence of ozone and nitrogen dioxide in quantities that can react with hydrocarbons constitutes the primary poison. Any subsequent reaction with hydrocarbons removes the poison in large degrees; further, there is no proof that the reaction products of ozone, nitrogen dioxide and gasoline vapors are even remotely as poisonous as the ozone and nitrogen dioxide mixture alone.

The auto as well as other combustion processes produces aldehydes. These compounds are irritating if in sufficient concentration. The MAC for formaldehyde is 5-10 ppm, though irritation in some individuals occurs at a lower figure. The Los Angeles Air Pollution Control District (1) found a maximum of only .4 ppm aldehydes on days of intense smog in downtown Los Angeles; Stanford Research Institute (2) has found maximums of over 1 ppm. Therefore, except in a confined space such as a garage, the aldehydes are no problem. The maximum values decrease to infinitesimal quantities in the open country. It should be noted that if ozone plus hydrocarbons account for part of concentration of aldehydes, the ozone dioxide is many, many times more poisonous and irritating than the resulting compound. What aldehydes are present are most concentrated in heavy traffic but smog is often absent in heavy traffic.

With a low inversion and the sun shining, there may be no smog or eye-smarting in heavy downtown Los Angeles traffic. This is particularly true in winter when often the natural ozone and nitrogen dioxide from the Pacific are not in the area. For instance, on New Year's morning, 1954, it was estimated that over 300,000 cars were jammed in the Pasadena area. The U. S. Weather Bureau data recorded a temperature of 54° aloft over the Los Angeles basin and the official ground temperature near sunrise in Pasadena was 37°, in other words a 17° inversion existed. Winds were light. Despite this concentration of

THE BLEWETT REPORT:

"The alleviation of smog in Southern California lies in the development of a catalyst or neutralizer that will destroy the mixture of nitrogen dioxide and ozone. . . ."

autos plus sunshine and a strong morning ground inversion, there was no smog!

Many cities report higher auto exhaust concentrations than does Los Angeles. Shindman (20) lists six references from as far as Berlin and Paris where the concentration of carbon monoxide, the indicator of auto exhaust concentrations, far exceeds that found as a maximum in Los Angeles smog. Taller buildings and narrower streets in other cities are factors. Los Angeles, then, does not have a high concentration of auto exhaust gases as compared with many major cities throughout the world. The total number of autos, therefore, is not a measure of the expected exhaust concentration. The auto has nothing to do with Los Angeles smog.

A false idea persists among laymen and many scientists that the contaminants build up daily under the inversion during a smog siege. These persons do not understand that diffusion, adsorption and precipitation prevent such an occurrence. For instance, at the end of the seventeen day smog period in October, 1954, no contaminant was seventeen times as strong as the first day; nor was there a continuous steady build-up of any one contaminant. The psychological effect does build up and after a long siege the attempted anti-smog actions of the suffering citizens do multiply.

A record smog day could occur at the start of a smog period as well as in the middle or at the end. This proves that the Los Angeles basin is not a potential "death trap of local pollution" as is widely supposed. There are thousands of cubic miles of atmosphere to handle local contaminants in any twenty-four hour period and were it not for the natural ozone and nitrogen dioxide, only a minor air pollution problem would exist except in the immediate vicinity of large contributors.

IV. OUTLOOK

No quick cure is advanced by this report. It is theoretically possible to disperse a neutralizing or catalytic material into the air upwind of populated areas and precipitate or change the form of the ozone and nitrogen oxides. This is obviously a gigantic task and would require a full scale research program.

In the meantime, it will be well to examine the local contaminants going into the air with the idea of leaving any harmless material that will unite with ozone and nitrogen oxides. For instance, the home incinerator, although causing a drop in visibility, does discharge material that unites with ozone and nitrogen oxides. This is also true of many industrial contaminants as well as the automobile exhaust.

Conclusions

1. The poison in Southern California smog is a mixture of ozone and nitrogen dioxide. These gases account for all the serious health-damaging aspects of smog. Other contaminants never even approach toxic levels except in the immediate vicinity of discharge; whereas ozone and nitrogen dioxide often exceed the maximum allowable concentration over thousands of square miles.

2. The source of the ozone is the stratosphere over the Pacific Ocean. It does not form from auto exhausts but is destroyed by exhaust gases.

3. The principal source of the nitrogen dioxide is meteorological over the Pacific Ocean. The amount of nitrogen dioxide from automobiles and industry is insignificant in producing smog.

4. Smog has increased markedly during the past ten years due either to the increased formation of nitrogen dioxide and ozone or to the dry, stagnant weather cycle that has allowed an increase in the gases reaching the surface, or to both. Smog has occurred in cycles throughout the history of Southern California and accounts of it can be found in old records.

5. Los Angeles does not have an unique temperature inversion condition. Similar and equally strong inversions are of daily occurrence throughout the world.

6. The smog found at sea and which often blows inland along the coast of Southern California does not originate in Los Angeles and is entirely of natural origin.

7. The automobile exhaust has an unpleasant odor in a confined space but is not a cause of Southern California smog; it actually destroys ozone, one of the two gases forming smog.

8. The backyard incinerator does not cause smog. Although the smoke does lower visibility it also aids in destroying smog by destroying ozone.

9. Industry does not cause Southern California smog although careless operation or breakdown can damage health or property in the vicinity of a plant.

10. Present smog control methods are now increasing smog by removal of contaminants that are in harmless concentrations in the air and which, if left, would help destroy ozone.

11. The alleviation of smog in Southern California lies in the development of a catalyst or neutralizer that will destroy or precipitate the poisonous mixture of nitrogen dioxide and ozone.

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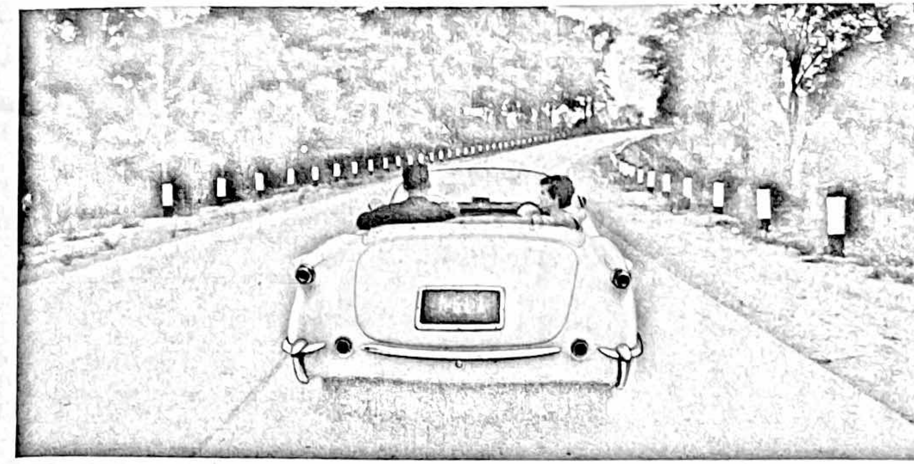

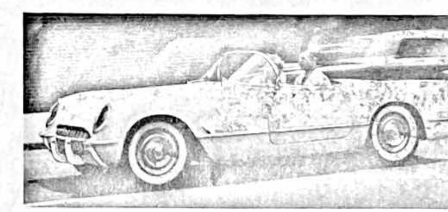

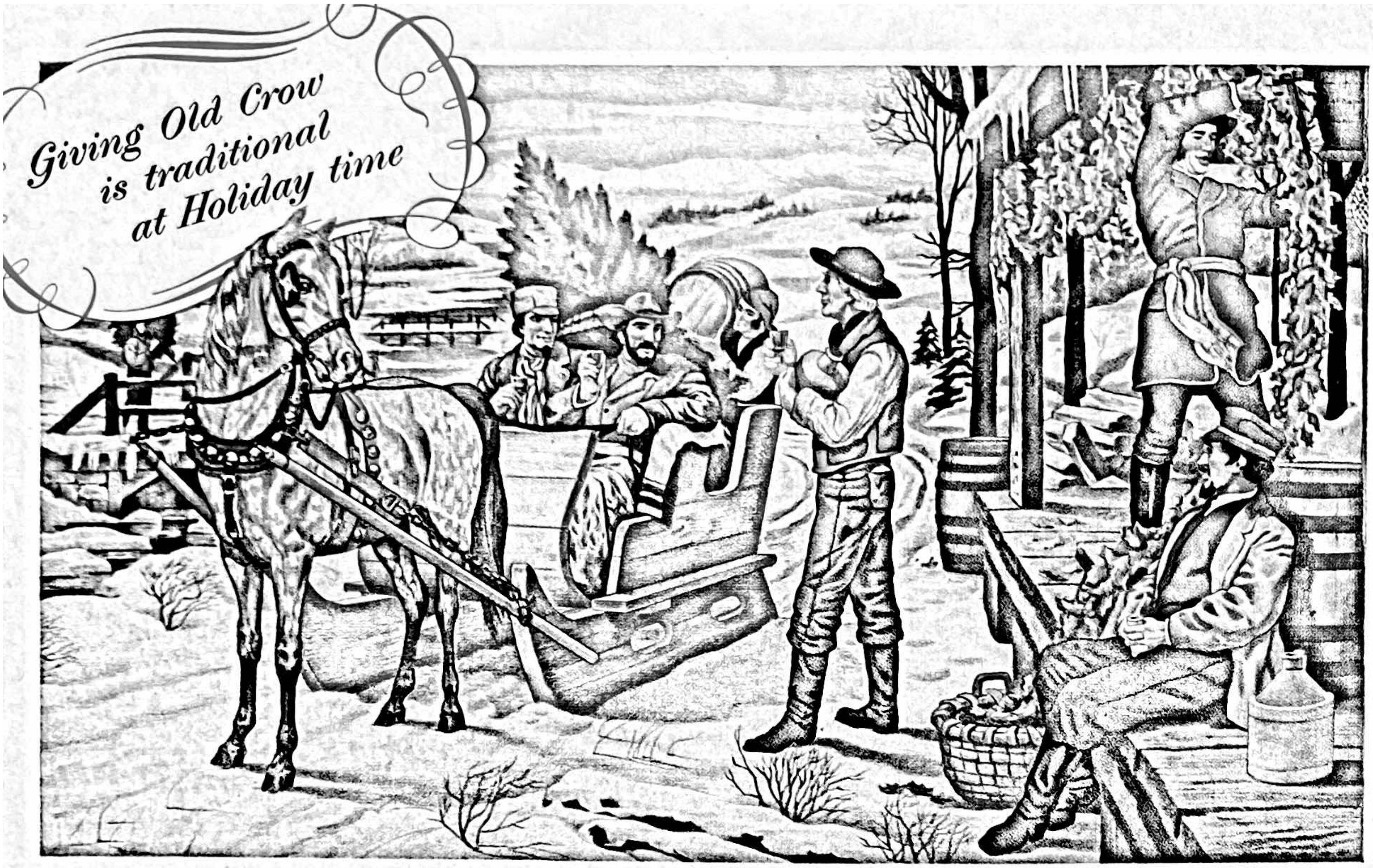

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Los Angeles Battles the Murk

Each day its autos and industry pour more than 2000 tons of smog-forming pollutants into the air. A report from the city which leads the fight against a growing urban menace.

By ARNOLD NICHOLSON

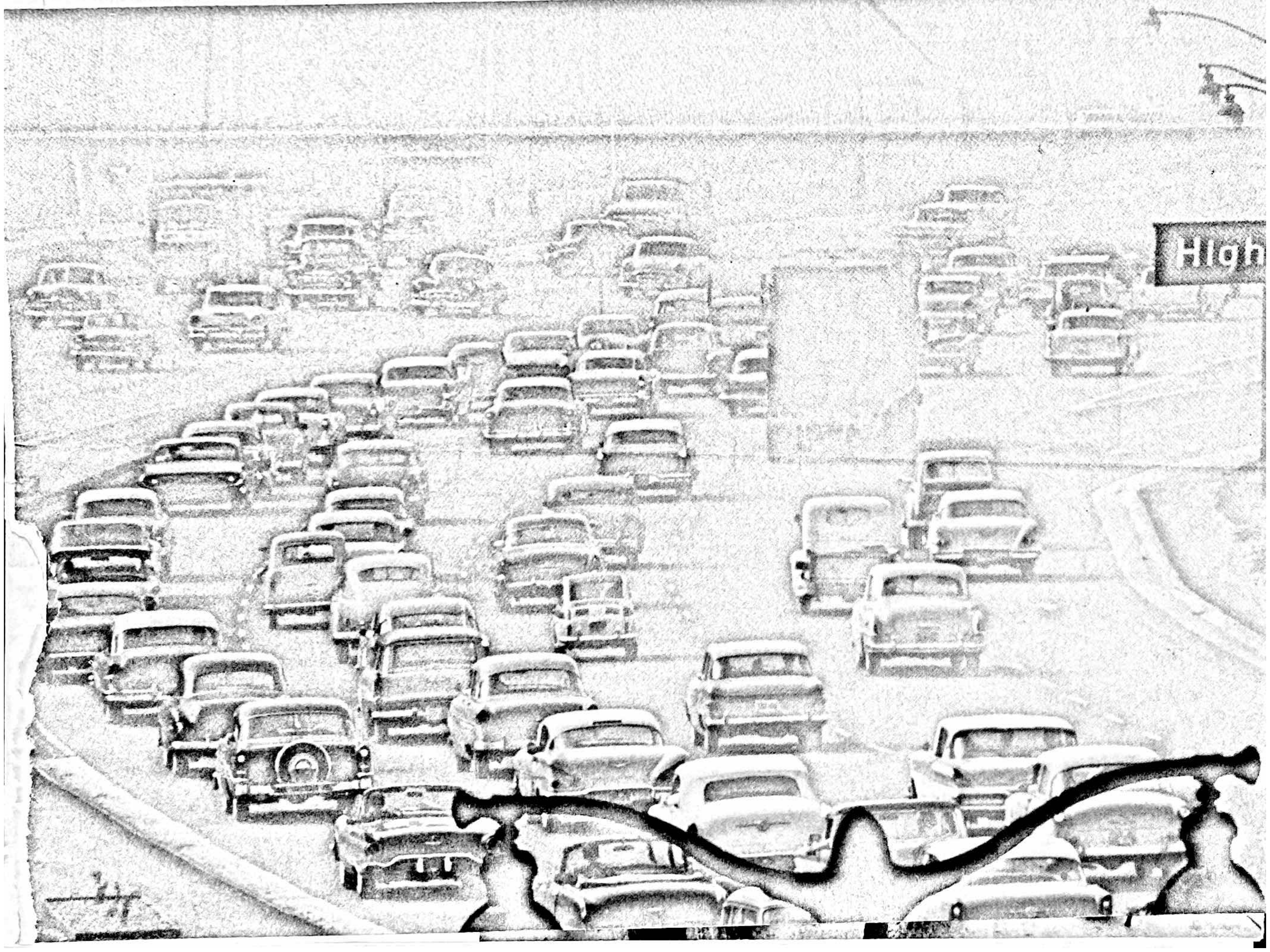
The reception room of a Los Angeles office is almost sure to display an enlarged aerial photograph of the city and its environs. The view is impressive. You are looking at a vast plain carpeted with gleaming white buildings, threaded by multilane highways and caught between the Pacific and a rim of mile-high mountains north and east. Each tiny dot of a house on slopes twenty, thirty miles away is sharply etched in the clear atmosphere.

These stimulating panoramas, it has been said, are kept on the wall for the benefit of visitors who come to town when Los Angeles is either lightly hazed over or chokingly blanketed in smog. This, for years, has averaged two days out of three. Mayor Norris Poulson, however, claims that the picture in his office hangs "as a reminder of the day when Detroit does something to bring us relief."

The mayor, as befits a good politician, has been the leader in a mounting chorus of citizen complaint directed to the automobile manufacturers. "You lured us into this mess," is the theme of motorized Angelenos, "and you will have to invent something to get us out of it."

Another vociferous bloc has zeroed in on the petroleum companies. "Either put something into our gasoline or take something out," they say. "Give us a smog-free fuel."

Rush hour on the Hollywood Freeway. Autos, buses and trucks are responsible for two thirds of the region's aggravating pall.



Volunteers wearing smog-filled masks during an eye-irritation test at the Stanford Research Institute. Here subjects record their reactions to five-minute doses of "gunk." Despite extensive research, all of the compounds that cause the irritation are not identified.

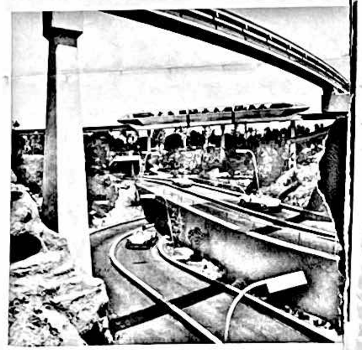
What the 6,000,000 inhabitants of Southern California's smogland want is a way out of the nation's most persistent, aggravating and peculiar air-pollution problem—a monumental dilemma, now that it is fully understood. Fifteen years of acrimonious debate, costly control measures and research indicate that the sprawling Los Angeles basin, having fashioned a way of life around the automobile, is literally stewing in its own tail-pipe juice. The basin's 3,000,000 motor vehicles—one for every other man, woman and child—at the present rate of use put 5700 tons of exhaust gas into the air each day. An almost odorless, invisible part of this atmospheric load is the principal cause of smog.

The irritating murk was long considered a strictly local phenomenon, compounded by Los Angeles' geography and weather conditions. Both, it is true, contribute to the problem. Yet San Diego and the San Francisco Bay area now are troubled with similar smog. Fresno and Sacramento, in California's great Central Valley, have joined the list, along with Tucson and Phoenix, in Arizona. Honolulu and Denver report a suspicious haze. There's a growing conviction in city halls and medical circles far to the east that every big metropolis, as population and motor vehicles multiply, may be headed for some sort of exhaust-gas dilemma unless gasoline power is modified by a scientific breakthrough or public-transportation systems are revived.

"California's battle against smog," says Surg. Gen. Leroy E. Burney of the United States Public Health Service, "may furnish a lucky break for other cities which, although seldom caught in the same weather trap as the Southwest, now realize that automobile gases are one of the major air-pollution problems. A solution for Los Angeles would almost guarantee success anywhere."

Other cities already are deeply in debt to Los Angeles. The millions invested in smog research have unveiled important atmospheric mysteries. Her citizens and industry together have demonstrated workable controls for almost every source of pollutant except the automobile. No community of comparable size even approaches Los Angeles' strict regulation

Dr. Aric J. Haagen-Smit, Cal Tech biochemist and pioneer smog fighter. His solution: "Limit industry and the concentration of people." Haagen-Smit calculates that Los Angeles' tremendous future population growth will cancel out all the new antismog controls.



High-speed monorail transportation, such as the example at Disneyland above, has been suggested as a way to lure Los Angeles commuters out of their cars.

of what goes into the air. A white shirt, smog or no smog, is still a white shirt after two days' wear in the heart of the city.

All trash or leaf burning within Los Angeles County has been prohibited since 1957. No factory stack may emit more than a wisp of smoke or the faintest plume of vapor, other than steam. The eighteen oil refineries in the basin have spent $35,000,000 capturing waste material, capping tanks and sealing off leakage. An equal amount has been invested in smoke and fume controls by all other industries. The big electric power plants, which burn almost smokeless oil, are now required, during the summer and fall smog months, to burn even cleaner natural gas.

The agency which establishes and enforces these regulations, usually branded "impossible" when first proposed, is the Air Pollution Control District, an arm of the Los Angeles County Board of Supervisors. It is spending $3,750,000 this year. Many of the district's air-scrubbing rules—they now number sixty-four—tap the pockets of the people, either directly through taxes or through higher costs of products or services. Payments for trash collection throughout the county, after the no-burning edict, soared from $12,000,000 to about $29,000,000 a year.

These financial burdens only add to the tension throughout the basin when a clear, hot morning dawns and the course of early traffic on each freeway is marked by streaks of dirty brown haze directly overhead. The whole valley grows hazier and hazier as the sun mounts in the sky, and swelters in a faintly malodorous, acrid murk by noon. Eyes weep and tender plant leaves are seared. The switchboard at district headquarters blossoms with hundreds of calls, every one from an irritated, irate taxpayer demanding relief. One ghoulish soul, who has either perished or moved away, day after day never uttered a word to the operator—just coughed harshly two or three times and then hung up.

The moment comes when an attendant at one of the district's seven monitoring stations, scattered at strategic points throughout the county, reports "first alert" levels of stuff in the atmosphere. The word goes out to newspapers, radio and TV stations, to public agencies and to industrial plants. It used to signal an end to trash burning in the valley. Today it is supposed to limit auto use, on a voluntary basis. No one, however, has observed much thinning in the streams of cars when the smog is at its worst. News of the alert over car radios simply confirms the irritation of hot, tired drivers jousting through traffic.

The alert is usually over by late afternoon. One of the causes is then on its way out of the sky. This is California's bright and blazing sun. Cause (Continued on Page 90)

Anything for relief: Whenever the murk becomes unbearable, Edward M. Baker, a Hollywood messenger, makes his rounds wearing a gas mask.

"Will it ever come to this?" Among the more bizarre reminders of the city's plight is this asbestos fire-fighting suit which one Los Angeles merchant offered to smog-weary customers.

Los Angeles Battles the Murk

(Continued from Page 19)

No. 2 also has begun to dissipate. This is the "inversion," an atmospheric phenomenon which has acted like an invisible lid over the valley floor. Both are beyond the control of man.

If the air in the basin could escape the surrounding rim of mountains, the inversion would not be so troublesome. Air normally grows cooler with altitude, but in Los Angeles' case a band of warm air often rides overhead, sometimes only a few hundred feet above the ground. The surface air, and its load of pollutants, cannot rise and escape. The bright sunshine pours its energy into this stagnant, surface atmosphere, and a photochemical change occurs as the rays of light bombard, split and regroup the molecules of exhaust gas. Smog takes form.

This strange process, by which the thinly dispersed stuff in the air changes its chemical identity, has complicated research and prolonged public misunderstanding of smog's origin and control for almost a decade. Southern Californians got their first taste of smog early in World War II. They blamed a petrochemical plant making butadiene, an ingredient of synthetic rubber, for the cloud on their climatic paradise. This source was controlled by the end of the war, but Los Angeles' normal, tropical haze continued to possess unpleasantly persistent and smelly dimensions. The oil refineries then became suspect.

A hotel executive and a determined woman touched off the organized campaign to clean the air in 1945. Stephen W. Royce, of Pasadena's Huntington Hotel, who had put a man on his payroll with instructions to track down the source of the stuff repelling his guests, found an ally in Mrs. "Buff" Chandler, wife of Norman Chandler, publisher of the *Los Angeles Times*. She was the one who spoke up with a resounding "yes" when Royce asked her husband if the *Times* was going to do anything about smog.

Los Angeles that year adopted its first air-pollution ordinance. The law applied only to the city and unincorporated areas within the county, and an effort was made to have all of the forty-six municipalities—there are sixty-three today—adopt similar measures. Failure led, in 1947, to passage by the state legislature of a bill which permitted the County Board of Supervisors to establish the present control district and override local jurisdiction.

The initial drive on manufacturing plants, refineries in particular, was for control of sulphur compounds, of which sulphur dioxide is most common and a troublesome pollutant for industrial centers everywhere. It was readily identified by the air-pollution experts Los Angeles had imported from the smoky cities back East, and control measures were begun. But it wasn't, the district discovered, the principal source of smog.

The Chamber of Commerce had established an air-pollution committee. One of the members in 1949 was Dr. Arie J. Haagen-Smit, a Netherlands-trained biochemist on the faculty of the California Institute of Technology. His field of research was, and is, flavor analysis—tracking down the essence of pineapple, for instance. One technique is to freeze out the elusive compounds with extremely low temperatures. Haagen-Smit told the worried businessmen that something of the sort might help analyze the murk closing in on Los Angeles. They asked him to try.

"It was not difficult," he recalls, "and the nature of the stuff I extracted from a test tube indicated that chemical change by an oxidizing process in the atmosphere had produced it. I advanced a theory as to how it might be formed, the control district really dug in, and a lot of people started spending a great deal of money to see whether we were right or wrong."

Nearly all the major research laboratories in the United States have since had a whack at different phases of the problem. Perhaps $10,000,000 has been spent on smog research by the district and other governmental agencies, the American Petroleum Institute and the Air Pollution Foundation. The foundation, which has a budget of $500,000 a year contributed by basin commercial and industrial leaders, was established in 1953 for "impartial fact finding."

The scientists are now agreed that there are two principal ingredients from which smog is made. They are the reactive hydrocarbons that occur in raw gasoline, partially burned fuel and in other petroleum vapors, and the oxides

Magi and Manger

By Robert Besch

Bearded and bangled,
Over the hill they came;
Sand in their eyes,
Seared by a desert flame;
Burning with thirst
Of body and soul, they saw
Eternal oasis
Cupped in a pile of straw.

of nitrogen that are the product of combustion of almost any fuel. When both are suspended in the air in amounts that average only one part per million, the energy of the sunlight triggers a chain of reactions. A bewildering variety of unpleasant oxidant compounds is produced, including those which contribute to the haze, irritate the eyes and nose and are harmful to plant life. Another annoying product is ozone, a chemical form of oxygen with an odor and other properties like chlorine gas.

Smog elements are measured by the air-sampling devices maintained by the Air Pollution Control District, and the most used index is the concentration of ozone. Half a part per million is "first alert" level.

"At this concentration of ozone," says Dr. Leslie A. Chambers, research director for the control district, "the smog is more than an annoyance. We consider it a threat. A second alert, which would halt all traffic and industrial operations, is set at one part per million—an emergency that has never yet occurred, although we came close in the fall of Nineteen Fifty-four and again in 'Fifty-five.'"

First alerts occur perhaps half a dozen times in the average year, even though "the gunk is cooking," as its victims say, to a disagreeable degree sixty to seventy days out of the 365 and is present in a thinned-out version another 120 to 160 days.

The ozone test to measure smog intensity was devised by Caltech's Haagen-Smit and his associates when he served as consultant to the control district in the early '50's. "Haagy," as the professor with the Dutch accent is widely known, way. All incentives to learn and all penalties for not learning will vanish. The few who might want to learn will be prevented—who are they to overtop their fellows? We shall no longer have to plan and toil to spread imperturbable conceit and incurable ignorance among men. The little vermin themselves will do it for us.

Of course, this would not follow unless all education became state education. But it will. That is part of the same movement. Penal taxes, designed for that purpose, are liquidating the middle class, the class which was prepared to save and spend and make sacrifices in order to have its children privately educated. The removal of this class, besides linking up with the abolition of education, is fortunately an inevitable effect of the spirit that says "I'm as good as you." This was, after all, the social group which gave to the humans the overwhelming majority of their scientists, physicians, philosophers, theologians, poets, artists, composers, architects, jurists and administrators. If ever there was a bunch of tall stalks that needed their tops knocked off, it was surely they. As an English politician remarked not long ago, "A democracy does not want great men."

Public Nuisance

By Ethel Jacobson

She only took one parking spot,
This blithely heedless
parker ——
Half of it on either side
Of the dividing marker.
I hope she stays there
overtime
And gets two tickets for her
crime.

It would be idle to ask of such a creature whether by "want" it meant "need" or "like." But you should be clear. For here Aristotle's question arises again.

We, in Hell, would welcome the disappearance of democracy in the strict sense of that word—the political arrangement so-called. Like all forms of government it often works to our advantage; but on the whole less often than other forms. And what we must realize is that "democracy" in the diabolical sense—"I'm as good as you," Being Like Folks, Togetherness—is the finest instrument we could possibly have for extirpating political democracies from the face of the earth.

For "democracy" or the "democratic spirit" (diabolical sense) leads to a nation without great men, a nation mainly of subliterates, morally flaccid from lack of discipline in youth, full of the cocksureness which flattery breeds on ignorance, blustering or whimpering if rebuked. And that is what Hell wishes every democratic people to be. For when such a nation meets in conflict a nation where children have been made to work at school, where talent is placed in high posts, and where the ignorant mass is allowed no say at all in public affairs, only one result is possible.

The democracies were surprised lately when they found that the Soviet Union had got ahead of them in science. What a delicious specimen of human blindness! If the whole tendency of their society is opposed to every sort of excellence, why did they expect their scientists to excel?

It is our function to encourage the behavior, the manners, the whole attitude of mind, which democracies naturally like and enjoy, because these are the very things which, if unchecked, will destroy democracy. You would almost wonder that even humans don't see it themselves. Even if they don't read Aristotle (that would be undemocratic) you would have thought the French Revolution would have taught them that the behavior that aristocrats naturally like is not the behavior that preserves aristocracy. They might then have applied the same principle to all forms of government.

But I would not end on that note. I would not—Hell forbid!—encourage in your own minds that delusion which you must carefully foster in the minds of your human victims. I mean the delusion that the fate of nations is *in itself* more important than that of individual souls. The overthrow of free peoples and the multiplication of slave states are for us a means—besides, of course, being fun—but the real end is the destruction of individuals. For only individuals can be saved or damned, can become sons of the Enemy or food for us. The ultimate value for us of any revolution, war or famine lies in the individual anguish, treachery, hatred, rage and despair which it may produce. "I'm as good as you" is a useful means for the destruction of democratic societies. But it has a far deeper value as an end in itself, as a state of mind which, necessarily excluding humility, charity, contentment, and all the pleasures of gratitude or admiration, turns a human being away from almost every road which might finally lead him to Heaven.

But now for the pleasantest part of my duty. It falls to my lot to propose on behalf of the guests the health of Principal Slubgob and the Tempters' Training College. Fill your glasses. What is this I see? What is this delicious bouquet I inhale? Can it be? Mr. Principal, I unsay all my hard words about the dinner. I see—and *smell—that even under wartime conditions the college cellar still has a few dozen of sound old vintage Pharisee. Well, well, well! This is like old times. Hold it beneath your nostrils for a moment, Gentledevils. Hold it up to the light.* Look at those fiery streaks that writhe and tangle in its dark heart, as if they were contending. And so they are. You know how this wine is blended? Different types of Pharisee have been harvested, trodden and fermented together to produce its subtle flavor. Types that were most antagonistic to one another on earth. Some were all rules and relics and rosaries; others were all drab clothes, long faces, and petty traditional abstinences from wine or cards or the theater. Both had in common their self-righteousness and the almost infinite distance between their actual outlook and anything the Enemy really is or commands. The wickedness of other religions was the really live doctrine in the religion of each; slander was its gospel and denigration its litany. How they hated one another up there where the sun shone! How much more they hate one another now that they are forever conjoined but not reconciled. Their astonishment, their resentment, at the combination, the festering of their eternally impenitent spite, passing into our spiritual digestion, will work like fire. Dark fire. All said and done, my friends, it will be an ill day for us if what most humans mean by "religion" ever vanishes from the earth. It can still send us the truly delicious sins. The fine flower of unholiness can grow only in the close neighborhood of the Holy. Nowhere do we tempt so successfully as on the very steps of the altar.

Your Imminence, your Disgraces, my Thorns, Shadies and Gentledevils: I give you the toast of—Principal Slubgob and the college! THE END

enjoys unique prestige as a smog fighter, not only for his discoveries but also because he speaks with academic freedom from political or business pressures.

The pressures have been inevitable. The average citizen, for instance, for a long time was unwilling to believe that his car, or the little pile of leaves smoldering in his back yard, was contributing to his own discomfort. Industry was reluctant to spend millions without positive proof that the conditions to be corrected were a source of smog.

The persistence of the murk, despite all the restrictions, hasn't soothed either the public or the businessmen. But no one, at this juncture, can dispute the control district's estimate that automobiles, buses and trucks create two thirds of the stuff that makes smog. Their exhausts pour 900 tons of hydrocarbons and 430 tons of oxides of nitrogen into the basin atmosphere each day. The other third comes from industrial sources, all tightly regulated with the exception of small plants, such as dry cleaners, that employ solvents in their operations. Solvent users are believed to lose 300 tons of hydrocarbons to the air per day, which is twice the amount that now escapes from the refineries. The balance of auto exhaust—three fourths of it—is carbon monoxide, a deadly killer which also is monitored by the control district, but seldom reaches dangerous concentrations in the open. The monoxide is not believed to take part in the smog reaction.

The fight against smog, like most air-pollution-control measures, was initiated to end a nuisance which was also an economic threat. It is now, however, underlaid with an uneasy suspicion that the nature of the stuff, and its effects on the people who breathe it, deserve a great deal more study before proper health standards can be established. Both the California State Department of Public Health and the United States Public Health Service are working toward this goal, along with the local agencies. A $10,000,000 study of the effect of exhaust gas on human health, to be conducted by the Sloan-Kettering Institute for Cancer Research, has been proposed by General Motors.

No one, to date, has analyzed all components of the gunk that causes eye, nose and throat irritation. Physicians, however, know that several days' exposure is a threat to the aged and infirm. The interference with breathing taxes both the lungs and the heart. They think it may be linked to the sharp increase in California during recent years of emphysema, a degenerative lung disease. They have ordered many patients to leave the basin and find smog-free residences in the foothills or along the seacoast.

The most disturbing compounds identified in smog are carcinogenic and quite similar to those earlier found in air polluted by coal smoke. No final proof has been obtained that these substances, in the minute amounts present in the air, have been the cause of cancer in humans. But concentrations of the stuff do induce both skin and lung cancer in experimental animals. City residents the world over do have a higher incidence of malignancies than those who dwell where air pollution of all sorts is less.

A much-used, costly research device is the artificial smog chamber, where auto exhaust from a controlled source can be mixed with air and then irradiated under high-intensity lights to produce gunk for analysis. Use of this apparatus in Southern California requires special filters to desmog the air that is used to make the artificial stuff. The Stanford Research Institute and the control district operate chambers in Los Angeles County, a third is in Riverside, at the University of California agricultural experiment station, and the fourth has been established at the United States Public Health Service's Sanitary Engineering Center in Cincinnati, Ohio.

The agricultural scientists are deep in smog studies because it damages many crops, from orchids to oranges. Most growers of leafy-vegetable crops, such as spinach, which are particularly susceptible, have left the Los Angeles basin, where smog losses have been estimated as high as $8,000,000 a year. The full extent of the damage there and in other areas cannot be calculated. Dr. John T. Middleton, who heads the university's state-wide smog committee, is convinced that ozone and the hydrocarbon oxidant compounds, both of which can cause visible damage, also reduce the yields of many seemingly healthy crops.

Men at Riverside record an ever-widening zone where damage occurs throughout California, though the Los Angeles County troubles have decreased a bit. Doctor Middleton, incidentally, does not confine his bad news to the West Coast. He has spotted telltale signs on petunias and other flowering plants in several Eastern big-city parks. Oxidant damage begins with gray seared areas on the underside of the leaves. Ozone decomposes patches of leaf from the top, and is especially toxic to many varieties of tobacco. Cigar leaf has been spoiled in the Connecticut Valley and at the Department of Agriculture experimental farm at Beltsville, Maryland, near Washington, D. C. The ozone concentrations there at times ran from a half to two thirds as high as Los Angeles' first-alert level.

The smog poisoner of crops was once thought to be the same compound that causes eye irritation, but was recently identified and is not. The Air Pollution Foundation believes the principal irritants are formaldehyde and acrolein, a tear-gas ingredient. Measurement of the illusive irritants depends on apparatus reminiscent of medieval torture. This is the eye-irritation booth or aperture in an artificial smog chamber, where human guinea pigs patiently expose their eyes to a series of five-minute doses of gunk and record the effects. A sign in full view of the paid student volunteers who sit alongside the S.R.I. chamber, wearing smog-filled goggles, advises, KEEP SMILING—HAVE FAITH.

The politicians especially find it difficult to smile in the face of the smog dilemma. "We're victims of excess horsepower and tail fins," says Mayor Poulson, who delights in publicizing his ownership of a compact, small American car and insists that the city buy Detroit's stripped-down economy models for official use.

The harried mayor, in his central domain, is a captive of forces beyond his control. The control district, for instance, is not his agency, but an arm of the larger county and sharply critical of smoke from city-owned power plants and incinerators. The roaring freeways, creations of the state, pour 300,000 cars a day not just in and out of the city, but through it to other destinations.

The bordering municipality of Vernon, for instance, siphons 76,000 motorized workers in and out each working day. Less than 200 of this huge working force live within that community. Los Angeles' young Transit Authority, still fighting its way out of financial tangles, talks grandiose schemes for high-speed monorail transport while patronage of buses and vestigial streetcar lines is hard to maintain. The diesel power plant of a modern bus, incidentally, puts much less gunk into the air than a gasoline motor, but invariably rouses public suspicion because of the exhaust odor.

The frustration of Mayor Poulson boiled over in a verbal battle with the mayors of Detroit and Pontiac last winter. The Michigan mayors suggested a boycott on California vacation travel to counter his threats of a ban on automobiles sporting tail fins instead of smog-limiting devices.

"It isn't the tail fins that bother me," says Warren M. Dorn, a county supervisor who was elected on a clean-up-the-smog ticket. "*It's the olefins.*"

Olefins are the most active smog makers in the hydrocarbon family. They are also the basis of a heated dispute. The control district claims that the more olefins in the fuel, the more come through the tail pipe. The refineries counter that they are the natural product of gasoline combustion, and not significantly reduced by their removal from the fuel. The oil companies now must comply, however, with the district's Rule 63, which calls for a reduction in fuel olefins, beginning in July, 1960.

Smith Griswold, control district director, and his iron-willed assistants have evolved a formula to clean the skies that again carries the "impossible" label. It is obviously costly and depends on inventions still a long way from perfection. They propose, first, to cut down the gasoline olefins, which will require millions for new oil-refinery equipment. Following steps would be the use of a tail-pipe device on cars, to burn away at least part of the offending gunk; and a different carburetor and fuel system, to eliminate the escape of hydrocarbons by evaporation.

"Gradual change in the fuel," Doctor Chambers says, "in my opinion will be more effective in reducing smog than the installation of afterburners on our cars."

One oil company—Tidewater—put a "smog-reducing" premium fuel on the market before passage of Rule 63. It is the product of a new refinery process which is said to cut down on the content of olefins and other volatile, reactive fractions and available in premium grade only because plant capacity is limited. The Union Oil Company, which took the lead in the refinery cleanup six years ago, has outlined a "no-loss" fuel system which would save gasoline for the car owner and eliminate hydrocarbon evaporation, which on a hot day in the basin is estimated as high as 150 tons.

The oil companies have an uphill fight finding friends. A hard core of refinery haters continues to insist that production, storage and marketing of gasoline are a major smog source. They are the people who long ago nominated Dr. Eugene J. Houdry as public enemy No. 1. *They claim his invention of the catalytic cracking process in the late 1930's launched the era of smog by helping refineries to extract many more volatile, quickly evaporated elements from each barrel of crude.*

Today they stand in a strange attitude of obeisance before the same Doctor Houdry, hopeful that he has found a way, through the use of a car muffler filled with another magic catalyst, to burn off the olefins and other hydrocarbons before they reach the open air. Houdry's catalytic muffler, under development with General Motors, is one of the most publicized tail-pipe control devices. Ford also has a catalytic muffler. Chrysler is working with a direct-flame afterburner developed by Thompson Ramo-Wooldridge.

Charles M. Heinen, Chrysler engineer who heads an industry-wide exhaust research group, estimates $5,000,000 has been spent by the auto companies on this project in recent years. Detroit turns to the tail-pipe afterburner with reluctance, having hoped that the problem might be solved within the power plant itself. Carefully tuned motors, the auto engineers have shown, emit fewer hydrocarbons.

None of the tail-pipe devices is ready for mass production and use. The catalyst types have useful lives estimated at not much over 10,000 miles, due to gradual accumulation of lead from the tetraethyl compound which is a component of today's high-octane fuel. They also have a critical operating temperature which is not reached until the motor has been in use for about fifteen minutes. The direct-flame device operates at an even higher temperature, which is a problem under the car body, but may be an advantage if attached to the motor itself—an experiment now under way.

(*Continued on Page 93*)

"Notice how it fits over the shoulders!"
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(*Continued from Page 91*) Cost estimates for perfected models range from thirty dollars to $100 per car. The expense to motorists, multiplied by Los Angeles' 3,000,000 cars alone, is awesome, and installation and continued inspection of tail-pipe devices would create a monumental chore. Yet the California legislature, spurred by Gov. E. G. Brown, has a program under way which will require the State Department of Public Health to publish standards for the discharge of pollutants from motor vehicle exhausts during 1960. Legislation to require tail-pipe smog control presumably would follow just as soon as a workable device is ready.

Haagen-Smit is proposing a smog solution that is almost sacrilege to his neighbors. "Limit industry and the concentration of people," he says in a mild voice, touched with the accent and stubborn tenacity he brought from the Netherlands to Pasadena. "Create more open space and parks."

This is heresy in the basin, where orange groves have been replaced by supermarkets, where bean fields now sprout endless miles of industrial plants and 600 new citizens drive in and become residents every day.

"I am not a planner, of course," says Haagen-Smit, fingering a simple chart of what he sees in the local skies five, ten or fifteen years hence. "But I can calculate what to expect from all the proposed controls, including a device on automobile exhausts, as Los Angeles' population grows. They could bring some immediate relief, but not clear the air. Ten years from now we'll be no better off than today."

The Dutch biochemist recently returned to his flavor laboratory from a two-year chore designing and overseeing the construction of apparatus to eliminate smoke and fumes at the Southern California Edison Company's El Segundo power plant. The company's million-dollar investment has set a new standard of combustion efficiency and cleanliness for the industry.

The Edison company intends to experiment with a new type of all-electric car which has a top speed of fifty-five miles an hour and will travel about eighty miles before the batteries have to be recharged. It is obviously no substitute for a gasoline-powered machine, but the company feels this silent, no-smog vehicle might be useful for meter readers and other stop-and-go jobs.

Monorail transport is also on display in Southern California. Walt Disney has installed nearly a mile of suspended track at Disneyland. Monorail has long been touted as the only type of high-speed transit that could be superimposed on Southern California's map without messing up the highways. "Unobstructed roads, however, wouldn't do much to get motorists out of their cars," one engineer comments. "As long as times are good no one is going to get out from behind the steering wheel."

The control district pursues long-range studies of basin air currents, relating them to transportation and the future location of people and industry, but the influence of city planning on smog problems is not notable to date. "We're dealing with an incredible number of political subdivisions in the county," Smith Griswold points out. "There are sixty-five planning commissions alone. All we can do is to suggest."

The basin's bold thinkers and inventors feed a constant stream of antismog ideas to the control district. About 100 inventions a year warrant testing. "Most of them are petroleum and gasoline additives," Griswold's men report, "and none of them work any better than the thousands of substances the oil-company chemists have investigated."

A recurring suggestion is the use of airplane seeding either to dispel the inversion hanging over the basin or to counteract the stuff in it. Professional weather makers have offered to try, but even a modest experiment would cost several hundred thousand dollars.

"The meteorologists see little chance for man to break the inversion," Haagen-Smit says. "But something like activated charcoal in the air could soak up a lot of the hydrocarbons. It would be just like sprinkling soot, however. The cure might be worse than the disease."

The smog dilemma obviously will not vanish soon, or without cost to everyone. Some of the refineries are considering an end to further expansion in the Los Angeles basin. "What happens to us if the antiolefin blend and then the tail-pipe device fail to sweep the skies clean?" they ask.

Haagen-Smit, in suggesting dispersal of industry, has answered this question. But he is too much a Southern Californian to have abandoned all hope. "The haze is not as thick as five years ago," he says. "The plant damage is less, and the alerts are not as frequent and do not last for as long a period. The measures of the control district have held us back from disaster, even made conditions a little better—but will have to achieve a miracle if they banish smog in Los Angeles' booming future."

Los Angeles may achieve that miracle through tighter and tighter controls. If they get tough enough, the end result will approximate Haagen-Smit's prediction. The people will have limited their own activities and population density. This seems unlikely. Predicted shortages in Los Angeles' other limited resource, water, have never halted the basin's growth.

The one certainty is that Southern Californians, goaded by a nuisance of their own making, can't afford to drop the smog fight. Whatever they themselves do, or can induce government agencies and the motor world to do for them, will profit the nation. Other cities may only rarely duplicate their sun-bright skies and atmospheric inversions, but it is already obvious that the more we herd together and mill around under gasoline power, the more important it becomes to analyze and to keep acceptably clean the stuff we breathe.

Apache Attack (Continued from Page 31)

corral where the teams were waiting. Leisurely he rolled a cigarette, at the same time keeping an eye on the plateau and on the willows. There was little doubt in his mind now that the Apache renegades, after ripping up the Flat Rock Station, had bypassed Sherman City and were now preparing an attack on the Stony Creek Station, first stop out of Sherman.

Touching a match to the cigarette, Ben moved down toward the corral and sat down on the low wall. From this position he could watch both the creek and the plateau from under the brim of his flat-crowned black hat. It was now impossible for the Apaches to close in on him without revealing themselves.

The Apaches weren't going to close in on him yet, though. The Apaches, wild, tamed or renegade, were wise in the ways of the white man, and they also had seen that small cloud of dust to the west, which would be the eastbound stage now approaching Stony Creek Station. The Apaches were waiting for that stage to pull into the swing station before they went into action. It was much easier attacking an unsuspecting, standing stagecoach, with the teams out of the traces, than to attack one on the road with fresh horses in the traces.

This bunch, according to Dave Barrister, had been at Flat Rock only yesterday, a distance of about sixty-five miles. Ben Carrigan could believe that they'd covered that distance in twenty-four hours because the Apache was known to ride a horse for thirty miles at a killing pace, and then push the mount brutally another ten or fifteen miles until the horse dropped dead. Then he would calmly eat his means of transportation and continue on foot.

Ben smoked his cigarette and watched the column of dust drawing closer. Joe Stanhope would be handling the reins on this eastbound, with Bud McNeil riding shotgun. The three of them could withstand this Apache attack now that they were forewarned, but Ben dreaded to think what would have happened had he not heard those curlews as the Apaches moved into position for their raid.

A faint trace led down along the creek, skirting the willows where some of the Apaches were concealed. The trace led out to the abandoned Jud Evans homestead, empty now since Jud had died of the fever almost three months ago. Ben had ridden out to the Evans place only two days before, noticing that the weeds were growing in the tiny flower patch which Callie Evans had tended so heroically the short while she'd been married to poor Jud.

For some weeks Ben had kept up that flower patch after Callie had moved in to Sherman and taken the job waiting on tables in Bill Montrose's restaurant. Ben was not a flower lover, but he'd seen how Callie had tried so hard to bring just a little beauty to that barren, sun-scorched spot. He had done it, he told himself, because there was still a little of Callie Evans out at the Evans homestead, and it had been very nice having the couple less than four miles away and being able to drop in on them once in a while.

All the time he'd wondered how it was that a nester like Jud could have had the good fortune to marry a girl like Callie while he, Ben Carrigan, lived at his station alone. One thing about a swing station, *lonely as the job was, and with only one tender, you got to see things coming and going.*

He'd met Callie even before Jud had because Callie had come through on the stage to marry Jud, whom she had never seen, having contracted to do so through a newspaper "lonely hearts" column.

He'd helped Callie move into town after they'd buried Jud Evans, and now he would be the last one to see Callie go because she was riding out on the eastbound this afternoon, going back to live with a sister in Indiana.

The day before yesterday Ben had been in town, having his supper at Montrose's, and Callie had told him that Montrose was bringing his niece to Sherman from California, and that the niece would be waiting on tables in the restaurant, and the services of Callie Evans would no longer be needed.

"No other jobs in Sherman?" Ben had asked, very much troubled by the news.

"I've asked around," Callie had told him, and Ben could see how it was with her. Callie had to work or remarry, and it was too soon after Jud's death to think of marrying again. Jud had been a good husband in his way, doing the best he could all the time, even bringing her little things like flower seeds.

Callie was going back to her sister's, but from the way she'd said it, Ben knew that the sister back east was not particularly eager to have her return, and probably had been quite happy a year ago when Callie had headed west to marry Jud.

"Ain't no rush goin' back," Ben had tried to tell her, and he'd wondered what she would have said if he'd mentioned the fact that Great Western had offered him charge of their big home station at Whistle Springs another fifty miles beyond Stony Creek, and that the operator of a home station was ordinarily a married

". . . And when did you first notice this ringing in your ear, Mr. Wallace?"

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man with a woman to cook for the passengers as they came through.

Ben was twenty-nine now, and he'd been with Great Western for seven years, for a while in the yard at Sherman and for the last three years at Stony Creek Station. He was old enough to marry, and he was quite willing to marry Callie if she would have him, but it was not proper to propose marriage to a woman a matter of months after the death of her husband, who had been Ben's friend.

It was too late now because Callie was headed back east, and he would never see her again. Ben knew that he was going to miss her. He almost wished now as the stage drew near that he had said something to Callie, but he'd always been a mite backward about women.

What he'd needed was a little more time, but he wasn't getting that time now, and for two days he'd been sick about it. He should have spoken to her, but he hadn't, and now the deal had passed out of his hands.

The eastbound rolled down the grade toward Stony Creek, and Ben Carrigan stood up, flipping away his half-smoked cigarette. As he did so, he caught a glimpse of sunlight reflected on the barrel of a rifle up on the rocky plateau north of the creek. Then the curlew sounded again from the willows, and he wished now more than ever that Callie Evans had not decided to return east, at least not on this particular run.

The big Concord rolled across the ford and swung into the yard, muddied creek water dripping from the wheels. Ben had not led the three fresh teams from the corral as was his custom when a stage came into sight, and he noticed that Joe Stanhope, the driver, a short, blocky man with red hair, looked at him curiously as he set his brake.

"Them grays goin' with me," Joe grinned, "or you keepin' 'em fer ridin' *into Sherman, Ben?"*

"How many passengers you got inside?" Ben asked.

Joe looked at Bud McNeil on the box beside him, and he said, "Just the Evans woman goin' back to Indiana."

"We'll get her into the hut quick," Ben said briefly. "Renegade Apaches been waitin' for your stage past hour or so."

He heard the hammer on McNeil's shotgun click softly, and then McNeil stepped down from the box without any particular haste, a big fellow with a blond mustache and very pale blue eyes.

"Where, Ben?" he asked casually.

"Some of 'em in the willows down along the creek," Ben said, "an' the rest up on that plateau behind you, Bud."

"Same bunch jumped the Flat Rock station?" Joe Stanhope asked.

"Reckon so," Ben nodded. "Six of 'em, I hear. There's three of us."

"They're in rifle range," Joe pointed out. "Ain't we takin' a chance, Ben?"

"Injuns can't shoot," Bud McNeil told him, "an' it's a long shot from the willows an' the plateau."

"I figure they'll move up closer," Ben said, "after I get the hosses out o' the traces an' then rush us." He got the three teams out of the traces, and then the door of the stage opened, and Callie Evans appeared. Callie had brown hair, and she was not a beautiful woman. She had brown eyes and a rather wide mouth, and there were freckles around her nose.

Callie smiled and said, "You going to say good-by to me, Ben?"

"Soon as we chase off a bunch of Apaches been waitin' for this outfit," Ben nodded, and he gave her his arm down to the ground, noticing that her face paled slightly.

"You want me to stay in the hut?" she asked.

"Walk easy," Ben told her. "This bunch don't know we're on to 'em."

"I can shoot a gun," Callie said. "Jud taught me."

"Rifle just inside the door," Ben nodded. Then he said again, "Walk easy."

He went back to the stage as Callie moved toward the hut. Joe said as he came up, "Your show, Ben."

McNeil nodded and looked at Ben expectantly.

"Might be smart," Ben observed, "if we edged up closer toward the hut. Figure they'll start their rush any minute now."

He had been facing the willows downcreek as he spoke, and then he saw at least a dozen Indians break out of the willows and scatter and come toward the hut at a sharp rush, making no sounds as they came on, a body of short, compactly built, mahogany-skinned men, the only thing distinguishing them from white men being the varicolored bandannas they wore around their long black hair. They wore shirts and pants, and every man carried a rifle.

"Run!" Ben shouted, and even as he turned and sprinted toward the hut he saw four more Apaches jump up on the plateau and sprint toward them.

They were less than half a dozen strides from the hut door, but before they could make it several rifles cracked and Ben heard Bud McNeil gasp and stumble. The shotgun rider would have gone down if Ben hadn't caught his arm and half dragged him into the hut.

The Apaches were screeching like wild animals now as they came on, and more bullets caromed off the stone hut as the three men stumbled inside.

Ben let McNeil slide to the floor and then he slammed the door shut, sliding the bolt across it, and he leaped to the window, noticing as he did so that Callie Evans was kneeling there, poking the barrel of the rifle around the wooden shutter.

Standing to one side of the window, Ben fired his pistol at one of the oncoming Apaches, now less than forty yards from the hut. Callie's rifle cracked at the same time, and one of the Apaches was knocked from his feet, rolling as he fell, and then dragging himself behind a rock like a stricken lizard.

Joe Stanhope was at the other window on the far side of the little room, and the Apaches quickly scattered, finding cover miraculously, as Joe opened with his gun.

Stepping across to Callie's side of the window, Ben took the rifle from her hand and said quietly, "Better have a look at McNeil. He's been hit."

Callie moved away from him, and Ben crouched at the window, waiting for an Apache to reveal himself. Joe Stanhope called, "More'n six out there, Ben."

Ben was sure that there were at least sixteen Apaches in the group which had attacked them. "Must have been another bunch joined up with that crowd at the Flat Rock Station," he observed.

"Cavalry should be on the heels o' this bunch," Stanhope scowled, "but likely they ain't."

"How's McNeil?" Ben called back.

"He has a bullet through his shoulder," Callie told him, "and he's losing blood."

"Find a towel or something around here," Ben said, and then he caught a glimpse of an Apache with a red bandanna streaking across the ground from one rock to another. He fired, and the Apache stumbled and fell, and then picked himself up and lurched behind a rock which only partially concealed him.

Joe Stanhope's rifle banged, and the Apache rolled out into the open and lay on his stomach, face in the dust.

"One fer sure," the stage driver said.

"Plenty more out there," Ben murmured, and he didn't like the thought of it. The Apaches had seen Callie getting out of the stage, and they were probably reasonably sure that the cavalry were not in the vicinity, or they would not have attacked the station to begin with.

"Ain't so good," Stanhope said. "You see where Bud dropped that shotgun?"

Ben saw it lying on the ground about ten feet away from the door.

"We could use that gun," Stanhope murmured, "especially if they come in close. Injuns ain't never had much to do with shotguns. Man could blow 'em to hell if they ever come in close enough, an' they was bunched."

Ben frowned at the gun lying on the ground so near and yet so far. With at least fifteen rifles trained on the door of the hut, a man would be dead the moment he opened the door. The Apaches were in close now, most of them probably within fifty yards of the hut, getting ready to rush *it. It was sheer suicide to attempt to retrieve the shotgun.*

Bud McNeil said in a weak voice, "Should o' brought that gun in, boys. No chance o' gettin' her?"

"Not much," Ben told him.

"Man should never lose his gun," McNeil muttered.

"You notice they ain't throwin' lead around," Stanhope observed. "Reckon they ain't got much to begin with, an' when they come they'll come quick, all at once." He paused and then added, "Sure wish we had that shotgun in here, Ben. One dose an' they might have their bellies full."

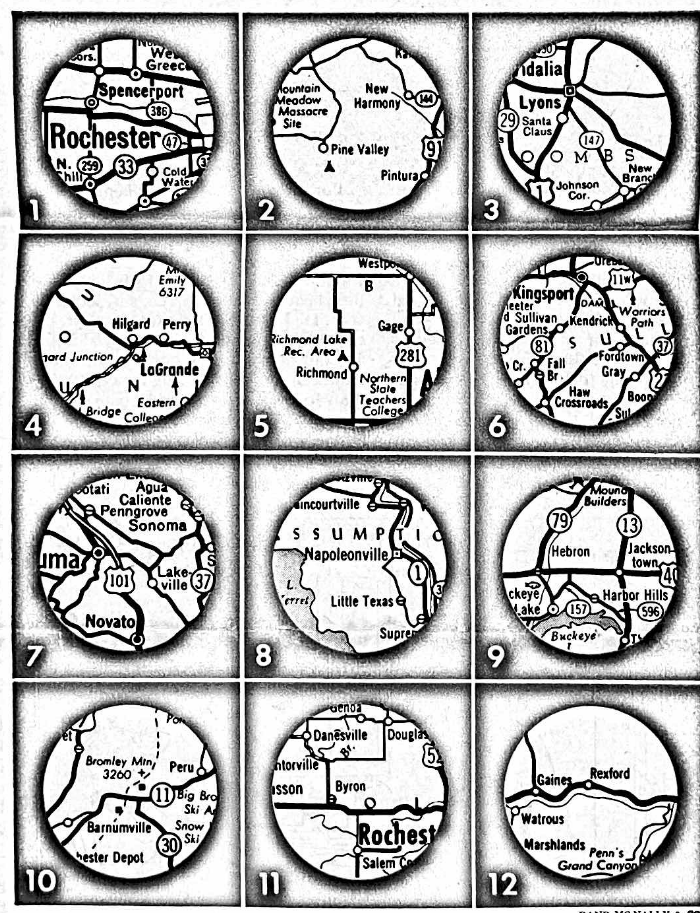
"Reckon I could crawl out," McNeil said from the floor. "Reckon I ain't much good anyway, as I am, an' I kin crawl."

"Stay where you are," Ben told him.

He measured the distance carefully between the door and the shotgun. It was possible to make it in two big strides, and then dive back in through the open doorway. There was a chance, just a chance, that a man could get back with the gun. He might not come back all in one piece, and he might not be alive to use the gun once it was inside the hut, but they would have it, a deadly, double-barreled shotgun which could enfilade the entire front yard of the station. Unsuspecting Apaches charging across that yard, and anticipating rifle fire only, would be in for quite a surprise. Ben Carrigan knew definitely, though, that they would not bunch at all. The Apaches were not sheep; they were tigers, sleek and cruel and deadly, and there was a white woman in the hut.

Now they could hear the Apaches talking, calling across to one another from their concealed positions behind rocks and hillocks.

"Lot of palaverin' goin' on," Stanhope said. "Reckon they figure they got to make a play of some kind if they want to git in here. Wasn't fer Mrs. Evans here, they might not (Continued on Page 96)



RAND McNALLY & CO.

Where Do You Think You Are?

East or West, North or South, each of the distinctive areas above appears on the road map of a single state. There is, as the saying goes, "no place like it." Can you identify the states? **Harley P. Cook**

(*Answers on Page 96*)

3/1/65

350,000 TONS OF SMOG A DAY— AND THE FIGHT AGAINST IT

Even the air you breathe is becoming a government concern —and an expense to you.

Cities and States are passing new laws to clean up air. President Johnson pushes a national plan. Poisoned air is seen as a serious, growing menace.

Describing the air that Americans now breathe, President Lyndon Johnson in a recent message to Congress made these points:

• Entire regions and river basins, not just a few big cities, are bathed in air that is "heavy with noxious materials."

• Every day, almost 50,000 tons of "unpleasant, and sometimes poisonous, sulphur dioxide" are added to the atmosphere of the U. S.—plus almost 300,000 tons of other pollutants from automobiles and trucks.

• Serious illnesses and some deaths were produced by sharp increases in air pollution in Donora, Pa., in 1948 and New York City in 1953. The chance of such "killer smogs" is increasing.

• In New Orleans, "epidemic outbreaks of asthmatic attacks are associated with air pollutants. Three fourths of the 8 million people in the Los Angeles area are annoyed by severe eye irritation much of the year."

• Federal health authorities are increasingly concerned with "the damaging effects of the continual breathing of polluted air by all our people in every city in the country."

"In addition to its health effects," said the President, "air pollution creates filth and gloom and depreciates property values of entire neighborhoods. The White House itself is being dirtied with soot from polluted air."

President Johnson then pointed out that he is asking for 24 million dollars to finance federal anti-air-pollution programs in the year starting July 1.

The President also seeks an amendment to the 1963 Clean Air Act to let federal officials investigate potential air-pollution problems, instead of having to wait until damage occurs.

Other signs of times. There are other signs of a developing campaign to do something about smog. For instance:

• A crankcase device to reduce impurities in auto exhausts has added about $7 to the cost of most new automobiles produced in the U. S. since 1963. This change was brought about largely through U. S. Government pressure.

• A more elaborate antismog system, costing around $25, will be required starting with 1966 models on every new car sold in California. In Washington, Congress is considering a bill compelling the auto industry to install this system on all new cars. All 1966 cars bought for federal use will be so equipped.

• Used cars are to be the next targets. California's law requires antismog devices on all used cars as soon as devices meeting State requirements can be developed. The probable cost to 3 million owners of older cars in the State: Around 60 million dollars. The prospect is that federal action will follow State action in this field, too.

• U. S. Secretary of Health, Education and Welfare Anthony J. Celebrezze has moved, on his own, to investigate the effects on Staten Island, N. Y., of industrial pollution generated in New Jersey. The Secretary was given jurisdiction in such cases by the 1963 Clean Air Act. So far, he has authorized consultations and studies only, but, if no informal solution is found, the U. S. can take court action to require an end to the pollution.

• Legal battles among the States over dirty air may come next. Polluted air and dust can be carried for long distances by the wind, then dumped. Detroit must contend not only with its own smog, but with clouds of pollution drifting from Chicago, South Bend and as far away as Salt Lake City.

"Like a dirty snowball." Northeastern States are particularly vulnerable to smog from other parts because the prevailing winds across North America are from west to east. Here is how New York City's Mayor Robert F. Wagner describes the situation: "Our region is the terminus of a 3,000-mile-long sewer of atmospheric filth starting as far away as California and growing like a dirty snowball along the way."

The day may be coming when States a continent apart will send envoys to Washington for settlement of disputes about dirty air.

Thirty-three States and about 100 cities have enacted air-pollution laws, some of them stringent. New York has a 15-year program to impose standards of air purity in every county. Colorado, once renowned for its pure air, is working on a similar plan. Los Angeles County has forced its industry to switch, where possible, from fuel oil to natural gas—more expensive, but cleaner.

New York City alone is spending about a million dollars a year to combat air pollution. A sampling system throughout the city tests for poisons in the air. In the last few years, the monthly deposit of soot on the city has been reduced from 70 tons to 60 tons per square mile. Even today, fashionable apartment buildings on the East Side are said to be "belching poisonous black smoke just as if they were a fleet of old-fashioned steamboats."

Businessmen are finding that clean air costs money. A single steel mill in Cleveland spent 2.5 million dollars on a precipitator to combat pollution. In rural Pennsylvania, the money spent for air-cleaning equipment at one power plant amounted to more than $3,000 for every man, woman and child in the township.

In Los Angeles, a stiff county code required the owner of a meat smokehouse that cost $18,000 to spend $42,000 for equipment to clean up the emission from his smokestacks.

Those are extreme cases. A million-dollar facility may be able to get by the same Los Angeles code with $10,000 worth of air-cleaning equipment, depending on the type of operation. But one manufacturer of air-cleaning equipment warns: "As antipollution regulations tighten, control equipment is going to become more and more expensive."

Tax angles. Some States offer tax relief to industries which must make heavy investments in air-cleaning equipment. Wisconsin allows a tax write-off. Idaho and Massachusetts offer property-tax deductions for equipment used solely to reduce air pollution. One Midwestern community offers a sliding scale of taxes, with reduced taxes for industries producing minimal air contamination.

Some businessmen are urging direct subsidies from government to help pay for air-cleaning equipment which government requires to be installed.

Homeowners, too, face more regulations—and more expenses. Montgomery County, Md., just outside of Washington, D. C., is considering a ban on burning of leaves and trash in suburban areas. In New York City, 3 million customers of Consolidated Edison Company were warned last November they eventually would be faced with slightly higher electric bills as a result of the city's antipollution regulations which will require the company to use a more refined fuel oil. Similar things are happening in other cities and suburban areas across the land.

Behind all the ferment is a growing feeling that the air over the U. S. is becoming too dirty for people to live with, and a financial hazard too.

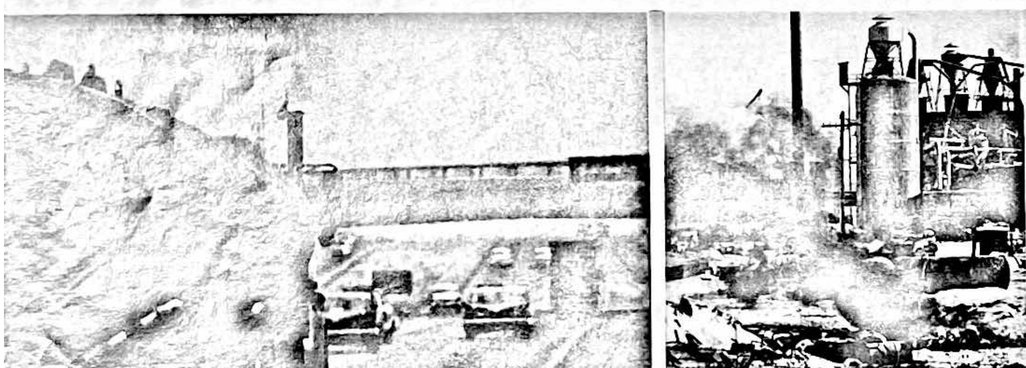
What foul air can do. Chemicals pouring into the air, offensive to begin with, become more toxic when acted upon by water and sunlight in the atmosphere. When weather is calm, with little air movement, the toxic mixture is trapped near the ground where it can affect people, animals and objects.

Dirty air is believed to aggravate a number of human illnesses ranging from asthma and lung cancer to the common cold. It also poses the danger of "killer smogs," such as those at Donora and New York City.

Polluted air has been known to kill vegetable crops in 27 States from California to New Jersey. It has stunted tobacco in Maryland and deformed livestock in Florida. It can crack paint, corrode metal, eat holes in rubber, erode buildings and monuments, cause "runners" in women's stockings.

As more and more people crowd into U. S. cities with more cars, more furnaces, more incinerators, the air gets more clogged, the damage and discomfort more noticeable.

Now, it seems, something is being done about it. The air no longer is to be "free." But it may be a little cleaner as the result of growing efforts and expense in the war against smog.



"Filth and gloom" across nation—exhaust fumes and industrial smoke imperil health in urban areas

Photos: USN&WR, Black Star

5 MAJOR CITIES WHERE SMOG IS A GROWING PROBLEM

*Per cent of days in a year when smog is bad enough to produce odor, eye irritation, plant damage or reduced visibility**

Los Angeles	**34.3 per cent, or 1 day in 3**
Chicago	**15.7 per cent, or 1 day in 6**
Washington, D. C.	**11.5 per cent, or 1 day in 9**
St. Louis	**8.6 per cent, or 1 day in 12**
Philadelphia	**8.2 per cent, or 1 day in 13**

Many other cities where the air is not currently tested by the Federal Government are plagued with smelly, hazy, eye-irritating smog from time to time.

*Based on air tests by the U. S. Public Health Service, January-June, 1964. "Smog," as defined by the Public Health Service, is a specific kind of air pollution produced in the atmosphere by the action of sunlight on gases which come chiefly from motor-vehicle exhausts.

Car Smog Devices Reducing Air Pollution By Approximately 50%, Club Tests Show

BY LOUIS J. BINTZ
Automotive Engineer

CAR SMOG control devices are reducing air pollution from automobiles by approximately 50%, a year-long test involving more than 1,000 1966 vehicles at the Auto Club's Los Angeles headquarters has disclosed.

Despite apparently conflicting reports, this is a giant step forward in the fight against air pollution. Further, there are important fringe benefits for the motoring public.

It was in November, 1965, that the Auto Club, in cooperation with state and federal agencies, embarked on a program of testing the smog emissions (see *Auto Club News Pictorial* for April, 1966). To obtain a representative sample of cars being driven by the public, a program was set up wherein Club members' cars are tested for air pollution emissions at the same time their speedometers are calibrated. During the past year, the information gleaned from the more than 1,000 cars tested has been given the auto industry, and state and federal agencies.

Tests to date have been performed on cars which have been driven about 15,000 miles. It is too early, therefore, to foresee how well they will be operating after 50,000 or 100,000 miles.

Cars are equipped with either one or the other of two basic exhaust emission devices—one used by Chrysler and the other by General Motors, Ford and American Motors.

To properly understand how well these devices are working, it is helpful to review how California's smog emission control standards came into being.

Shortly after World War II, Los Angeles discovered it had a smog problem. After much scientific investigation, the conclusion was reached that smog is caused primarily by unburned gasoline and oxides of nitrogen. Prime sources: stationary facilities such as power plants and refineries and moving sources such as the automobile.

Under the leadership of the Air Pollution Control District of Los Angeles County, the stationary sources have been controlled to a very large extent.

To attack the problem of air pollution from moving sources, the Motor Vehicle Pollution Control Board, directly responsible to the Governor, was established.

One of the Board's first responsibilities was to set standards that the automobile must meet in controlling its smog emissions.

In cooperation with the California Public Health Service and the auto industry, tests were conducted to determine how much air pollution cars were emitting. Next step was to decide how much of this had to be eliminated for the well-being of all of us.

Since investigation found the air pollution level in the Los Angeles Basin in 1940 was satisfactory, that year became the basis for comparison. By comparing the vehicle population of 1940 to that which might be expected in ensuing years, it was decided that approximately an 80% reduction in auto emission would give us air quality equivalent to 1940.

Tests showed that approximately 14 parts out of every 10,000 parts of exhaust emission were unburned fuel—a major smog villain. An 80% reduction would leave a permissible 2.75 parts per 10,000—or, as the standard is expressed, 275 out of every 1,000,000.

Shortly thereafter, the Board decided that carbon monoxide, which is a deadly poison when concentrated, should also be controlled. The standard set after conferring with the public health agencies was that no more than 1.5% of the exhaust emissions could be carbon monoxide.

We now have, therefore, the standards of 275 parts per 1,000,000 of unburned fuel and 1.5% carbon monoxide.

About 1959, the auto industry discovered that automotive emission came not only from the exhaust but also from the crankcase.

Crankcase emissions, which amounted to about 20% of the total auto smog output, were caused by combustion gases forcing themselves past the rings into the oil pan area. From here they escaped into the atmosphere via the oil filler tube. The auto industry soon developed a simple system to eliminate these gases and it has been installed on all new cars since 1962.

The control of exhaust emissions didn't get well under way until 1964 when the MVPCB approved four so-called "tack on" devices which would have replaced the muffler. The auto industry did not like this solution to the problem, however, and moved to develop systems of its own. The Chrysler approach was to burn the gasoline more efficiently thereby reducing air pollution. This was accomplished by a redesign of engine components.

General Motors, Ford and American took the position that there must be an additional system to convert the unburned fuel after it leaves the engine to harmless products. Their process involves, among other things, the addition of a pump that by injecting air into the exhaust manifold burns the gasoline left in the exhaust gases.

The MVPCB has tested these two basic smog control systems and has certified that they meet California's standards. So both systems are found on 1966 and 1967 automobiles.

Are these systems reducing air pollution? The answer is yes. The California law requires that the average emissions of all cars equipped with these systems meet a given standard. Our tests at the Automobile Club have indicated that this *average* is under the 275 parts per million standard set by the State of California. What this means to the California driver is that his car does not necessarily have to meet the standard. Without some ready means of testing every car on the road, and a logical tune-up procedure that has proven that it will reduce air pollution, the method of averaging all cars together is the only approach that can be taken.

As a result of California's pioneering efforts in this field, and the cooperation of the driving public, automotive engineers throughout the world are redesigning engines not only to reduce air pollution but to improve fuel economy and drivability.

The air pollution systems we see on cars today are merely the forerunners of newer and better systems—systems that will not only clean the air but, by their very nature, will give your engine longer life, increase gasoline mileage and increase your driving pleasure.

FORTY CENTS

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THE WEEKLY NEWSMAGAZINE

THE POLLUTED AIR

LARRY LEE—PI

VOL. 89 NO. 4

(REG. U.S. PAT. OFF.)

ECOLOGY

Menace in the Skies

(See Cover)

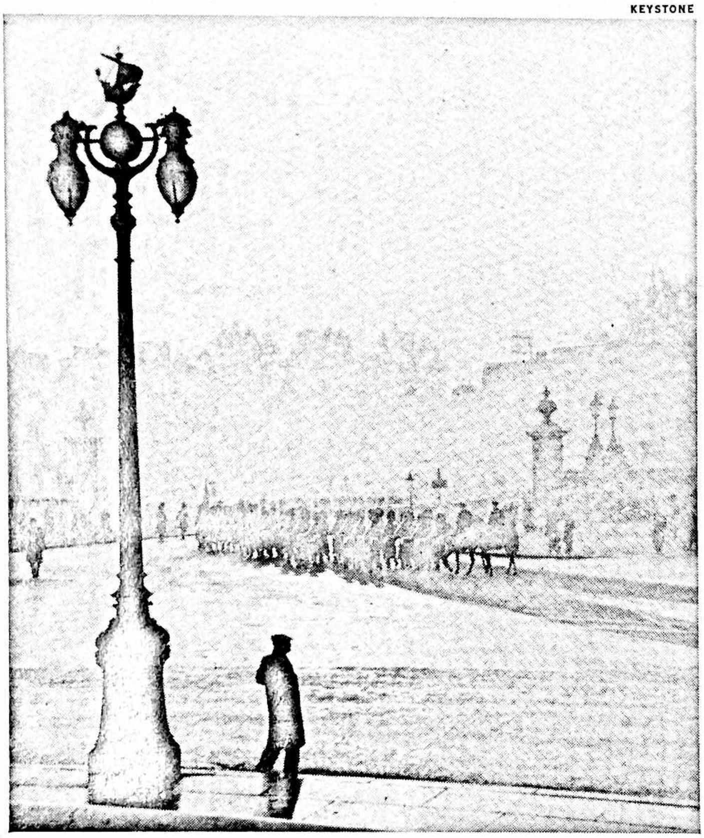
On the morning of Oct. 26, 1948, at Donora, Pa., the skies delivered a deadly warning that man had poisoned them beyond endurance.

As workers trudged to their jobs, a heavy fog blanketed the bleak and grimy town. It hung suspended in the stagnant air while local businesses—steel mills, a wire factory, zinc and coke plants—continued to spew waste gases, zinc fumes, coal smoke and fly ash into the lowering darkness. The atmosphere thickened. Grime began to fall out of the smog, covering homes, sidewalks and streets with a black coating in which pedestrians and automobiles left distinct footprints and tire tracks. Within 48 hours, visibility had become so bad that residents had difficulty finding their way home.

Donora's doctors were soon besieged by coughing, wheezing patients complaining of shortness of breath, running noses, smarting eyes, sore throats and nausea. During the next four days, before a heavy rain washed away the menacing shroud, 5,910 of the town's 14,000 residents became ill. Twenty persons—and an assortment of dogs, cats and canaries—died.

Investigating the tragedy, meteorologists concluded that it had been triggered by a temperature inversion, an atmospheric phenomenon that prevents normal circulation of air. Ordinarily, warm air rises from the earth into the colder regions above, carrying much of man's pollution with it. Occasionally, a layer of warmer air forms above cooler air near the ground; the inversion acts as a lid, preventing the pollutants at lower altitudes from rising and dispersing. Inversions are no novelty, but what happened at Donora shocked public-health officials into an awareness that such layers pose a deadly threat to an increasingly industrialized and pollutant-producing society.

KEYSTONE



CHANGING OF THE GUARD AT BUCKINGHAM PALACE DURING 1952 SMOG

Abrade, corrode, tarnish, soil, erode, crack, weaken and kill.

Sulky Sun. On Dec. 5, 1952, a thick fog began to roll over London. Hardly anyone paid any attention at first in a city long used to "pea-soupers." But this fog was pinned down by a temperature inversion, and was steadily thickened by the soot and smoke of the coal-burning city. Within three days, the air was so black that Londoners could see no more than a yard ahead. Drivers were forced to leave cars and buses to peer closely at street signs to find out where they were. Policemen strapped on respiratory masks. The Manchester Guardian reported that London's midday sun "hung sulkily in the dirty sky with no more radiance than an unlit Chinese lantern."

Hospitals were soon filled with patients suffering from acute respiratory diseases; deaths in the city mounted. The British Committee on Air Pollution finally estimated that during the five days that the smog smothered London, there were 4,000 more deaths than would have occurred under normal circumstances. During the next two months, there were another 8,000 excess deaths—most of them apparently caused by respiratory disease—that scientists suspected were a direct result of the killer smog.

Extreme air pollution again darkened London in 1956, killing 1,000, and in 1962, claiming more than 300 lives. In 1953, a ten-day temperature inversion over New York City trapped so much air pollution that 200 excess deaths were attributed to the smog by Dr. Leonard Greenburg, then New York's commissioner of air pollution. Another New York smog in 1963 killed more than 400, and there were 80 excess deaths recorded in New York during a four-day siege over the last Thanksgiving Day weekend. Scientists suspect that thousands of deaths each year in cities all over the world can be linked to air pollution. Says U.S. Assistant Surgeon General Dr. Richard Prindle: "It's already happening. Deaths are occurring now. We already have episodes in which pollution kills people. And as we build up, we're going to have an increasing frequency of episodes."

"Take a Deep Breath." Such warnings, added to the widely publicized New York and Los Angeles air-pollution alerts and open bickering between politicians and industry over pollution controls, have made the U.S. suddenly aware that smog is a real and present danger. The belching smokestacks that long symbolized prosperity have now become a source of irritation; the foul air that had come to be accepted as an inevitable part of city living has suddenly become intolerable. "Tomorrow morning when you get up," reads a recent magazine ad placed by New York's Citizens for Clean Air, Inc., "take a nice deep breath. It'll make you feel rotten." Indeed, as the adjoining color pages show, the U.S. city dweller had only to look at his skyline last week to see the startling and ominous inroads that smog has made.

Air pollution has become a worldwide preoccupation. Some 230 miles southwest of Tokyo, for example, school yards in the port city of Yokkaichi are filled with children running and playing games. But their shouts and laughter are muffled by yellow masks impregnated with chemicals to protect them against air polluted by nearby petrochemical plants. In Tokyo, where smog warnings were issued on 154 days last year, policemen in ten heavily polluted districts return to the station house to breathe pure oxygen after each half-hour stint on traffic duty in order to counteract the effects of

DON CARL STEFFEN

WASHINGTON, D.C.

Only five miles from the White House, a holocaust of smoke and grime is sent up by open-air burning at Kenilworth garbage dump, operated by the District of Columbia on land owned by the National Park Service. Stacks in back belong to a Potomac Electric Power Co. generating plant.

NEW YORK

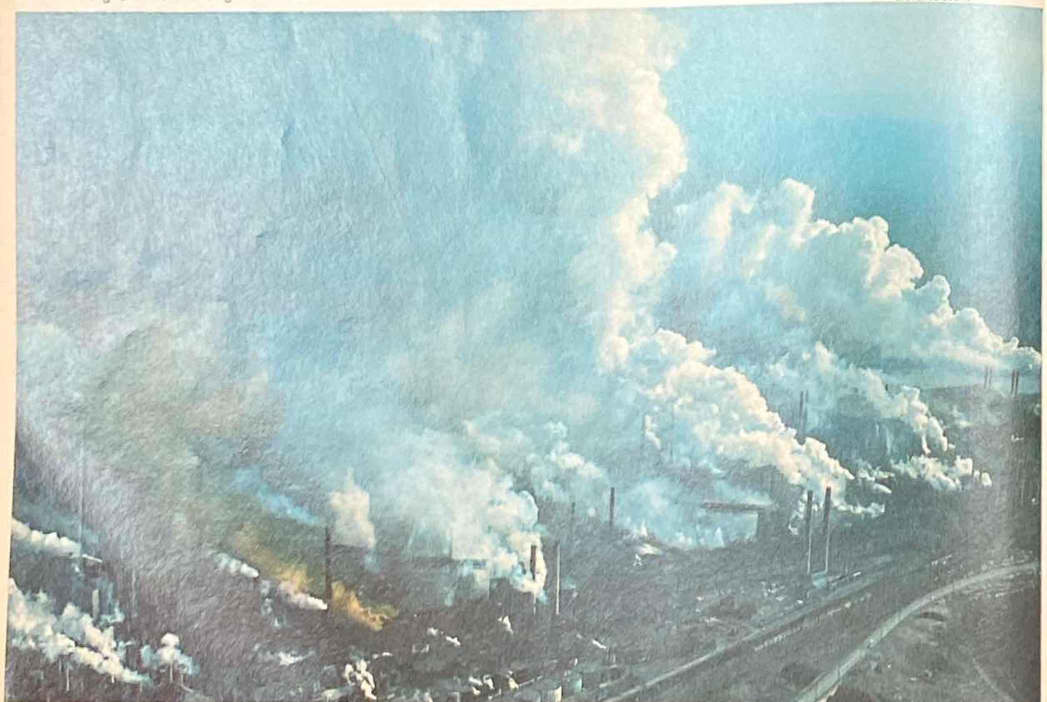
Manhattan at sunset, seen from Riker's Island in East River, seems wrapped in a fiery fog. At right are stacks of Con Edison Company's Ravenswood plant, which manufactures power for all parts of city. To left, company's Waterside plant. In the center, the U.N. Building.

J. ALEX LANGLEY

PITTSBURGH

Though it is credited with a good cleanup record, Allegheny County still has formidable problems, as shown in this morning view of U.S. Steel's Clairton Works, looking east to Monongahela River.

LAURENCE LOWRY



BALTIMORE

Pungent clouds of smoke climb skyward at noon from just one of hundreds of industrial plants in the area near Patapsco River.

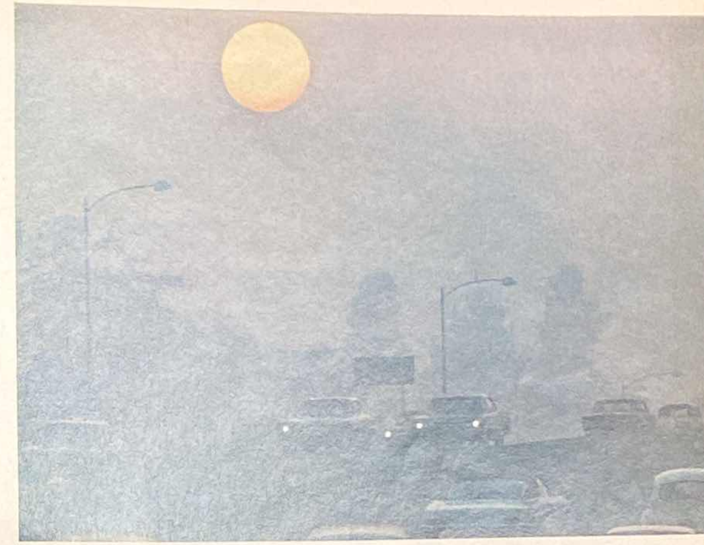
WALTER BENNETT

BERT BRANDT

ODESSA, TEXAS

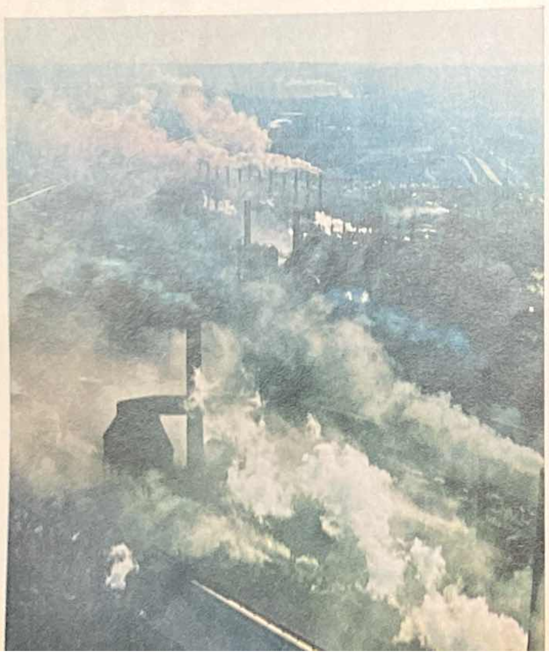
Fat, black billows hover over plant of Sid Richardson Carbon Co., which runs seven days a week. Though factory is located ten miles west of Odessa, part of the dense smoke still drifts into city.

JIM COLLISON



LOS ANGELES

Riding along Wilshire Boulevard at 4:30 p.m., with the sun looking more like the moon, drivers need headlights in order to pick their way through the midafternoon smudge.



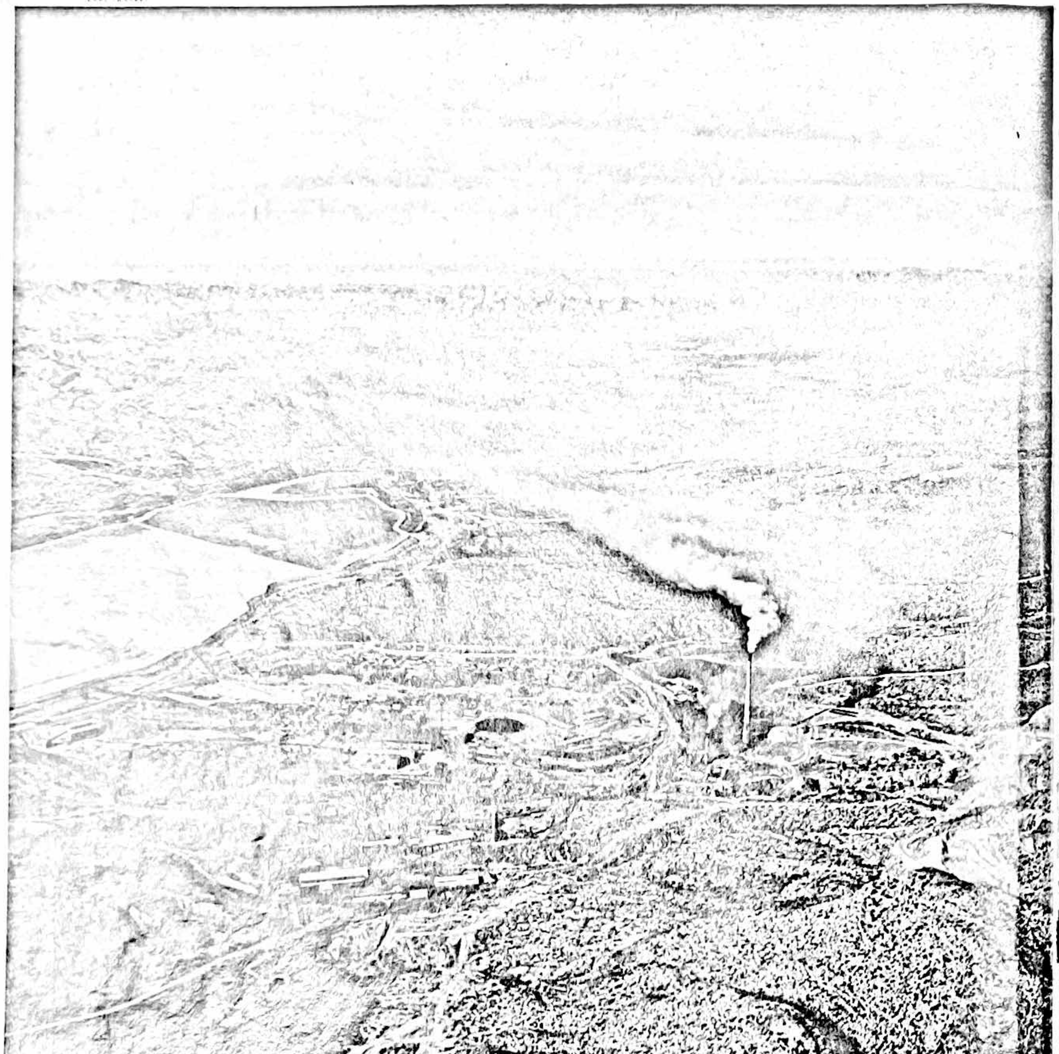
BIRMINGHAM

The South's biggest steel producer, Birmingham pays a price in pollution for its distinction. This picture was taken on Sunday afternoon, when plant exhausts are one-third less than usual.

HOUSTON

Its sides lined with 125 plants—paper, fertilizers, chemicals, cement—Houston Ship Channel, shown here at midmorning, is a prime source of both wealth and grime for Southwest's richest city. →

BERT BRANDT



HAYDEN, ARIZ.

Not even the widest-open spaces of the U.S. West are left untouched. At 10:30 a.m. in the foothills of the Pinal Mountains, inversion layers of sulphur-dioxide fumes unfurl from smelters operated by Kennecott Copper. Winds will push much of this large trail of smoke across the desert to Phoenix, 80 miles to the northwest.

breathing excessive amounts of carbon monoxide.

"Sitting on the hill of Lycabettus, overlooking the valley of Athens," writes Greek City Planner Constantinos A. Doxiadis, "I can see early Monday morning the first dark clouds building in the lower part of the valley, where the industries are. It grows, it covers the middle and lower parts of the city. Gradually it reaches the eastern part, and by expanding in height it covers the rock of the Acropolis and the Parthenon. By then everybody in the city of Athens has had to breathe the polluted air."

Authorities in the German state of North Rhine-Westphalia are so concerned about the dangers of smog in 15 Ruhr districts that they have posted warning signs that will bar traffic from roads in the event that air pollution becomes extreme. And out in space last September, after other astronauts had repeatedly failed to photograph Houston because of the dense brown disk of smog that usually hangs above it, Gemini 11 Command Pilot Pete Conrad finally shot a picture of the city on one of its better days. Discussing the photograph after his return to earth, Conrad pointed to the reduced but ever present pall over the city. "Notice the air pollution drifting out there," he said, "in case anybody thinks we don't have it."

Smog disintegrates nylon stockings in Chicago and Los Angeles, eats away historic stone statues and buildings in Venice and Cologne. Rapidly industrializing Denver, which for many years boasted of its crystalline air, is now often smogbound. In Whiting, Ind., a concentration of fog and pollution from an oil refinery produced a chemical mist that one night last year stripped paint from houses, turned others rusty orange, and left streets and sidewalks covered with a greenish film.

Pollution's First Victim. Air pollution, commonly thought to be a result of the industrial revolution, actually preceded man himself. Nature has long contaminated the air with sand and dust storms, with forest fires and volcanic eruptions that spew tons of particles and gases into the atmosphere. When Krakatoa, a volcano in the East Indies, blew up in 1883, the debris and dust it hurled into the air spread around the globe, darkening daytime skies for hundreds of miles. Krakatoa dust, suspended in the atmosphere, produced spectacularly ruddy sunsets and sunrises the world over for months after the blast.

Nature even produces its equivalent of smog. Over large fir forests, there is a continuous bluish haze produced by terpenes—volatile hydrocarbons that are emitted by the trees. Decaying animal and vegetable matter give off gases. Flowers saturate the nearby air with pollen that causes such allergic reactions as hay fever in man. It was natural air pollution rather than the man-made kind that claimed the man who is probably the first recorded human victim: Pliny the Elder died in 79 A.D. after breathing in an overdose of sulphur oxides emanating from erupting Vesuvius.

Once man mastered fire, however, he was superbly equipped to surpass nature's contribution to air pollution. The burning process—combustion—powers most transportation in the U.S., plays a vital role in its manufacturing, generates electric power, heats homes and buildings, and consumes much of its refuse. But this year it will also pour 140 million tons of pollutants into the air. And as population, industrial production, number of automobiles, and other indices of U.S. prosperity increase, the upward flow of contaminants will increase correspondingly.

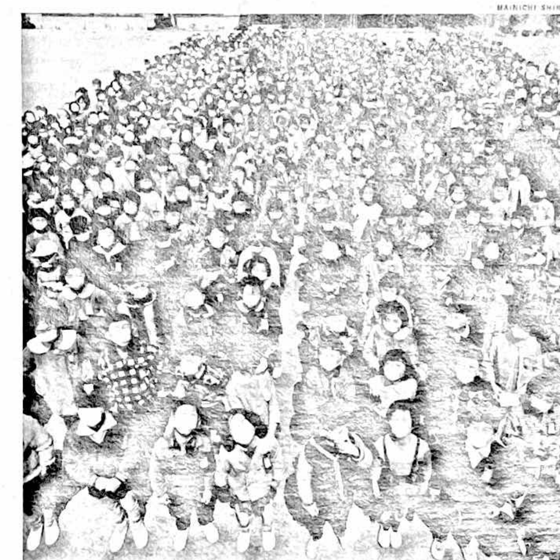
Colorless Contamination. The most obvious component of polluted air is the smoke that pours from millions of home chimneys, power-plant and factory smokestacks, incinerators and garbage dumps. It consists of tiny pieces of carbon, ash, oil, grease, and microscopic particles of metal and metal oxides. Some of these particles are so large that they settle rapidly to earth, but many are small enough to remain suspended in the atmosphere until they are removed by rain or wind. Though the particulates, as they are called, are highly visible and often the first target of antipollution officials, they constitute only about 10% of the pollution in the air over the U.S.

Cities such as Pittsburgh and St. Louis, which after World War II enforced vigorous and successful campaigns to clear smoke from their skies, have now discovered that their drives against pollution have only just begun. A full 90% of U.S. air pollution consists of largely invisible but potentially deadly gases. More than half of the contamination in the air over the U.S., for example, consists of colorless, odorless carbon monoxide, most of it issuing from the exhaust pipes of automobiles, trucks and buses.

The second most plentiful gas pollutant is composed of oxides of sulphur, produced by home, power-plant and factory combustion of coal and oil containing large percentages of sulphur. More than a tenth of air pollution consists of hydrocarbons, most of them emanating as unburned or only partially burned gaseous compounds from automobile fuel systems. Combustion also produces large quantities of carbon dioxide, nitrogen oxides and other gases.

As if these products of combustion were not unpleasant or dangerous enough by themselves, some also undergo complicated chemical changes in the atmosphere that make them even less attractive. In the presence of sunlight, the hydrocarbons and nitrogen oxides emitted largely by automobile exhausts react to produce the sort of brownish and irritating photochemical smog that blankets Los Angeles for most of the year. "Los Angeles smog" is a highly complex soup containing, among other

MAINICHI SHIMBUN



JAPANESE SCHOOLCHILDREN WEARING RESPIRATORY MASKS
What symbolized prosperity is now a source of irritation.

things, nitrogen dioxide, hydrocarbons, ozone (a highly active and poisonous form of oxygen) and peroxyacyl nitrate (commonly called PAN). "London smog," on the other hand, usually contains high quantities of sulphur oxides that react with moisture to produce a dilute but corrosive sulphuric-acid mist.

Though air conditioners can effectively filter pollutant particles out of the air, the troublesome gaseous contaminants pass through unhindered. Thus city dwellers who feel that they have found sanctuary from the smog in sealed and air conditioned offices and apartments are actually in an atmosphere that may be little better than the foul air of the streets.

$600 for Cleaning. The unwholesome mess that U.S. citizens and corporations spew into that great sewer in the sky costs them dearly—$11 billion a year in property damage alone, according to the Department of Health, Education and Welfare. Air pollutants abrade, corrode, tarnish, soil, erode, crack, weaken and discolor materials of all varieties. Steel corrodes from two to four times as fast in urban and industrial regions as in rural areas, where much less sulphur-bearing coal and oil are burned. The erosion of some stone statuary and buildings is also greatly speeded by high concentrations of sulphur oxides.

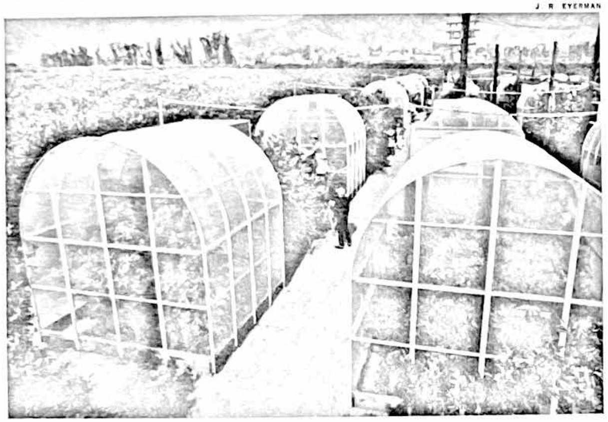
Heavy fallout of pollution particles in metropolitan areas deposits layers of grime on automobiles, clothing, buildings and windows; it adds about $600 per year in washing, cleaning, repairing and repainting bills to the budget of a family with two or three children in New York City, according to a study made by Irving Michelson, a consultant in environmental health and safety. Because of fly ash and soot from smokestacks, the main façade of Manhattan's New York Hilton was so badly discolored that it had to be replaced last year, only 3½ years after the hotel was completed. Ozone, a principal component of photochemical smog, discolors and disintegrates clothing and causes rubber to become brittle and crack.

Vegetation, too, suffers from polluted air—even in rural areas that until recently were believed to be out of the range of contamination. Sulphur dioxide causes leaves to dry out and bleach to a light tan or ivory color, kills the tips of grasses and of pine and fir-tree needles.

Scientists are certain that the ozone and PAN in Los Angeles smogs have caused the serious decline in the citrus and salad crops in the area. In one of the many smog experiments they are conducting, they have planted lemon trees in small greenhouses in a grove near Upland. Pure, filtered air is pumped into some of the greenhouses, air containing measured amounts of pollutants into others. When the fruit is finally picked, the scientists will compare the quality and yield of lemons from trees in different greenhouses, hoping to learn more about how each component of smog affects the crop. Some effects of the smog are indisputable. Such diverse plants as orchids and spinach can no longer be grown in metropolitan Los Angeles.

In semi-rural Florida, east of Tampa, large amounts of fluorides emitted from phosphate plants have rained down on nearby citrus groves, ranches and gladiolus farms. Orange and lemon trees that absorbed the fluorides produced smaller yields, and gladioli turned brown and died. A national air-pollution symposium reported that cattle grazing on grass that was contaminated with the fluorides developed uneven teeth that hindered chewing and joints so swollen that many of the animals could not stand. Fluorides have also etched windowpanes, giving them the frosted appearance of a light bulb.

J. R. EYERMAN



CALIFORNIA LEMON TREES IN SMOG-TEST GREENHOUSES
Trading orchids and spinach for ozone & PAN.

Damage to People. Pollutants that injure plants and erode stone are likely to have a damaging effect on humans too. Motorists who would never contemplate committing suicide by running a hose from their exhaust pipe into the car often unknowingly endanger their lives by exposing themselves to large amounts of carbon monoxide on expressways and in tunnels and garages. Though an hour's exposure to 1,500 parts of monoxide per million parts of air can endanger a man's life, only 120 parts per million for an hour can affect his driving enough to cause an accident. And concentrations of about 100 parts per million have been found in tunnels and garages and on the streets of Chicago, Detroit, New York and London.

Assistant Surgeon General Prindle points out that a heavy cigarette smoker carries a 3% to 4% concentration of carbon monoxide in his bloodstream. Thus it is not surprising, he says, that habitual smokers are the first to turn up at hospitals during periods of extreme air pollution; carbon monoxide concentrations in their bloodstream reach a toxic 25%-30% level before those of nonsmokers.

Chief culprits in the Donora, London and New York smog disasters were probably sulphur dioxide and sulphur trioxide, which, either in gaseous form or converted into sulphuric-acid mist, can irritate the skin, eyes and upper respiratory tract. Extreme exposure, such as might occur in an industrial accident, can do irreparable damage to the lungs—and even attack the enamel on teeth.

Arsenic & Heart Disease. Ozone and PAN produce the eye irritation, coughing and chest soreness experienced by many Los Angeles residents on smoggy days. In laboratory experiments, continuous exposure to ozone shortened the lives of guinea pigs. Scientists have also calculated that a child born in New York City after World War II has now inhaled the pollution equivalent of smoking nine cigarettes per day every day of his life. Like those in cigarettes, some of the hydrocarbons identified in automobile exhausts have produced cancer in laboratory animals.

The particles in pollution are injurious to humans also. Carbon particles that blacken the lungs of residents of London and New York carry gases adsorbed onto their surface. They enable sulphur dioxide, for example, to penetrate deeper into the lungs than it could on its own; without particles to carry it, the gas can be exhaled relatively easily from the upper respiratory tract. Other particulates act as catalysts in the atmosphere, speeding the conversion of sulphur dioxide into more harmful sulphuric acid. Particles of arsenic, beryllium, cadmium, lead, chromium and possibly manganese, discharged into the atmosphere by a variety of man-made processes, may contribute to cancer and heart disease.

Though researchers have not been able to prove a direct cause-and-effect relationship between air pollution and disease, they have found that the incidence of chronic bronchitis among British mailmen who deliver mail in areas with heavy air pollution is three times as high as among mailmen who work in cleaner regions. Researchers also know that there are more deaths from chronic pulmonary disease in high-pollution areas of Buffalo than in other neighborhoods. Boston policemen working around high concentrations of carbon monoxide seem more susceptible to the common cold.

Evolution of Control. Alarmed by ever-murkier skies, increasing property damage, unpleasant odors and more frequent pollution alerts, communities, states and the Federal Government have finally begun to mount a systematic attack on air pollution. They have been able to use as a model the pioneering antipollution program of Los Angeles, which evolved out of sheer necessity. Though the city has frequent temperature inversions and lies in a mountain-rimmed bowl that traps the pollutants, Los Angeles had practically no pollution problem until the 1940s, when it began its explosive growth in population and industry.

Almost overnight, the clear air that had played so important a role in drawing moviemakers to Hollywood was replaced by palls of smoke, a brownish haze and offensive odors that made city life irritating and unpleasant. Concerned Angelenos began to come forward with California-size plans to solve the problem. One suggestion was to bore mammoth tunnels through the surrounding mountains, install huge fans in them and literally suck the smog from the Los Angeles basin into the desert to the east. There was one drawback: operating the fans for a day would require the total annual power output of eight Hoover Dams. A proposal to install giant mirrors to focus the sun's rays, heat the air, and thereby cause it to carry pollution up through the inversion also turned out to be impractical; even if the entire basin were a giant mirror, scientists calculated, not enough heat would be generated to do the job.

Then, backed by aroused citizens, Los Angeles County established a control board and vested it with the authority to control any pollution released into the atmosphere from Los Angeles County, an area of 4,000 sq. mi. Running roughshod over objections from many business leaders, the board established regulations to limit the amount of pollutants released into the air by industry, banned the use of high-pollution fuels and the burning of junked cars and garbage. To further limit pollution, the board even ordered that paint containing volatile, smog-forming chemicals not be sold in containers larger than quart size. It reasoned that such a regulation would discourage large users from purchasing high-pollutant paints.

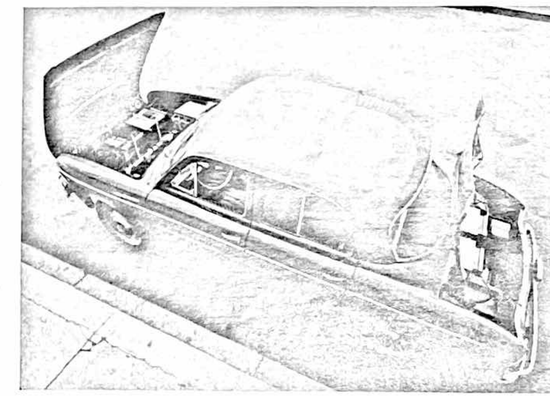
To prove that it meant business, the board brought to court and won conviction of thousands of pollution violators. It was backed to the hilt by Angelenos. In protest against an oil company that was convicted of a pollution offense, 1,500 residents returned their credit cards issued by the firm. On a single day in 1958, the board closed down $58 million worth of incinerators; instead of burning garbage, the county began hauling it as far as 40 miles away to use as land fill. Aided and goaded by the board, Los Angeles oil refineries developed new techniques to reduce sulphur and to trap and recycle malodorous wastes; the refineries became the cleanest and least offensive in the world. Power companies were ordered to use low-sulphur natural gas whenever available, and required to use fuel containing a minimum amount of sulphur the remainder of the time.

Losing Battle. Instead of disappearing, however, Los Angeles' characteristic whisky-brown smog has actually grown worse. The culprits are Los Angeles County's 3.75 million autos, which produce 12,420 of the 13,730 tons of contaminants released into the air over the county every day. (Some of the remainder is contributed by planes; a 4-engine jet expels 88 lbs. of pollutants during each takeoff.) In addition to nearly 10,000 tons* of carbon monoxide, autos exhaust 2,000 tons of hydrocarbons and 530 tons of nitrogen oxides daily, enough to form a substantial brew of irritating smog.

At the urging of the pollution-control board, California decreed that cars sold in the state from 1964 on be equipped with a "blow-by" connection to feed unburned gasoline in the crankcase back into the engine manifold. Another law made it mandatory for all 1966 cars sold in the state to have devices that would reduce carbon monoxide emitted from the tail pipe by 50%, hydrocarbons by 65%. A further reduction in tail-pipe emissions will be required in 1970. Taking its cue from experts, the Federal Government has ordered Detroit to make similar improvements on all of its 1968 cars. But California—and the U.S.—are fighting a losing battle against the autos.

Inspections of California cars that have been driven more than 20,000 miles and are equipped with antipollution devices have shown that as many as 87% fail to meet state requirements for the suppression of hydrocarbons and carbon monoxide; the devices generally become less efficient with age and are improperly maintained. Even if the devices work perfectly, however, they cannot keep pace with the rapid growth of Los Angeles' auto population—which is expected to increase by another 2,000,000 vehicles by 1980. "Even if by then the average motor vehicle is producing only one-half of the pollution of today's average car," says County Air Pollution Control Officer Louis Fuller, "motor-vehicle pollution will be greater than it is now."

Electric Car Research. To solve the dilemma, Fuller believes, legal limitations may have to be placed on the movement of autos into heavily contaminated urban areas. Frank Stead, a top official in the state's public-health department, has a more drastic solution. "It is clearly evident," he says, "that between now and 1980 the gasoline-powered engine must be phased out and replaced with an electric-power package." The only realistic way of bringing about such a change, Stead feels, is to "serve legal notice that after



ELECTRIC-POWERED DAUPHINE WITH SILVER-ZINC BATTERIES FRONT & REAR
And some day convenience may have to give way to survival.

* The volume of carbon monoxide produced in one day is computed by multiplying the amount released by the burning of one gallon of gasoline by the average number of gallons consumed in Los Angeles. The weight of this volume of gas is influenced by existing temperatures and pressures, and can be easily calculated.

1980 no gasoline-powered motor vehicles will be permitted to operate in California."

Californians have not overstated the auto-pollution case. In a speech that had ominous implications for Detroit's automakers, HEW Secretary John Gardner suggested that "we need to look into the electric car, the turbine car, and any other means of propulsion that is pollution-free. Perhaps we also need to find other ways of moving people around. None of us would wish to sacrifice the convenience of private passenger automobiles, but the day may come when we may have to trade convenience for survival."

Detroit has responded by talking up its electric-car research, demonstrating new batteries and fuel cells, and driving newsmen around in battery-powered compact cars. And Ford President Arjay Miller insists that a crash program is on to build an electric car. But most auto officials believe that between five and ten years will pass before moderately priced electric cars can be produced in volume. In Washington last week, to emphasize the need for electric cars, New York Democratic Representative Richard Ottinger drove an electric Dauphine, powered by silver-zinc batteries (developed by New York's Yardney Electric Corp.), about 70 miles on trips around the city.

Fines & Prison Terms. While Los Angeles ponders new strategies in its fight against pollution, other cities—aided by increasing federal technical and financial aid made possible by the Clean Air Act of 1963—have begun to take tentative and sometimes faltering steps in the same direction. To reduce New York City's dirty smog, some 50% of which comes from chimneys, smokestacks and open fires (compared with only 10% of Los Angeles' smog), a regulation has recently been passed to limit the sulphur content of fuel burned within the city. It came none too soon; the U.S. Public Health Service describes the sulphur-dioxide concentrations in the New York–New Jersey metropolitan area as "the worst, the most critical" in the U.S.

In heavily polluted New Jersey, which shares high sulphur-dioxide concentrations with New York, a state assemblyman introduced a bill that would empower the Governor to shut down plants and incinerators and prohibit the movement of vehicles and the burning of any fuel during smog emergencies. Private citizens or corporate officers refusing to comply could be fined as much as $100,000 and imprisoned for as long as ten years.

To clear the air in Chicago, the city has launched a campaign to force local steel plants to adopt costly antipollution techniques, and transportation officials are investigating combination diesel-electric buses that would reduce exhaust fumes. An Illinois legislator has gone so far as to introduce a bill that would limit the use of Illinois coal—which has a high sulphur content—in public buildings.

Gradual Suffocation. But with these few exceptions, most communities in the U.S. have still to come to grips with the problems. There is still time to do so, but it is dwindling. U.C.L.A. Meteorologist Morris Neiburger points out that the air that now streams across the Pacific from Asia is clean when it reaches the west coast of the U.S. It picks up pollution over the coastal states, loses some over the Rockies, and becomes dirty again as it moves toward the Eastern Seaboard. "Imagine the smog that would accumulate," he says, "if every one of the 800 million Chinese drove a gasoline-powered automobile—as every Angeleno does."

The Chinese autos and the new factories that produce them will quickly pollute the Asian skies, Neiburger fears, dirtying the air currents even before they reach the U.S. Eventually, if air pollution increases beyond the capacity of the atmosphere to cleanse itself, smog will encircle the earth, he says, "and all of civilization will pass away. Not from a sudden cataclysm, but from gradual suffocation by its own effluents."

Other scientists are concerned about the tremendous quantities of carbon dioxide released into the air by the burning of "fossil fuels" like coal and oil. Because it is being produced faster than it can be absorbed by the ocean or converted back into carbon and oxygen by plants, some scientists think that the carbon dioxide in the atmosphere has increased by about 10% since the turn of the century. The gas produces a "greenhouse" effect in the atmosphere; it allows sunlight to penetrate it, but effectively blocks the heat generated on earth by the sun's rays from escaping back into space.

No Apocalypse. There has already been a noticeable effect on earth—a gradual warming trend. As the carbon-dioxide buildup continues and even accelerates, scientists fear that average temperatures may, in the course of decades, rise enough to melt the polar ice caps. Since this would raise ocean levels more than 100 feet, it would effectively drown the smog problems of the world's coastal cities.

The waters, however, need never rise. Within his grasp, man has the means to prevent any such apocalyptic end. Over the short run, fuels can be used that produce far less pollutant as they burn. Chimneys can be filtered so that particulate smoke is reduced. Automobile engines and anti-exhaust devices can be made far more efficient. What is needed is recognition of the danger by the individual citizen and his government, the establishment of sound standards, and the drafting of impartial rules to govern the producers of pollution. Over the long run, the development of such relatively nonpolluting power sources as nuclear energy and electric fuel cells can help guarantee mankind the right to breathe.

LOS ANGELES SMOG CAUSES TEARS

HOW SMOG HURTS LUNGS

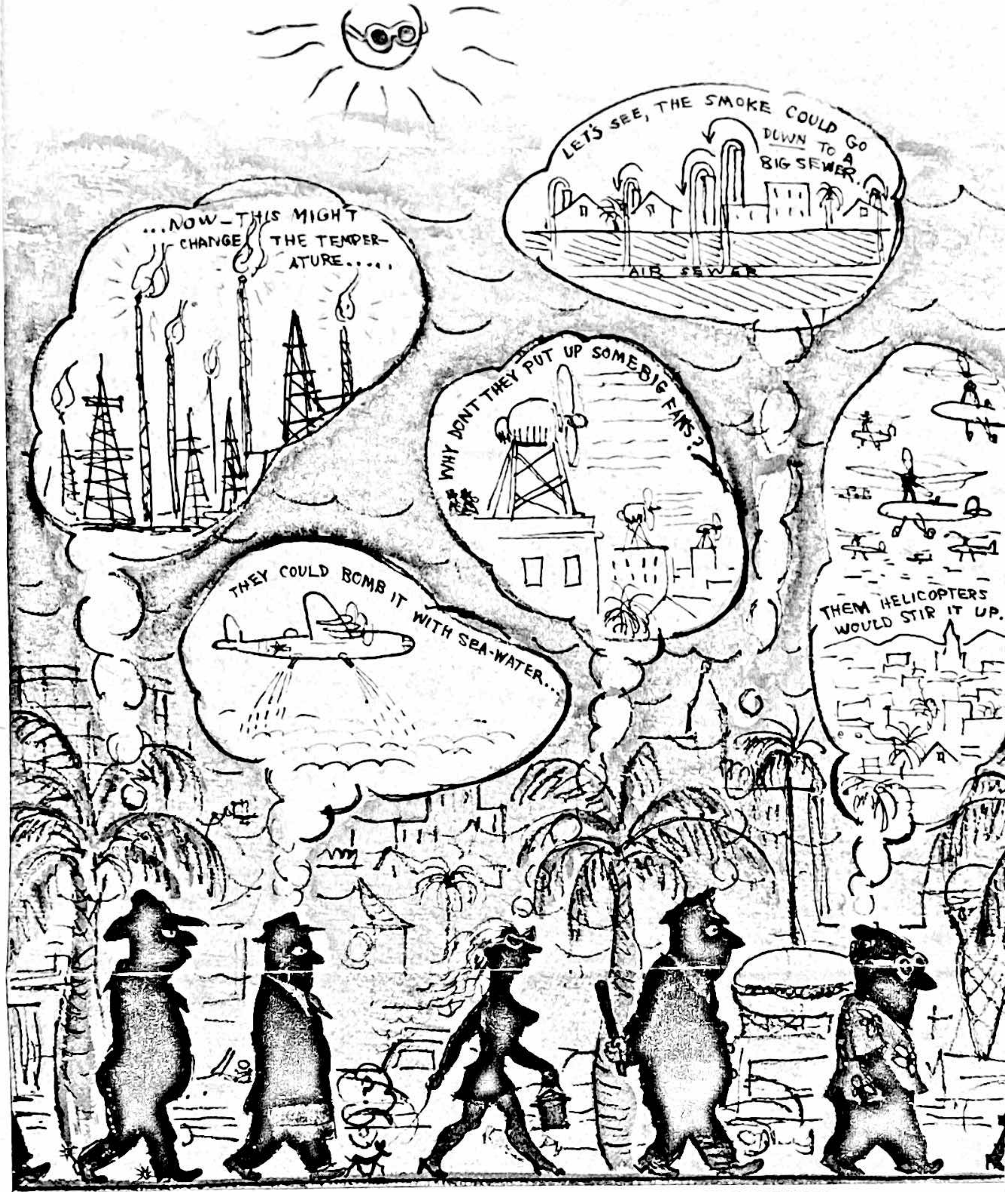
Tests show it can overstrain them

Every time a New Yorker takes a breath he inhales 69,000 particles of grit and dust. His lungs are nearly black (*left*). Almost everywhere in the U.S. the city dweller lives in a sea of coal grime, sulphuric acid, ammonia and other aerial garbage that—whether or not fog may be involved—is generally called "smog."

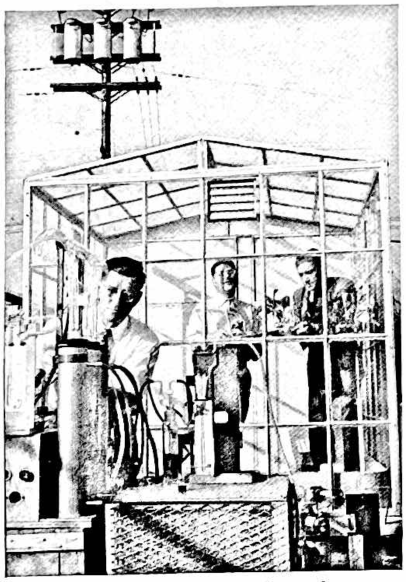
The smog problem is an old one. In the 14th Century one Londoner was even executed for burning coal in the city. Over the years there have been many debates about the effects of polluted air. But only during the past two years have comprehensive scientific tests of smog been made. The tests have proved that smog is a definite health hazard. Healthy young persons can nearly always resist the effects of smog, but elderly people, asthmatics and heart disease patients frequently cannot. Smog irritates the mucous membrane lining of their respiratory tracts, causing them to choke up and cough violently. Result: possible heart failure, overstraining of the lungs or partial "drowning" in the body's own oversecretion of fluids.

For many cities the smog problem is aggravated because they are set in natural mountain-rimmed bowls which trap the dirty air. One such city is Donora, Pa., where smog caused 18 deaths and 5,910 illnesses in five days (LIFE, Nov. 15, 1948). Another is Los Angeles, which was once a quiet mecca for retired elderly people and sun-loving visitors. Now industrialization has caught up with Los Angeles to the extent that its own special brand of smog—less grime but more eye-burning chemicals—is endangering its multimillion-dollar tourist business.

Engineers know how to prevent smog: stop it at the source by using smokeless fuel, collecting smoke in chimneys with ultrasonic, mechanical or electrostatic traps, or by getting more thorough utilization of fuels and raw materials. Some public-spirited manufacturers have applied these methods, and some cities—notably Pittsburgh and St. Louis—have passed good laws that are rapidly eliminating pollution of the air. But it will be a long—and costly—time before the country has complete smog control.



DRAWING ILLUSTRATES FANCIFUL SMOG "CURES" THAT DESPERATE LOS ANGELENOS HAVE PROPOSED



SMOG CHAMBER in Los Angeles produces smog (*foreground*) so scientists can test its effects on humans and plants and learn how much sun it cuts out.

SMOG TUNNEL in New York is used to study the path of Consolidated Edison smoke as it blows past U.N. buildings which are being built near the plant.

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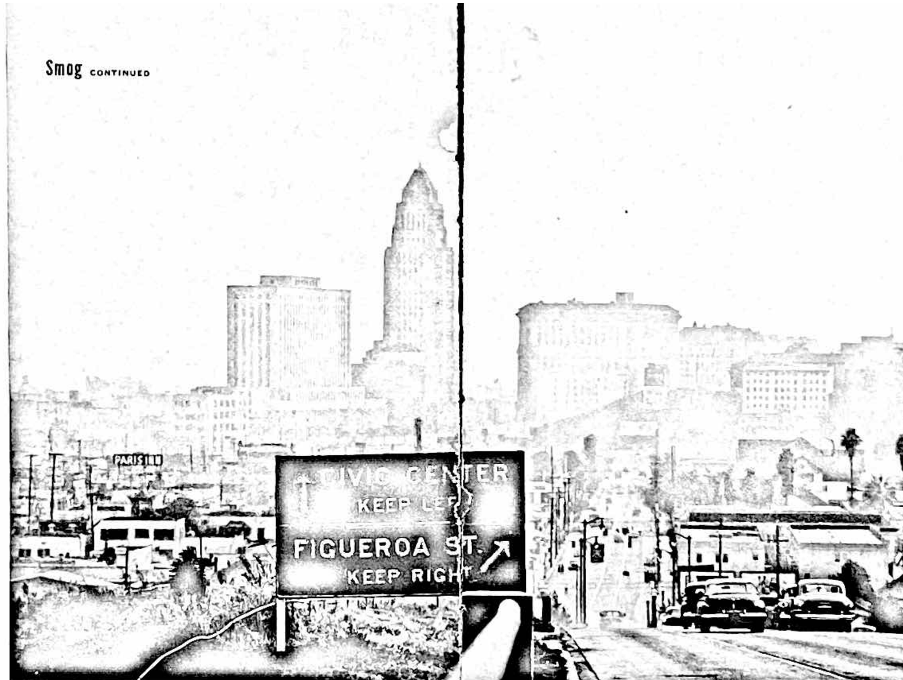
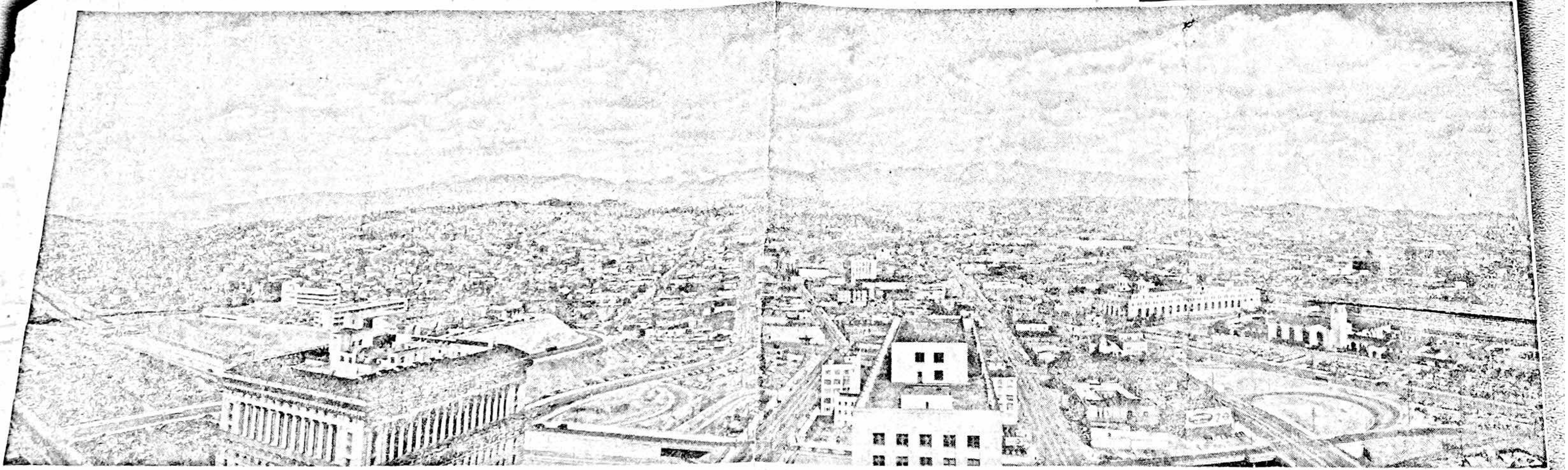


LOS ANGELES' FAMOUS SMOG is seen here in views taken from same spot on a fairly clear day and a smoggy day. Los Angeles' smog is so bad police cars get lost, football teams practice at half speed, choice real estate is marked "smog-free." A one-eyed man who moved to the city had to get a reddened glass eyeball to match his smog-irritated real one. Movie producers have to use "smog-making" machines to keep lighting constant in case of clear weather.

2072 W.W. Robinson Papers
Box 93 Research material
f.25 Los Angeles. City services. Air pollution. General. 1952 - 1966. Newspaper clippings.



Los Angeles Enjoys Day of 50 to 60-Mile Visibility

LONG VIEW—This photo was made from the 25th floor of the City Hall at 1 p.m. It covers a north[illegible] [illegible]trates that snowcapped mountains were easily visible. Yesterday set no record, but was unusually clear.

Story on Page 1, Part I

Times Photo

Study of Winds Turns Up Clues

Scientists Reveal L. A. Smog Findings

A study of wind currents in Los Angeles County is strengthening the belief of many smog experts that autos are the major offenders in air pollution.

Scientists of the County Air Pollution Control District, now halfway through a three-year wind study, say their findings show:

1. Eye-smarting smog in the San Fernando and Western San Gabriel valleys rarely comes from the industrial and refinery sections of Los Angeles, as popularly believed. It originates mostly from traffic in downtown Los Angeles, Hollywood, Beverly Hills and adjourning beach cities.

2. Smog which damaged plant life as far north as Santa Barbara and south near the Mexican border probably did not come from Los Angeles, but originated mostly from traffic in those areas.

3. Smog from Los Angeles' great industrial and oil refinery sections on both sides of the Los Angeles River generally heads into Orange County. Some of these air pollutants reach the Eastern San Gabriel Valley, starting about at Azusa.

4. The best location for new factories which emit air pollutants is near the ocean where sea breezes—stronger than inland winds—can more quickly disperse pollutants.

Local winds moving inland during the day and seaward at night, average only 5 mph, hal the average rate in other bi American cities.

Although only half finishe the air study already is bei used by the County and C Planning commissions in sidering petitions for indus zoning.

End of Smog as Major Problem Seen Within 5 Years by Griswold

11-15-61 Times

An optimistic report stating that smog as it is now known will not be a major problem in the Los Angeles Basin within five years was handed to the Board of Supervisors Tuesday.

S. Smith Griswold, head of the Air Pollution Control District, said, however, that smog could again become a major problem after 1970 unless automobile control devices are improved to keep pace with the growing number of vehicles.

His comments on the problem after 1970 came in response to a question by The Times and were not included in the biennial review of smog conditions that he gave the Board of Supervisors.

In the report to the supervisors, Griswold said, "Smog will go, as it came, gradually.

"Within the next five years, undoubtedly we will have put behind us the problem of the automobile, as we already have those of incineration, refining and metallurgical processing.

"With the exhaust of our more than 3 million motor vehicles controlled, smog as we know it will no longer be a major problem in the Los Angeles Basin."

Griswold said, however, that once "clean air" is again achieved, there still remains a permanent need to maintain it with strict enforcement of regulations. Future growth, he said, must be "oriented to avoid overburdening the air.

"In an area, and in an age, when man is placing increasing stresses upon the limitations of his environment, control of pollution of the atmosphere will continue to require diligent attention."

The report reviews the APCD's work from 1959 to July 1 of this year, and also traces the 14-year history of the fight against smog in Los Angeles County.

Griswold said air pollution from industrial sources has been decreasing but pollu-

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Comic Dictionary

COURTSHIP

The period during which a young man cannot be too careful in his choice of a mother-in-law.

SMOG CONTROL

Continued from First Page

tion from automobiles has continued to rise until now about 80% of the air pollution in the county can be attributed to automobile exhaust.

But with effective legislation and a program of testing smog controlling devices on automobiles by the State Motor Vehicle Pollution Control Board under way, Griswold said, "The final chapter in the story now remains to be written by the state agency and by the automobile manufacturers."

It will take several years to develop and install control devices on automobiles, but smog will diminish each year as more vehicles are equipped, he said.

The report said more than 9,000 polution control devices have been installed at industrial plants in the county at a cost approaching $100 million.

Dustfall in the downtown area has declined from a high of 42 tons a square mile in 1956 to a 1960 low of 21 tons a square mile.

Alert days have also decreased — from a high number of 15 in 1955 to two in 1960 and two so far this year.

"Other smog symptoms such as eye irritation and visibility also show an improving situation over the five-year period since 1956," he said. "Counterbalancing this trend, however, is the increased area of the county affected by generalized smog conditions as traffic intensities have increased in expanding suburban areas."

The report also noted that the number of persons employed by the APCD has been reduced from 444 at the 1957-58 peak to 296 persons as of July 1.

TIMES EDITORIALS

The Dismal Facts of Smog

First we had to learn what smog is, then we had to learn what causes it. Somewhere between these two steps many of us lost touch with reality, and there is still an overlay of superstition or misunderstanding hanging over us like the notorious temperature inversion that imprisons the foul air in the Los Angeles bowl.

Bleak Facts of Pollution

Irving S. Bengelsdorf, Times science editor, has done as much as a thorough researcher can to give Los Angeles and many other places the bleak facts of air pollution. There is not much we can do—now—to eliminate smog; possibly we can hold our own, or for a few years take steps to check it or abate it so that it will be no worse than it was in 1948.

Then air pollution will rise again with all the measures against it overwhelmed by the growing population.

Photochemical air pollution—smog—can only be beaten by a revolution, but the instrument of the revolution is not yet at hand.

Bengelsdorf wrote: "We have nothing to replace it with now, but at some point in the future the automobile engine as we know it must be drastically changed if we are to eliminate smog. This is the almost unanimous opinion of California scientists and engineers."

This is not a counsel of surrender; Bengelsdorf's authorities are nearly unanimous in advising the use of by-blow and tailpipe devices to reduce the spilling of hydrocarbons into the sodden air, but they "would just be buying time—keeping our heads above water while we look for a new type of power plant to drive our cars."

If this kind of dismal fact-facing makes people unhappy, we are sorry for their injured feelings, but we have no regrets for Bengelsdorf's salutary plain-speaking. The public should have known sooner. The last sentence of his series of articles simply says:

"Time is not on our side."

Small cars would help: "Los Angeles air pollution could easily be cut 60 to 70% if everyone drove a car small enough to get 35 miles per gallon." This is so obvious that few laymen have pondered it. But as the unburned remnants of gasoline cause most of the smog, cars which use less than half the average amount of fuel would reduce the air pollutants in the same proportion.

The almost invisible "new type of power plant" must be the answer in the end, an electric power plant perhaps. Unquestionably there is scientific and engineering talent enough to design acceptable electric cars. But the batteries of these cars would have to be recharged, perhaps every night, and the power load would be transferred from the gasoline motors of the present automobiles to a multitude of steam power plants of the public utilities. Then these plants would pour the byproducts of combustion into the air.

Warnings to Industry

Production of electricity through nuclear fusion, cheap and pollution free, is the hopeful answer to this objection. But controlled nuclear fusion is still a laboratory problem. No time schedule can be built on it.

So we must do what we can with half measures, and with the sharpest of warnings to the great automobile industry that it has a national obligation. It could ignore the responsibility while smog seemed to be a parochial problem of Californians who buy only 7% of its product.

But now that smog has become a universal problem, it must seek a solution under the threat of national legislation. Time is not on their side either.

SECTION C

Los Angeles Times

METROPOLITAN NEWS

VOL. LXXXII † CC SUNDAY, MAY 26, 1963 Times Mirror Square, Los Angeles 53, Calif. MAdison 5-2345

Need for School Bond Issues Told

$137.5 Million Items on Ballot Tuesday for Classrooms, Sites

BY DICK TURPIN, Times Education Editor

Los Angeles city school planners need no crystal ball to tell them how many new students will be entering the system nor how many new classrooms are needed to accommodate them.

In the words of Jack P. Crowther, superintendent of the country's second largest school system, the "children are here now!"

Propositions A and B on Tuesday's ballot call for voters' approval of $137.5 million in bond issues to build classrooms and schools, buy land for new schools and added acreage at overcrowded existing sites and to rehabilitate pre-1933 masonry buildings.

All those projects must be carried out, according to Crowther, if the schools are to keep pace with growth and keep half-day sessions at a minimum.

Voter approval of the bond issues will not increase taxes, he said.

The annual bond retirement levy, expected to be 59 cents in the next budget, should remain at that level because mature bonds from earlier elections are now being paid off at about the same rate at which the new bonds would be sold.

The current rate for bond retirement is 62 cents while the previous rate was 63 cents.

Propositions A and B enjoy the endorsements of

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BY THE WAY

Barry Bandwagon Starts Rolling

BY BILL HENRY

WASHINGTON—Although planet-looper Gordon Cooper was hogging the headlines this past week, this politically-conscious community with its stethoscope constantly on the public pulse, noted some significant stirrings. They might be listed as follows (1) President Kennedy said that any of the the three Republican "reluctant dragons" (Rockefeller, Goldwater and Romney) would "answer the call" if it came from their party, and that he'd do the same himself, (2) Nosed-out 1960 Presidential candidate Richard Nixon said that Eisenhower-Nixon Republicans could support any of the three current GOP possibilities, (3) Front-running GOP candidate Rockefeller was bringing his out-of-the-country, wait-till-the-storm-blows-over hibernation to an end and returning to public life, (4) The reluctant Gov. Romney "bashfully" returned to the spotlight of the National Press Club and thereby contradicted his reiterated denials that he's a candidate. (5) Barry Goldwater, the man-to-watch, kept his finger in the dike holding back a torrent of grass roots support but is in grave danger of being swept off his feet. And this town, where political opinions are as freely given as political promises, and as frequently changed, had reached a point where the experts were ready to draw up their first form charts on the Republican Presidential handicap. They don't all agree, of course, but a quick pulse-taking indicates as follows: Rockefeller, has faded rapidly but is by no means out of the running. Romney, nice conformation but looks green breaking out of the starting gate. Goldwater, steadily improving his position—definitely the one to watch.

They Think Rocky's Been Hurt

The political experts always have two opinions—the one they express publicly and the one they really believe. Richard Nixon voiced the one that all Republicans are repeating—Rockefeller's divorce and remarriage to a recently divorced woman are a "private matter" and shouldn't enter into a discussion of the man's qualifications for the Presidency. Just what Nixon really believes may or may not be the same but a lot of other politically astute individuals are saying, "off the record" that they believe Rockefeller has been badly hurt by these developments and many say that he's definitely a dead duck politically and might just as well hope that his marital situation will have been forgotten by 1968.

Goldwater-Morton, GOP Ticket

The feeling about Romney is that he is strictly a stop-gapper. He is personable but inclined to be a bit on the vague side—painting his opinions with a big brush but that he is inexperienced in answering sharp specific questions and can be cut to pieces if he doesn't sharpen up—and he hasn't much time. Right now the fellow with the big ground swell of popular support is Sen. Goldwater and quite a few Republicans are coming to feel that maybe this really is the time to let the conservative element make its run for the big money. In 1960 there was a lot of Goldwater sentiment at the GOP convention but it was all noise and no organization. This time it looks better organized and much stronger. The experts, this week at least, are saying that unless the Madison Avenue GOP liberals decide to use Romney in a stop-Goldwater movement an Arizona-Kentucky Barry Goldwater and Thruston Morton ticket may represent the Grand Old Party next year.

Damaging Blanket of Smog Spreads to Much of State

SMOG—Large map indicates how smog has become a statewide problem, ranging from as far north as Shasta County to the Mexican border. Inset map indicates the "lakes of air" over the state into which air pollutants flow and under the sun's rays become smog. Living in the areas affected are 97% of California's people, 70% of whom suffer eye irritation from the spreading gray plague.

Gray Plague Burns Eyes and Kills Vegetable Crops From S.F. to San Diego

Smog, long considered peculiar to Los Angeles, now is a statewide and national problem. This is the first of a series on smog and its causes, why it is spreading, and what can be done about it.

BY IRVING S. BENGELSDORF
Times Science Editor

Twenty years ago, a sinister, eye-irritating, gray haze began to blanket the Los Angeles basin.

Like the "Man Who Came to Dinner," smog has been with us since. And it has spread.

Smog respects no city, county, state or national boundary. Twenty-six of California's 58 counties, including some of the nation's most profitable agricultural areas in the Central San Joaquin Valley, now suffer from plant and vegetable damage.

Eye-irritation now pesters Sacramento. The citizens of San Francisco to the north and San Diego to the south also experience the sting of burning eyes.

Smog also is becoming a national problem. Hartford, Conn., Washington, D.C., Detroit and Denver, for example, all show symptoms of the "gray plague."

International Problem

And the smog problem is international, too. It may spill into Mexico from San Diego or into Canada from Detroit—or it may be generated locally in Buenos Aires or Rome.

Smog is sneaky. It moves in slowly, barely noticeable at first, until it finally plagues the area with eye irritation.

The first sign of smog is reduced visibility, and the warning usually goes unheeded. Then, plants and vegetables, such as spinach and lettuce, are damaged and die. Eventually they no longer can be grown in the area. But, that is the farmer's problem.

And finally — eye irritation. At this advanced state, smog affects the individual and he demands that something be done.

Dr. Philip A. Leighton, professor emeritus at Stanford University, has drawn a map to show his estimate of the ominous situation of California's air pollution, or smog. The map represents a serious warning for the future.

Areas from as far north as Shasta County down to the Mexican border now have some degree of reduced visibility. If these areas don't do something about their smog problem they soon will have plant damage.

And if those areas which now show plant damage remain indifferent to their smog problem, they soon will be suffering from eye irritation.

If those communities whose air is so filthy that the eyes of their citizens sting and tear do nothing—they will become unbearable.

Grow Together

What's really important, Dr. Leighton points out is that 97% of California's population lives in the area of reduced visibility, while 70% of the state's inhabitants periodically suffers from eye irritation.

The map, therefore, is a striking illustration that severe smog occurs wherever

Please Turn to Pg. 7, Col. 4

Copter Saves Youth Trapped High on Ledge

John Farley, 13-year-old hiker, spent three hours clinging to a ledge 500 ft. up the side of Briggs Canyon Saturday before a sheriff's helicopter team rescued him.

Young Farley of 4944 Pennsylvania Ave., La Crescenta, was hiking in the canyon area north of La Crescenta with a friend when he got stuck.

Farley clutched a bush to keep from falling off the ledge while his companion descended the canyon to get help. The sheriff's station at Montrose sent 20 men on foot and dispatched three helicopters.

One of the helicopters spotted the stranded youth, lowered a rescue crew and the boy was lifted to safety.

Cycle-Auto Crash Fatal to Youth

John W. Robinson, 19, of 1620 Beach Dr., Hermosa Beach, died early Saturday after being struck by a car while riding his motorcycle at Grant Ave. and Green Lane, Redondo Beach.

The auto driver, Lyle E. Francis, 40, of 14912 Inglewood Ave., Lawndale, was booked on suspicion of manslaughter and felony drunk driving.

Southlander in Peace Corps to Wed Ghanian

Man From Orange Has to Pay His Future Father-in-Law Usual $70 to Seal Bargain

A 26-year-old Los Angeles area man serving as a Peace Corps volunteer became engaged Saturday to a 23-year-old Ghanian girl—but he had to pay his future father-in-law £25 ($70) to seal the bargain.

The husband-to-be is Dan Carmody, son of Mr. and Mrs. Fritz Carmody of 1520 W Almond Ave., Orange.

His parents refused to discuss their son's pending marriage to Grace Abenaa Oparebea Dei.

In Accra, young Carmody said his parents had not objected to the mixed marriage.

"I guess mixed marriages present certain problems but we are both prepared to meet them," he said.

Carmody will be the first Peace Corps volunteer to marry a Ghana girl.

At the traditional betrothal ceremony Saturday, he presented Grace with a ring and a Bible. They plan to wed in July when the summer vacation begins at the Ghanian school where Carmody teaches science.

"According to African custom," Carmody said, "the betrothal ceremony was more important than the actual wedding."

George Carter, Peace Corps chief in Ghana, was among those who attended the ceremony.

"I refuse volunteers permission to marry," Carter said, "only if I consider it

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PRICE OF STARDOM—Paul Newman and Joanne Woodward come up with cement on their hands Saturday as they become 140th and 141st film stars to be honored with foot and hand prints in forecourt of Grauman's Chinese Theater.
UPI photo

Scientists May Join Indians in Peyote Test

BY PAUL WEEKS

Peyote-worshipping Indians and medical scientists may join forces for a new showdown here on the California law prohibiting use of the dream-making cactus button, The Times learned.

The test would come June 11 should public defender William Larson move to reopen for testimony the trial of Ned Begay, 23, a Navajo, on charges of possessing narcotics—a peyote button.

Superior Judge Mark Brandler on Wednesday set the case over until that date to permit defense counsel to file further briefs.

ACLU May Appear

Meanwhile, however, A. L. Wirin, attorney for the American Civil Liberties Union, said the ACLU is considering asking the court for permission to appear "on the issue of religious freedom" in the case.

Defender Larson declined to comment on the case, or to confirm or deny he might seek to reopen it.

The Native American Church, a Pan-Indian movement which claims 225,000 members, contends states which forbid their use of peyote in church ritual are abridging their constitutional right of religious freedom.

Reports prevailed that the Begay case here may be used as a rallying point for both scientists and Indians to attack the state's classification of the hallucinatory drug as a narcotic.

Evidence Recalled

Last November, medical testimony was produced at the trial of three Navajos in San Bernardino that peyote is non-addicting, and that it does not excite violent passions.

Superior Judge Carl Hilliard found the defendants guilty, saying, "The court must accept the legislative definition of peyote as a narcotic."

The shy, black-haired Navajo around whom the Los Angeles case is revolving, spoke from the witness stand in a halting, broken voice in intoning a peyote prayer at

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Ex-Football Star's Kin Say Death Not Suicide

Note Written Long Ago, Family Contends; Coroner's Investigation Termed 'Shabby'

Los Angeles Times News Service

SOUTH BEND, Ind. —The family of a former Santa Ana (Cal.) football star who died in a 168-ft. fall charged Saturday that the St. Joseph County (Ind.) coroner's office had erred in terming the death a suicide.

David H. Betten, 21, former All-Parochial League center at Mater Dei School in Santa Ana and a junior psychology major at the University of Notre Dame, was found at 8 a.m. Thursday at the base of the tower under construction on the university campus.

France Betten of Leawood, Kan., a brother, said Saturday that the suicide verdict was based primarily on the testimony of a 19-year-old girl and the notation, "May God forgive me," found in a scrapbook in David's room.

"The investigators considered the notation a suicide note," said France Betten. "Actually, some members of our family had seen that notation written in the scrap book as long ago as last Christmas. It was written on a photograph and was some kind of a joke — a 'sick' joke, I guess — among the students."

Probe by Relatives

France Betten said he and other relatives had talked with persons never questioned by the coroner or sheriff, and had learned:

1—David often went to the tower to watch the sunrise.

2—He was in excellent spirits and doing well in school.

3—There was a low wall around the top of the tower that was wet with dew and David could have slipped.

4—David's neighbor heard him leave his room several hours before the fall and go off with another person. The other person has not come forward.

5—David had four books with him "and a person doesn't take books along to commit suicide."

Calling the coroner's investigation "shabby" and "incomplete," France Betten said he is convinced the death was either accidental or involved foul play.

Blaze Routs 4 From Home in Whittier

A pre-dawn fire Saturday routed four persons from their home at 444 N Stanford Way, Whittier.

The flames, which broke out in a furnace room at the home of Rollin Lee McNitt Jr., 46, president of Rose Hills Memorial Park, caused $20,000 damage.

McNitt, his wife, Elizabeth, 48, and their daughters, Evy, 15, and Marsha, 18, escaped unharmed.

Comic Dictionary

TEEN-AGER

An adolescent girl who always puts things back where she didn't find them.

BITE ON BENNY—Mrs. Marge Chandler persuades Jack Benny to part with some money at the annual relief party for SHARE at Moulin Rouge. Funds will aid retarded children. Some 800 Hollywood celebrities paid $50 a seat to see fun. Times photo

Filmland Goes Western for SHARE's Sake

Hollywood staged its biggest "live" western Saturday night for a bunch of kids who weren't there.

The event was the annual SHARE Boomtown party at the Moulin Rouge, with a cast of 800 cowboy-suited celebrities ranging alphabetically from Jack Benny to John Wayne.

And although the hour, refreshments and entertainment were strictly for adults, retarded children were expected to benefit to the tune of $125,000 or more when all the proceeds from ticket sales at $50 a seat and auction bids, on everything from songs to shoes, are totaled.

Even Benny Pays

Even Benny, who has made a career of penury, coughed up cash for a prize.

Dean Martin emceed the show, in which such stars as Frank Sinatra, Jack Lemmon, Kirk Douglas and Milton Berle contributed their talents as well as money.

They were backed up by possibly the most illustrious chorus line in show business history — Janet Leigh, June Hutton, Sheilah MacRae, Laraine Day, Jo Stafford, Helen Grayco and the wives of Martin, John Wayne, Billy Wilder and Berle.

Victims of Bel-Air Fire Enjoy Living in Trailer

BY MARY ANN CALLAN

On Nov. 6, 1961, Mrs. Burton Fletcher started to run from her car toward her hilltop house on Chalon Rd in Bel-Air Estates. Then she walked and finally stopped It was useless.

The raging, roaring fire had already gobbled up their 25-year-old, 17-room home She sobbed, mostly for the safety of her youngest child and her husband. She knew they had been at home.

But in a few moments their other car, choking with a near vapor lock, rolled down the hill toward her—with Nancy, then 4, their German shepherd dog, King, and her husband safely aboard.

Live in Trailer

That was 18 months ago . . .

The Fletchers, along with a dozen or so other families whose homes were in the path of the fire that ultimately destroyed 300 structures, thought of a solution live in a trailer — until a home can be financed and built.

This was as unheard of in that district of luxury homes as a high-rise apartment dwelling.

The West Los Angeles Department of Building and Safety and the Bel-Air Assn., which watch-dogs the high standards for building and landscaping in the area felt some leniency should be shown.

Permits Allowed

They allowed permits for trailers on a six-month basis, if property owners showed intention to build a new home.

According to George Richardson, manager of the association, some owners with trailers have dragged their feet on construction.

"But generally," he said, "most have been co-operative and have complied with our rules. A few have been granted extensions when their homes took longer to build than anticipated."

Building department officials estimate that about two-thirds of the 300 homes destroyed have now been replaced by owners, with most of the other third awaiting sale of property to new owners.

Enjoy Trailer Life

Mrs. Fletcher relates that her children — Burt Jr., 12, Susie, 10; Bobby, 8, and Nancy, now 6 — actually enjoy living in their 10x56-ft. trailer.

"It's a double-expandable, and the girls sleep in the master bedroom, the boys in separate rooms, and my husband and I on the couch," she explained.

They expect, by next February, to move into a two-story Normandy-type house, now being built behind the trailer on their one and one-half acre property.

In the meantime, two dogs, a young goat and a rabbit (all pets) bark, butt and hop over the landscape with the children, as if no tragedy had ever visited there.

Lucky Burglary

Mrs. Fletcher concludes "If this is all we lose in life, we're lucky."

And the luckiest part of all, she added, was a burglary that happened to their home a few months before the fire.

"At that time, we had everything in the original house appraised. We knew what everything was worth and got up to 80% of the value," she said.

Some, of course, are not so lucky and many still bristle at the memory of "mink-lined fire" descriptions in some periodicals during the fire.

"Believe me," said Mrs. Fletcher, "these trailers have helped many pull through."

U.S. Doctors End Tour of Red Europe

Five American heart specialists, home after a three-week lecture tour behind the Iron Curtain, were received with enthusiasm and acknowledgements of America's leadership in medicine, the group's leader said Saturday.

"They believe that by direct contact of medical scientists and cultural groups friendship and understanding between the peoples of our countries will be rapidly advanced," Dr. George C. Griffith said on his return.

USC Man Leader

Dr. Griffith, professor of medicine at the USC School of Medicine, headed the U.S. medical delegation which lectured to 10,000 physicians in Poland, Czechoslovakia and Yugoslavia.

The physician, who is president of the American College of Cardiology, said he was surprised to see how poorly equipped doctors are in the three countries visited.

The group returned Friday night from the tour sponsored by the U.S. State Department at the request of the foreign countries.

Professors from Moscow attending a lecture in Prague were so impressed they invited Dr. Griffith to Moscow. Seventeen nations have asked for the teaching program.

Trains Run Again at Griffith Park

Miniature trains start running again at 2 p.m. today in Griffith Park.

The new entertainment facility recently was completed and includes a replica of an early 20th century railway station, a 70-ft bridge over Lizard Creek, iron gates and an 85-ft tunnel.

...And Only YOU Can Prevent Forest Fires

Warning Repeated That Tossed Cigarette Could Mean Fine and Jail—or Liability

BY DON NEFF

The U.S. Forest Service warned Saturday that a cigarette flicked from a car window in the wrong area can cost you $500 and six months in jail.

Faced with another season of critical fire danger in the Angeles National Forest, Supervisor Sim E. Jarvi said fire prevention laws will be enforced rigidly.

Fifty full-time fire prevention officers tour the 691,212-acre forest — larger than the state of Rhode Island—on a lookout for violators.

Open fires never are allowed in the forest, smoking is outlawed from May 1 until the winter rains, and large parts of the foothill areas are closed starting July 1—inauguration of the "fire season."

Misdemeanor Penalty

All are misdemeanors punishable by a maximum fine of $500 and six months in jail.

It could be a cheap price to pay.

A violator faces a fine and jail term if he is caught before he causes a fire — but if his discarded cigarette starts a blaze, he is liable under law to pay for the fire-fighting costs which can run more than $1 million.

Recently the forest service received $5,493.75 as payment in full for costs of battling a blaze accidentally started by a 14-year-old boy who set off firecrackers in the Chilao recreation area.

The fire blackened only eight acres, but the force needed to douse the blaze included 100 men, 20 pieces of equipment, two airtankers and a helicopter.

90 Fires Last Year

There were 90 fires in the forest last year which destroyed vegetation in a 10,023-acre area. Only one was caused by lightning. Man caused the others.

Jarvi said the major cause of blazes in the forest is discarded cigarettes. The second cause is from children playing with matches, a danger that is increasing each year.

Since 1959 the number of fires started in the forest and adjacent areas by children with matches has jumped from 11 to 31, Jarvi said.

"We are trying to get across to parents that it is as dangerous to leave matches lying around the home as poison or a loaded gun," said Jarvi. "They not only may injure themselves or someone else in a fire, but their parents will be financially responsible."

The service strongly presses claims for carelessly set fires under the philosophy, "Why should everyone have to pay for one person's carelessness."

Scarred and Blackened

Costs are only for expenses of fighting the blaze—not reseeding or the lost esthetic value of Jeffery and Ponderosa pines and white and Douglas firs that are left scarred and blackened.

Nor does the cost measure the loss of wildlife killed, maimed or left homeless. Deer, rabbits, squirrels, quail, coyotes, bobcats and about 30 black bears live in the forest.

"Even more than beauty and wildlife, fire takes its worst toll by destroying watersheds, which can cause millions of dollars in erosion," said Jarvi.

The sprawling forest sits in the San Gabriel Mountains which are relatively young and still "growing."

Cracking Heard

This upward thrust plus a base of cracked and shattered granite cause the mountain slopes to disintegrate at such a rate that "you can actually hear erosion taking place after a fire," Jarvi said.

It is the heavy chaparral that holds back the crumbling slopes from sliding into the heavily populated areas in the foothills bordering the forest.

But it is the chaparral which also acts as the fuel for fires, making it indispensible but also a hazard.

The weather offers the same kind of dilemma—rain keeps down the fire hazard, but it also nurtures wild grass which is extremely inflammable when it dies in the hot summer.

"You can't win," sighed Jarvi. "The fire danger in Southern California is always bad."

WINNING SMILE—Bernice Engle, 12, 4-H Club member from Ontario, prepares to enter champion Holstein cow in Great Western Fair and Dairy Show.

20 Envoys to Visit Friday

Touring ambassadors of 20 Latin American republics will visit here Friday, Walter P. Coombs, executive director of the Los Angeles World Affairs Council, announced.

The delegation, made up of ambassadors accredited both to the United States and the Organization of American States, will be guests of the council at a Friday luncheon in the Ambassador.

Mr. and Mrs. Gilbert C. Van Camp Jr. will entertain the group at a dinner dance in the Crystal Room of the Beverly Hills Hotel.

Ambassador de Lesseps Morrison, U.S. representative to the OAS, will head the group, which includes the dean of the Washington diplomatic corps, Ambassador Sevilla-Sacasa of Nicaragua.

Dairy Show, Fair to Open Wednesday

If you want your children to know the value of dairy cows and goats, you should take them to the 6th annual Great Western Fair and Dairy Show which opens Wednesday at the Great Western Exhibit Center, Santa Ana Freeway and Atlantic Blvd., City of Commerce.

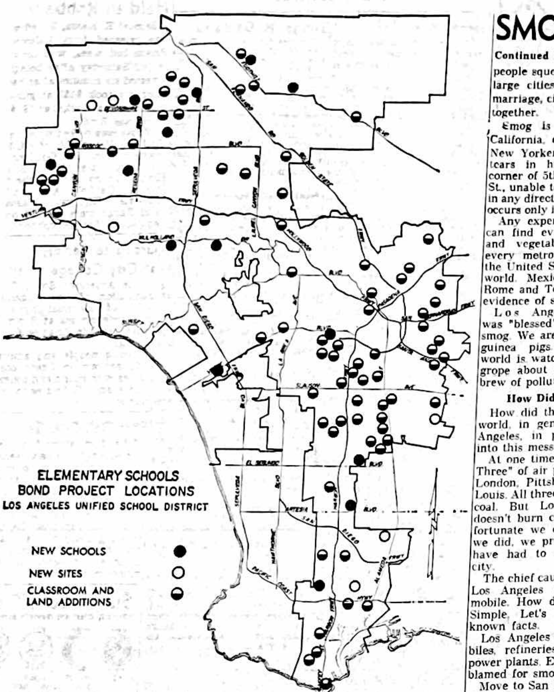
The fair highlights the fact that Los Angeles County is the largest dairy-producing county in the United States with over 110,000 cows.

Charles J. Lumpp, president of the 48th District Agricultural Assn. which sponsors the fair, said this year's show should be better than others from the standpoint of entrants and attractions.

Goats will be shown, he said, and there will be demonstrations of milking machines.

Senior Citizen Fete

Senior Citizens Day will be celebrated today at the Plaza, birthplace of Los Angeles, and festivities will be held there from 1 p.m. to 4 p.m., it was reported by the Los Angeles City Recreation and Parks Department.



SITES INVOLVED—Map locates sites affected by Tuesday's school bond issues.

SMOG GROWTH

Continued from First Page

people squeeze together into large cities. Like love and marriage, cities and smog go together.

Smog is not unique to California, even though the New Yorker, standing with tears in his eyes at 42nd corner of 5th Ave. and 42nd St., unable to see half a mile in any direction, thinks smog occurs only in Los Angeles.

Any experienced botanist can find evidence of plant and vegetable damage in every metropolitan area in the United States —and the world. Mexico City, Lima, Rome and Toronto all show evidence of smog.

Los Angeles, however, was "blessed" to be first in smog. We are "international guinea pigs." The whole world is watching us as we grope about in our witch's brew of polluted air.

How Did It Start?

How did the cities of the world, in general, and Los Angeles, in particular, get into this mess?

At one time, the "Terrific Three" of air pollution were London, Pittsburgh and St. Louis. All three cities burned coal. But Los Angeles doesn't burn coal. And it is fortunate we do not, for if we did, we probably would have had to evacuate the city.

The chief cause of smog in Los Angeles is the automobile. How do we know? Simple. Let's look at the known facts.

Los Angeles has automobiles, refineries and steam power plants. Each has been blamed for smog.

Move to San Diego. It has automobiles and steam power plants, but no refineries. Yet, San Diego has smog.

Fresno Cited

The clincher is Fresno. This city in the San Joaquin Valley has no refineries and no steam power plants; its electricity is brought in from hydroelectric plants located elsewhere. But Fresno has automobiles — and it has smog.

Look at our nation's capital, Washington, D.C. has no great concentrations of industry, but it does have lots of automobiles —and it has smog.

Tobacco plants grown around Washington show the same type of smog damage as found on leafy plants in the Los Angeles area. Farmers in the Connecticut River Valley near Springfield, Mass., can no longer grow certain choice tobacco leaves used as cigar wrappers; both the farmers and plants are victims of smog.

If you want dramatic proof of the dominant role of the auto as the cause of Los Angeles smog, visit any station of the Air Pollution Control District (APCD) which 24 hours a day sucks in air off the street and analyzes it for pollutants.

Each morning, between 6 and 9 o'clock, the records show increases in air pollution. They are repeated in the late afternoon and evening. These instruments are taking the pulse of a city which has linked its fate to the automobile and the freeway.

Each day you drive to work half of your time may be spent standing still with your engine idling. If you're lucky, you may move in a series of starts and stops.

And an automobile with its engine idling, or starting and stopping, is operating under the very conditions which pour the greatest amounts of pollutants into the air . . . a horrendous torrent of unburned gasoline, carbon monoxide and oxides of nitrogen.

Smog Litterbug

Each of us who drives is a "litterbug", pouring a constant stream of invisible garbage into our precious and limited supply of air. And when the 3½ million cars of Los Angeles do this—the it happens.

The sun, which made Los Angeles famous, shines into this mish-mash of automobile exhausts and kicks off a whole series of complicated chemical reactions.

The exhaust materials are turned into the familiar "hazy sunshine" which cracks rubber tires, damages and kills plants and irritates eyes.

Chemists refer to such changes, which depend upon sunlight, as photochemical reactions (Greek: photos means light).

Smog, therefore, is more correctly known as photochemical air pollution (PAP). The word smog is a misnomer originally coined to indicate a combination of smoke and fog.

Why Less Severe?

Other cities have lots of cars and sunlight. Although they show the same kind of air pollution as does Los Angeles, their troubles are not as severe. Why?

Again, the answer is simple. The very factors of climate and weather, which make Los Angeles such a desirable place in which to live, are exactly those which contribute to its smog.

Los Angeles is located in one of the worst possible geographic positions—if one intends to squeeze 18 million people into it.

The Los Angeles basin is a huge bowl surrounded by mountains and covered with a warm layer of air. Air movement is poor and the warm air cover further prevents circulation. The city suffers from poor air ventilation.

We live at the bottom of a lake of air—and a goodly portion of the year the air lake above us and around us is stagnant.

The smog woes of Los Angeles are a result of three f. ctors. poor air circulation, sunshine and pollutants.

The first two factors are due to nature, and we can't do anything about them.

But the poll.tion is man-made—and man should be able to do something about it.

Monday: The nature and sources of air pollutants.

County Board Curbs Density of Apartments

Any more extensions of the county's density ordinance to control apartment developments in congested areas like West Hollywood have been halted by the Board of Supervisors.

Supervisor Ernest E. Debs said the controversial law will take effect as scheduled July 1.

It will limit the number of apartment units which can be built on a single lot.

In an R-4 zone, each four-room apartment must have at least 800 sq. ft. of lot space. Smaller apartments must have at least 600 sq. ft.

Developers opposing the ordinance charged it would limit high-rise construction. Some asked extra time to process plans submitted under the old zoning law before the July 1 deadline. This was refused.

Attorney New Stanford Alumni Head

H. Melvin Swift Jr., Los Angeles attorney, is the new president of the Stanford Alumni Assn.

He was elected Friday by the organization's executive board.

Swift, a member of the class of 1948, is serving his fourth year as a member of the association's governing body.

Bay Area Pair Lead in Regional Bridge Play

BY ALFRED SHEINWOLD, Times Bridge Columnist

Don Oakie, veteran tournament player from San Jose, and Mrs. Alma S. Coleman of San Francisco led a field of 506 pairs Saturday in the first session of the open pairs championship, the opening event of a 10-day regional bridge tournament at the Ambassador Hotel. They had 226½ points. Harold Kandler of Pico Rivera and Maury Genud of Los Angeles were in second place with 219 points. J. Frederick Morrison and Andrew M. Taylor, both of Long Beach, were third with 217.

The championship will be decided during matches today and tonight.

Los Angeles bridge experts got off to a good start Friday night by defeating San Francisco in a special intercity team match before a large crowd of kibitzers and rooters. The locals won by 45 International Match Points after piling up a lead of 43 points in the first half of the match.

The match began with Lew Mathe, captain, and Meyer Schleifer playing for Los Angeles against Douglas Drury and Oakie in the first room. Edwin Kantar and Robert Hamman played for Los Angeles in the second room against Ronald Von der Porten and Kai Larsen.

Mathe Withdraws

In the second half Mathe withdrew in order to let Harold Guiver and Erik Paulsen put in some flying time on the local team. Frank Jackson, captain of the San Francisco team, put in Ed Barlow and Evan Bailey in a vain effort to pull the match out of the fire.

The most amusing hand of the match came when Barlow and Bailey talked their Lost Angeles opponents out of a vulnerable game:

North dealer. East-West vulnerable.

NORTH
♠ 5 4
♥ A Q 7 5 3
♦ 3 2
♣ Q J 8 5

WEST
♠ K 10 6 2
♥ 10 6 2
♦ A Q 6
♣ A 6 3

EAST
♠ A Q J 9
♥ K J 9 8 4
♦ J 5 4
♣ K

SOUTH
♠ 8 7 3
♥ None
♦ K 10 9 8 7
♣ 10 9 7 4 2

North	East	South	West
2 hearts	Pass	2 spades	All Pass

The opening bid was a "weak two-bid," much favored by most American experts. The response of two spades was larceny, pure and simple. Barlow knew his partner had a weak hand and had so little himself that the opponents surely had a game, probably in spades. He therefore bid spades himself, hoping to confuse the enemy.

The attempt succeeded since East liked both hearts and spades too much to intervene. Barlow managed to get two tricks but was delighted to pay a penalty of 300 points for being down six.

Bidding Normal

At the other table the bidding was more normal, and the San Francisco team got to four spades on the East-West cards, scoring 650 points. The daring "psychic" bid in the first room therefore gained 350 points, the difference between losing 300 and 650 on the North-South cards.

The tournament continues Monday and Tuesday with Men's and Women's Pairs in the afternoons and Mixed Teams at night.

Sheinwold bridge column on Page 8, Section H.

CHOOL BONDS

itinued from First Page

e California Taxpayers n., the Los Angeles mber of Commerce, the A, both the Democratic Republican State Central Committees, various ordinating councils ughout the Community the League of Women rs.

rollment in the schools is at the 700,000 mark ith 1,500 new residents ng California daily and t of 10 settling here, otal figure continues to se.

Birth Rate Rises

s year, about 71,000 will be born in the served by the city system. Since 1960, 00 new Californians een born in this area, te of one every seven s!

than three million s now live within the ries of the unified and college districts but , another 1.5 million living in this school 's jurisdiction.

enrollment keeps and the best ed- uesses are that with- years, student pop- vill increase by 34,- 5,900 in junior high 9,190 in senior high nd 6,500 in junior

decade between 1960, according to Census, California's increased by ile population of oup of 5-19 jumped

ucible Needs'

by such facts and , Crowther and ardly need a seer l ball. All they is count bodies. onstruction the two proposi- urvived a com- screening process of only those ch represent "ir- eeds," Crowther

of this school nclude the con- ,537 classrooms late 55,000 new said. aid 15,000 ele- pupils are -day sessions the two bond prevent that increasing to 6 in elementa- ndary grade

A, calling for

$127.5 million, is needed for use of the Los Angeles Unified School District, the superintendent said. The Los Angeles Junior College District is in need of $10 million.

For the unified district—elementary, junior and senior high schools and adult schools—passage of Proposition A would provide for construction of 20 new schools at a cost of $11,050,-000.

Included would be $9,310,-000 for 11 new elementary schools; $12,896,000 for four new junior high schools and $18,844,000 for five new senior high schools.

Buildings Unsafe

Earmarked for purchases of new land is $9,407,000 item. This money would buy eight new elementry school sites, two new senior high school sites and sites to expand area at 27 over-crowded elementary schools and at 13 junior and senior high schools.

Other major portions of the unified district funds would be $30,882,000 for classroom additions at existing schools; $2,240,000 for new schools for the handicapped and additions to similar existing units; $5,-680,000 for major alteration and improvement projects; $3,795,000 for equipment; $1,889,000 for administrative facilities and $1,962,000 for contingencies.

A vital section of this bond issue concerns a $37,010,000 program for structural rehabilitation of masonry buildings declared unsafe for occupancy in case of a major earthquake.

There are 104 of these buildings at 70 schools which do not comply with provisions of the state's Field Act which requires that school buildings have a degree of resistance to major quakes that is not required of any other type of masonry building.

The structures represent the last of the remaining pre-1933 buildings that have not yet been altered to comply with the state law.

College Program

The junior college bond program consists of $2,829,-000 for beginning work on a new college; $6,640,000 for additions at six of the seven existing colleges; $80,000 for alterations and improvements and other projects.

Approval of the measure would provide for first-phase construction of the new junior college in Culver City, to provide facilities for 2,500 students and to relieve enrollment pressures at Los Angeles City College.

Fireworks Show Tickets on Sale

Sale of tickets for the 31st annual American Legion fireworks spectacular to be held July 4 in the Coliseum began this weekend.

Richard M. Pittenger, the Legion's director of special events, said the theme of this year's show will be "A Salute to America's Youth."

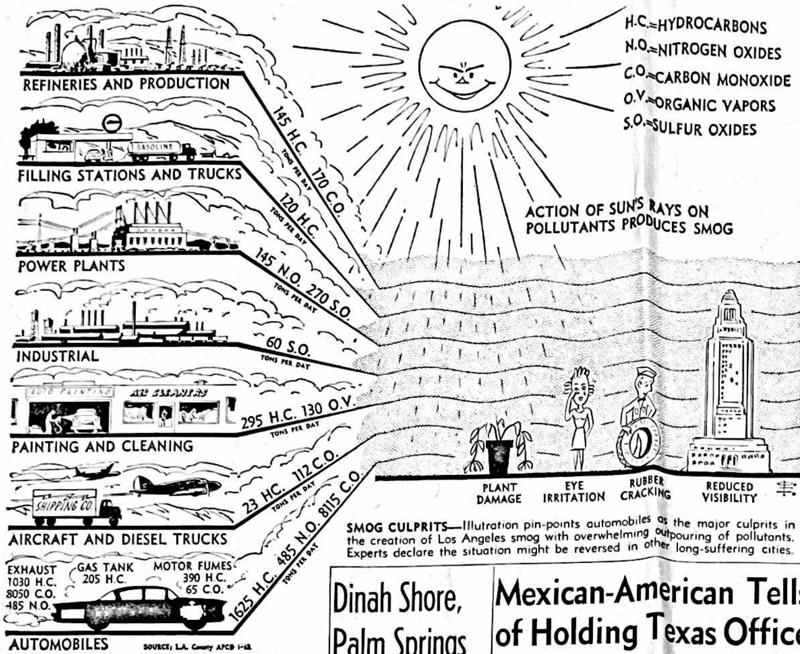
All proceeds from the show will go to Legion charities.

PART II

Los Angeles Times

METROPOLITAN NEWS
EDITORIALS

VOL. LXXXII 2† CC MONDAY MORNING, MAY 27, 1963 Times Mirror Square, Los Angeles 53, Calif. MAdison 5-2345



SMOG CULPRITS—Illustration pin-points automobiles as the major culprits in the creation of Los Angeles smog with overwhelming outpouring of pollutants. Experts declare the situation might be reversed in other long-suffering cities.

As the Autos Go, So Goes Smog in L.A.

Pollutants Grow With Population

Smog, long considered peculiar to Los Angeles, now is a statewide and national problem. This is the second of a series on smog and its causes, why it is spreading and what can be done about it.

BY IRVING BENGELSDORF
Times Science Editor

Los Angeles lies submerged under a lake of air, the same lake of air which 30 years ago bathed the basin in the clear air and sunshine that made the city famous.

Drastic changes have come in less than a generation. The tremendous increase in population, industry and automobiles is equalled by a tremendous increase in air pollutants.

If the Los Angeles air lake is stagnant, the sun is shining and if pollutant materials are present—the result is smog, or photochemical air pollution.

Two of these factors, the movement of the air and sunlight, are supplied by nature; we can't do anything about them.

The key ingredient, the pollutants, whipped up on a gigantic scale, results mainly from man's burning or combustion activities.

Fuel Burned

The 3.5 million cars in Los Angeles County burn up almost 7 million gallons of gasoline a day. In addition, the burning of fuel oil, mainly by steam power plants, can reach as high as 3.5 million gallons a day.

The nature and sources of pollutants emitted into the Los Angeles air lake are well-known and understood.

Broadly speaking, pollutants come from two kinds of sources: those located in buildings are called stationary sources; those located on wheels are known as moving sources.

Plants Co-operate

It is to the credit of the Los Angeles County Air Pollution Control District (APCD) that as far as stationary sources are concerned Los Angeles is one of the cleaner cities in the world. The industrial plants of Los Angeles—the power plants, chemical works, metal fabricators, the refineries—have co-operated, by and large, with the APCD.

The usual type of air pollution which has plagued London, Pittsburgh and St. Louis—the emission of sulfur oxides and small pieces of solid materials—is kept to a minimum. Los Angeles smog is different.

The only present major source of sulfur oxides in the Los Angeles basin is the steam power plants. They can put out as much as 270 tons of sulfur oxides a day during the five months (Nov. 15 to April 15) they burn fuel oil.

Natural Gas Burned

From April 15 to Nov. 15, because of Rule 62, the steam power plants burn natural gas. Their sulfur oxide emissions drop to three tons a day. With gas, the nitrogen oxide pollution also drops from 145 to 79 tons a day.

It is this added reduction in both sulfur and nitrogen oxides which has prompted S. Smith Griswold, air pollution control officer for Los Angeles County, to request the year-round burning of natural gas by steam power plants. Griswold's motto is: "If we don't have to put it into the air, then let's not." Gas company officials, however, feel that the added reduction in pollutants would not help the pollution problem significantly. The high use of natural gas in the winter months to heat homes comes at the same time when chances of severe

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FAN MAIL—Mrs. Grace Robertson, whose act of kindness in aiding a young sailor brought her more than 100 letters, gifts, flowers from Frank Sinatra.
Times photo

FROM SINATRA, TOO

Gifts, Letters Pour in for Kind Widow, 77

BY HOWARD HERTEL AND ARTHUR BERMAN

Few women are as widely admired as Mrs. Grace Robertson, pensioner.

Take last week. She received flowers from Frank Sinatra, candy from former Downey Municipal Judge Lynn W. Johnston, several cash gifts and more than 100 affectionate letters.

It's a sudden change for Mrs. Robertson because she was practically anonymous for the first 77 years of her life.

Then on May 16, Mrs. Robertson, a widow, stepped forward in a Federal courtroom and unwittingly delivered a simple but profound lesson in freedom and justice.

Mrs. Robertson, who likes to visit courtrooms, took pity on a destitute, 21-year-old sailor. In a note to U.S. Judge Thurmond Clarke, she offered to pay the fine anonymously, explaining:

"I do not know what his case is, but when they take a person's freedom away there is nothing left."

Impressed, the judge reduced the fine from $50 to $5 — and Mrs. Robertson paid it.

The next morning The Times told the story of the little white-haired lady with the big heart and before long her small hotel room at 426 S Hill St. was bombarded with messages of praise.

She received a large vase filled with peonies, lilacs, pink larkspur and iris — and a card:

"You're a fine person. (signed) Frank Sinatra."

Candy Next

Then came a box of candy from ex-Judge Johnston.

And there was a check from a Buena Park man for $78.95 to buy a round-trip ticket to Omaha (Mrs. Robertson had offered to pay the fine of sailor Tilden Lloyd Barnes with money she'd saved to visit the graves of her husband and a daughter in Omaha).

There were several cash gifts and a passbook and $5 deposit from American Savings, Redondo Beach.

And there were piles of letters — some from other parts of the country where Mrs. Robertson's story had been carried by wire services.

"I never dreamed of anything like this," said Mrs. Robertson. "I wish I could thank all of these good people."

Mrs. Robertson had taken

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Muslim Jury Will Weigh Case Today

The jury in the trial of 14 Black Muslims will hold its first full day of deliberation today.

The trial which resulted from a riot April 27, 1962, at the Muslim Temple, 5606 S Broadway, ended Friday afternoon, and the jury began deliberation Saturday morning.

In accordance with local court procedure, the jurors did not meet Saturday afternoon and Sunday. Instead, the jurors, who are living at an undisclosed hotel, were taken to eat and on a bus ride by bailiffs.

The defendants in the controversial case have been charged with 42 counts ranging from assault to assault with intent to commit murder.

Four Rookie Policemen Set Up Narcotics Raids

Undercover Work Supplies Evidence for 120 Arrests; One of Officers Beaten Up

Weeks of undercover work by four police rookies, one of whom was beaten savagely during the secret operation, supplied evidence for a massive weekend roundup of narcotics suspects.

At least 120 persons, 10 of them women, were arrested by more than 100 narcotics division officers who participated in the citywide raids which began at 9:30 a.m. Saturday.

Marijuana Grower

"It was the largest two-day roundup of narcotics violators in Los Angeles Police Department history," Capt. W. C. Colwell, narcotics division chief, said Sunday.

Among those caught in the raids, according to police, were:

A 20-year-old service station attendant who grew baby marijuana plants in an elementary schoolyard near his home for resale.

Grows Own Plants

"I grow my plants in the schoolyard because they get good care, are watered regularly, and I don't have to worry about them," officers quoted the suspect, Roosevelt Williams, 2515 W 132nd St., Compton, as saying.

Buzzar Stokes Jr., 1175 W 39th Pl., whom police described as a major supplier to teen-age peddlers "*who in turn sold marijuana to local high school students.*"

A four-year-old juvenile gang of marijuana peddlers whose 17-year-old leader's "office" was an abandoned auto on a vacant lot in the southeast section of the city.

Members of this gang were the ones who administered the beating to the rookie undercoverman.

ID Card Giveaway

The rookie had arranged to make a purchase from the 17-year-old who told him to be at a nearby housing development in 15 minutes. When the officer arrived there, the four boys jumped him, beat him and fled with his wallet containing $88.

The gang learned the rookie was a policeman from the ID card in his wallet. However, most of the other undercover operators who laid the groundwork and who joined in the raids did not carry identification, and none carried weapons.

Make 260 Purchases

The four rookies made 260 purchases, ranging from marijuana to heroin. These were the basis for 129 secret grand jury indictments and the issuance of several warrants which provided the basis for the weekend raids.

Police said late Sunday nearly 50 persons named in either the indictments, returned last Thursday, or the warrants are being sought.

Dinah Shore, Palm Springs Man Marry

Los Angeles Times News Service

REDLANDS—Singer Dinah Shore, 45, was married to Maurice F. Smith, 42, a Palm Springs contractor, here Sunday afternoon in a simple civil ceremony attended by her two children and his two sons.

Miss Shore's daughter, Melissa Ann, 15, was maid of honor. Smith's older son, Dexter, 12, was best man.

Only a handful of the couple's close friends and relatives witnessed the quiet ceremony performed by San Bernardino County Superior Judge Joseph T. Ciano in his Redlands home.

Housekeeper Attends

They included Miss Shore's son, John David, 10; Smith's younger son, Dana, 5; Miss Shore's two sisters, and her housekeeper, Pauline Bauman.

Miss Shore's divorce from actor George Montgomery became final May 9 and the wedding came just two days after she picked up her final decree in Los Angeles.

While the marriage came as a surprise to her friends, Miss Shore's name had been linked romantically for several months with that of Smith, who like the singer is a top-notch amateur tennis player. They met on the courts in Palm Springs where both have homes.

Judge Ciano, in addition to

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Mexican-American Tells of Holding Texas Office

Mayor of Crystal City Is Guest in City; He Still Encounters Racial Bitterness

BY RUBEN SALAZAR

Juan Cornejo, a 33-year-old teetotaler and non-smoking bachelor with dark Indian features and two gold teeth, sat in Mayor Samuel W. Yorty's Cadillac limousine talking politics.

Cornejo is mayor of Crystal City, Tex. It's an accomplishment which might best be described by saying that a few years ago it was as unlikely as it would be today for Dr. Martin Luther King to be elected mayor of Birmingham.

Here at the invitation of the Mexican-American Political Assn., Cornejo and Crystal City Councilman Antonio Cardenas are being feted by the mayor's office on down.

Change in 3 Months

"One of the beauties of democracy," Cornejo said Saturday on his way downtown from the airport, "is that about three months ago the Crystal City clerk wouldn't give me the necessary blank so I could file for political office and today I'm mayor and using Mayor Yorty's car."

Cornejo, a Teamsters Union business agent with a seventh grade education, did not become discouraged by the city clerk's snobbery. He and his four candidates for city council, all Mexican-Americans, typed out the complicated forms in five hours and waged a victorious campaign which made news across the country.

On April 2 Cornejo and his council took office as Texas Rangers patrolled the city to stop any violence.

"There was no violence and I don't expect any," Cornejo said here. "But there is bitterness and resentment in my city. I expect many are just waiting for us to fall flat on our faces but we can't afford that. Too much is at stake. Besides we're used to being mistreated. It's nothing new to us. We can survive it until things change."

Fired From Job

Antonio Cardenas, 41, the visiting councilman, knows what the mayor is talking about. Cardenas, a father of five, was fired from his truck driver's job after election. The mayor and city council jobs have no salary.

"They're trying to starve us out," Cardenas said, "but we're too Indian-stubborn to let them do it."

Crystal City has a population of 10,000 — almost 80% Mexican-American — and is about 120 miles south of San Antonio. It is the spinach-raising capital of Texas and all of the industry and farming are controlled by Anglo-Americans.

Cornejo and his council now hold all of the political power. They just appointed a

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WELCOMED—Visiting Mexican-American officials of Crystal City, Tex., are welcomed at International Airport. From left are Eduardo Quevedo, Mexican-American Political Assn. official; Antonio Cardenas, Crystal City councilman; Crystal City Mayor Juan Cornejo, Los Angeles Judge Leopoldo Sanchez.
Times photo

Hollywood Bowl Mails Programs for Summer

Seventy-five thousand illustrated folders describing Hollwood Bowl's 1963 season of summer concerts, which open July 9 with a Viennese program, will be in the mail this week.

The Hollywood Bowl Assn.'s prospectus lists 38 events of the nine-week season in one of the most diversified schedules of music and dance entertainment in Bowl history.

During the 42nd season two famous symphony orchestras, the Los Angeles Philharmonic and New York Philharmonic, will be heard, and Mexico's colorful Folklorico Dancers will have a run of five nights.

Eight Symphonies under the Stars (Tuesday and Thursday nights), nine Saturday Pops, seven Friday night extras, two Sunday nights, a Wednesday night, and a special Saturday morning Children's Concert complete the season.

Music in the season will range from the classics to Dixieland jazz. Zubin Mehta, music director of the Los Angeles Philharmonic, will head the list of 16 conductors. Leonard Bernstein will conduct the New York Philharmonic programs.

Among the "Pops" highlights will be the annual Rodgers and Hammerstein and Lerner and Loewe concerts, the perennial Gershwin night. "Song of America" with singers and dancers: Peter Nero, the pianist: Encores of American Musical Theater, and Victor Borge and his "Comedy in Music." Folk song programs, jazz and other features are on Friday "Extras."

Friends Flee, Boy Pays Price of Crime Alone

A 13-year-old boy was awfully anxious Sunday for the police to catch up with his two partners in crime.

Because if they aren't caught, the boy will have to clean up the mess they made in three classrooms at Markham Junior High School, 1650 E 104th St., all by himself.

Police said the three teenagers broke into the school and smeared mimeograph ink on walls, floors, and files.

Officers got a phone call from the mother of the 13-year-old after he told her he had taken a box of candy from the student store.

While police looked for his companions and while his mother stood over him, the 13-year-old spent Sunday afternoon at the school with a scrub bucket.

Comic Dictionary

HOUSEWORK

A form of unpleasant work to which a husband patiently gives the best years of his wife.

RETIRING—Dr. John A. Gocke and nurse Gertrude P. Stuart are impressed as Miss Nettie Stein, surgical nurse, removes her nurse's cap after more than 31 year's service at Georgia St. and Hollywood Receiving Hospitals. Miss Stein, of 4015 Council St., honored by party in her honor, plans trip around the world. Times photo

Board to Scan County Employee Health Plan

Program to Be Given to Supervisors Would Cost Taxpayers About $2 Million a Year

Revised plans for a health insurance program for county employees which may total $8 million annually and cost taxpayers between $1,776,000 and $2,052,000 a year will be submitted Tuesday to the Board of Supervisors.

L. S. Hollinger, county chief administrative officer, and a county medical-hospital plan advisory committee headed by Mrs. Marion S. Mayne will ask authorization to sign contracts for five different programs from which each employee could choose.

The county would pay up to $5 of each monthly premium. An employee would pay the remainder, ranging from less than $1 a month for an unmarried worker enrolling in the least expensive plan to $17 a month for a worker with two or more dependents signing for the most comprehensive program.

Enrollment Projection

The $1,776,000 to $2,052,000 annual cost estimates to the county are based on projections of John R. James, county personnel division chief, that 70% to 90% of the county's 37,000 to 38,000 permanent employees will enroll in one of the plans.

The supervisors passed a motion by Supervisor Ernest E. Debs on Feb. 19 to implement the insurance. The vote was 4-0 during the absence of supervisor Burton W. Chase, who has consistently said he would not vote for both pay hikes and an insurance program in the same year.

In their preliminary budget, the supervisors set aside $2 million to inaugurate the health insurance. Such an expenditure would be equivalent to 1.69 cents on the general fund tax rate for each $100 assessed valuation.

Committee Members

The insurance programs were worked out at the instigation of Mrs. Mayne's committee, which includes Personnel Officer James, County Treasurer Harold J. Ostly, Dr. Roger O. Egeberg and Edward Pratt, chairman of the Council of County Employee Organizations.

The five alternatives would be:

1—Blue Cross high option indemnity plan. Surgical benefits based on California Medical Assn.'s relative value study at $5 a unit. Hospital benefits $20 daily, plus 80% of other hospital costs.

In-hospital doctors' visits, $5 each. Emergency accident benefit, $50. Normal pregnancy, $100. All other medical costs, 80% paid after a $100 annual deduction.

Low Option

2—Blue Cross low option indemnity. Same as high option except that the "all other medical costs" category is not covered. Surgical benefits and in-hospital doctor visits paid after a $100 annual deduction.

(Maximum benefits under Plans 1 and 2 would be $10,000 for one illness and $20,000 in a lifetime.)

3—Blue Shield and Blue Cross (joint carriers) medical service plan. Same as Plan 1 except that hospital benefits would be limited to rates for a room with three beds plus 80% of other extras for 100 days of hospital confinement.

4 and 5—Comprehensive group practice medical care plans. One contract with Kaiser Foundation Health Plan and the other with Ross-Loos Medical Group and the Independence Life Insurance Co.

Committee Choices

The Ross-Loos, Independence and Kaiser contracts are recommended by the committee because many county employees already are enrolled with these groups.

The Blue Cross program is operated by the Hospital Service of Southern California and Blue Shield by the California Physicians Service. They were low bidders on the first three plans.

James explained that the county's $5 monthly expenditure for each worker would apply only to the employee's own insurance. Coverage of a spouse and dependents (through age 18) would be paid for entirely by the employee.

No medical examinations would be required to start the program, James said, however, that the drafting of final contracts, publicizing the program among employees and enrollment will prevent actual inauguration before Sept. 1 or Oct. 1, even if the supervisors approve all recommendations Tuesday.

Supervisors Seek Land Near Park

County supervisors have voted to urge the California Beaches and Park Commission to give No. 1 priority to acquisition of open space land adjacent to Puddingstone Dam State Park.

Speed was urged to prevent threatened subdividing of the property.

Latin Envoys Plan Goodwill Visit to L.A.

Twenty-five Latin American ambassadors to the United States and the Organization of American States will make a goodwill visit to Los Angeles Thursday and Friday.

They will tour Disneyland and attend a civic dinner at the Sheraton-West Thursday.

On Friday the group will attend a Solemn High Mass in St. Vibiana's Cathedral, place a wreath at the statue of Father Junipero Serra in the Old Plaza, appear at a World Affairs Council luncheon in the Ambassador and visit Universal Studios.

That night they will be guests of honor at a dinner-dance given by Mr. and Mrs. Gilbert C. Van Camp Jr. in the Beverly Hills Hotel.

VISITOR

Continued from First Page

new city manager, chief of police and municipal judge, all Mexican-American.

But they have no economic power.

"We expect to resolve this by inviting new industry and by coming to an understanding with the Anglo businessmen, ranchers and industrialists," Cornejo said. "We hold no rancor toward them. We don't want Crystal City to become another bitter cry like 'Remember the Alamo!'

"We want to forget all this and continue the progress we've made."

What about civil rights?

"Just before I left for Los Angeles, I discovered that some Mexican barbers and Mexican restaurants discriminate against Negroes," Cornejo said.

"When I go back I'll ask that this be stopped or I'll close the places."

CEMETERY UNVEILS MOSAIC OF ASCENSION

More than 600 persons attended outdoor religious ceremonies Sunday dedicating a million-piece mosaic of "The Ascension of Our Lord" at Forest Lawn-Cypress.

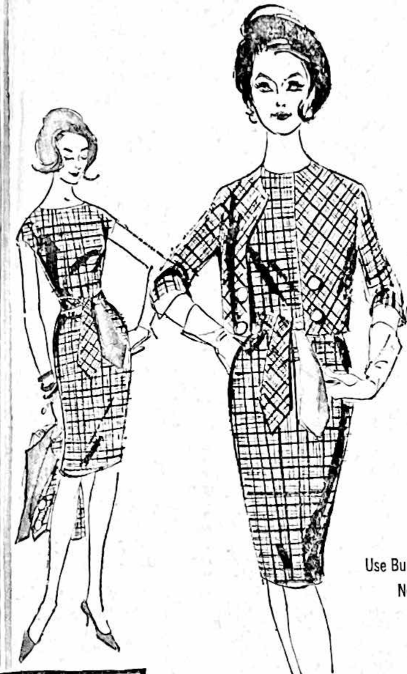
Unveiled as a highlight of Ascension Sunday, the 30x28½ ft. mosaic required four years to plan and construct.

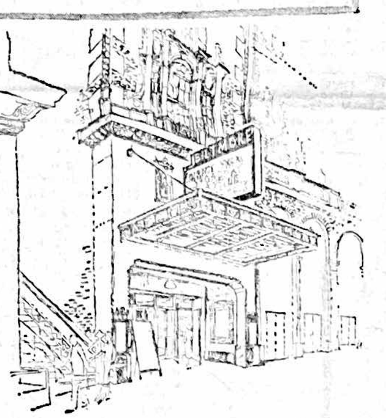
In imported Venetian glass tile, it consists of 3,000 shades of color and is a reproduction of John La Farge's famed painting in the Church of the Ascension, New York.

The Rev. Louis H. Evans Jr., pastor of Bel-Air Presbyterian Church, said in his dedicatory message, "The Ascension of Jesus provided the world with hope, as proof that death has no victor."

Fred Llewellyn, Forest Lawn executive vice president, said the mosaic carries out Forest Lawn's program of bringing the public great religious and patriotic art.

The 32-voice choir of the First Baptist Church, Long Beach, participated and the Rev. H. Carl Roessler, pastor of the Bethlehem Lutheran Church, Los Alamitos, presided over the ceremony.





Area's Smog Primarily Due to 'Moving Sources'

Continued from First Page

smog are small. They feel it unwise to add the burden of supply to industrial heating to this already high consumption by homes.

APCD has its hands full. The battle is never-ending to keep the Los Angeles area from getting worse than it is. Every month the District receives about 320 applications from new industries, or the expansion of older factories, which are involved in operations which possibly could pollute the air.

The major smog headache of the huge megalopolis we call Los Angeles is due to moving sources—and it is certain to get worse as the population increases.

The trouble with the automobile is that it is a unique source of air pollution. It is the "triple-threat" of smog. It represents the only man-made activity which puts out all three major sources of air pollution — carbon monoxide, oxides, of nitrogen and hydrocarbons — in staggering amounts.

But this sad tale begins long before you climb into your car and turn the ignition key.

Automobiles need fuel to run. The fuel, gasoline, is a mixture of materials, made up of carbon and hydrogen atoms, known as hydrocarbons.

Much Evaporates

Gasoline comes from petroleum, which is pumped from the ground. In the pumping operation, some of the petroleum hydrocarbons are lost by evaporation into the air. How much? Sixty tons a day.

The petroleum, now above ground, is changed into gasoline at refineries. Refineries also lose hydrocarbons to the air. Eighty-five tons a day.

Have you ever watched your car's gas tank being filled at the service station? Notice the shimmery, wavy air around the nozzle stuck into the gas tank. The waviness is due to the fumes of escaping hydrocarbons. You can smell them.

Each time gasoline is transferred, hydrocarbons escape. The refinery fills the storage tank, which fills the tank truck, which fills the local filling station's tank, which finally fills your car tank. About 120 tons lost per day.

Refineries have installed devices to keep their transfer loss to a minimum.

So long before you begin to drive your car, the production and marketing of fuel have made significant contributions to the day's smog problem. Incidentally, a large tank truck can lose about one ton of hydrocarbons during the time it moves through the city to make deliveries to service stations.

It is from Los Angeles' 3.5 million automobiles, however, that the largest hydrocarbon losses take place.

The automobile pollutes the Los Angeles air lake with hydrocarbons coming from three places: by evaporation from the gas tank (205 tons a day); "blow-by" loss in the engine itself (390 tons per day); loss of unburned hydrocarbons through the exhaust tail pipe (1,030 tons per day). Total: 1,625 tons of hydrocarbons a day.

To burn gasoline in your car requires oxygen from the air. Air is a mixture of oxygen and nitrogen. Although the car engine needs only the oxygen, the nitrogen in the air comes along with it.

The temperature of a car engine can get high enough to produce oxides of nitrogen, which also pour out of auto exhausts at the rate of 485 tons per day.

The only other major nitrogen oxide producers in the Los Angeles basin are the steam power plants. They have co-operated in the adjustment of their boiler burners to keep their nitrogen oxide emissions to a lower level.

Nor is the automobile finished yet. It also bestows 8,115 tons of carbon monoxide daily upon the Los Angeles atmosphere. There is no doubt about the central role played by moving sources in the smog woes of Los Angeles.

The San Francisco area is far behind Los Angeles in the control of its smog sources. Present estimates are that stationary sources account for 60%, and moving sources the remainder of the smog problems of the Bay area.

Cases Different

Each day's smog, whether that of San Francisco or Washington, is a different case. The steps taken to clear up the air of one metropolitan area may not apply to the air pollution problems of another.

It is important to emphasize again that Los Angeles has been fortunate in that the excellent work of the APCD began the control of stationary sources at an early date. If we now had a serious air pollution burden from stationary sources—in addition to the miserable smog created by the automobile—the citizens of Los Angeles probably would have to evacuate.

The smog problem hinges on this point. No matter how small, every bit of pollution kept out of the air counts.

Industrial uses of hydrocarbons, such as spray painting, degreasing of metals, cleaning operations, etc. put another 295 tons of hydrocarbons into the air each day—plus 130 tons of assorted organic vapors potentially capable of adding to the smog.

Diesel trucks and aircraft contribute to smog only in a minor way. Although one may see the exhausts from a Diesel engine, or from a jet aircraft on take-off, and smell them, they play insignificant roles in the Los Angeles smog situation.

It is the invisible exhausts of automobiles which do the trick.

Tuesday: How air pollutants are converted into smog.

WIDOW'S LETTERS

Continued from First Page

pity on young Barnes, an Atlanta (Ga.) sailor charged with unauthorized use of a motor vehicle.

The handsome sailor, who still faces a Navy a.w.o.l. charge in San Diego, was amazed but thankful for his unexpected benefactor.

"I just felt sorry for that boy," said Mrs. Robertson. "He seemed so alone.

"I lost a daughter when she was 21 . . . I can't help her anymore, but I can help others."

Since then, Mrs. Robertson has been checking with naval authorities on the progress of young Barnes, who still awaits court-martial.

The flowers from Sinatra "nearly floored me," said the soft-spoken woman. "I've always admired him. He's a good fellow. He's had his troubles, but he's learned from experience.

"I know I learned from experience—and I'm still learning."

Looking at her letters and gifts, the elated Mrs. Robertson explained:

"I've helped lots of people, but they didn't know it. I guess I didn't get away with it this time.

"I don't care about myself, though. I'd like to see that young man get out of the brig. I hope the Navy is charitable. He was in the County Jail nearly three months. He paid enough."

Purchasing Parley

County Purchasing Agent Fred Calin will participate in the governmental purchasing section of the National Assn. of Purchasing Agents' annual convention Saturday through June 5 in Atlantic City

DINAH

Continued from First P

being a close friend of Miss Shore and Smith, al a tennis enthusiast. He the couple notified hin their plans Friday.

Miss Shore said: "I ha thought of getting mar this soon. But it's a wom prerogative to change mind."

The couple refused disclose their honeym plans. But Smith said t probably would spend week motoring through N thern California before turning to Palm Spi where they plan to live.

Ex-Employees to Me

Retired county employe will discu health insu ance, retirement legislati and picnic plans at a me ing at 1 p.m. Wednesda June 5 in Patriotic Hall.

WORLD WATCHES L.A. SMOG BATTLE

Poisons Previously Unknown in Nature Brewed Up in Poorly Ventilated Basin

BY IRVING S. BENGELSDORF, Times Science Editor

Los Angeles smog is a witch's brew cooked up in the sunshiny caldron of its poorly ventilated geographical basin.

Third of a Series

Some of smog's foul ingredients have never before been known to man; they do not occur in nature.

These pollutants, previously unknown but now identified by science, are called peroxyacylnitrates (PAN). They are found only in the filthy, polluted air of Los Angeles, in particular, and of large metropolitan centers, in general.

Fatal to Plants

PANs are hellishly vile materials. They damage and kill plants and vegetables. They irritate, sting, and burn the eyes. What they do to people is unknown, at present.

The air you breathe contains them, and the damage they do to plants has been detected in 20 of our states.

Make no mistake. The rest of the world is watching Los Angeles. We are considered experimental "animals" frequently being exposed to fumigation with relatively unknown objectionable gases.

Man feels that the use of poison gas is inhumane, yet each day the inhabitants of Los Angeles, and other big cities literally and figuratively are involved in "chemical warfare" — gassing themselves with obnoxious pollutants in the air.

Principal Course

The PANs arise chiefly from the automobile. Auto exhausts and the production and marketing of gasoline put enormous tonnages of hydrocarbons into the air daily. Auto exhausts and steam power plants spew nitrogen oxides into the same air. The hydrocarbons and the nitrogen oxides combine in sunlight to produce an impressive number of pollutants — among which are the PANs.

The pollutants in Los Angeles smog are of three types: primary, secondary, and those which are both.

Primary pollutants are offensive materials which come out of auto exhausts and smoke stacks and are

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Pair Who Gas-Bombed Church Here Sentenced

Michael and Patrick Porter, 18-year-old twins, were committed Monday to the California Youth Authority for tossing a military gas grenade into a crowded church parish hall Jan. 25.

In committing the youths, Superior Judge John G. Barnes said it was "a wonder there wasn't a stampede in which someone could have been seriously injured."

Michael, a private in the Marine Corps at Camp Pendleton, admitted throwing the bomb, which caused 50 persons to be treated with inhalators and another 16 given hospital treatment.

Michael said he thought it was a "practice bomb" and would only make noise "that would scare some people" in St. Albert the Great Catholic Church at 794 E Compton Blvd., Compton.

The twins gave their home address as 1341 W 164th St., Gardena.

Comic Dictionary

CHEF

A head cook with a limited number of dishes but an unlimited number of names for them.

SMOG BATTLE

Continued from First Page

obnoxious in themselves. Nothing further has to happen to them; they are disagreeable as soon as they are emitted into the air.

Plague of London

The best known of these is sulfur dioxide, the material which plagues London and other coal-burning cities. Fortunately, through the vigilance of the Air Pollution Control District (APCD) and industry co-operation, sulfur dioxide is kept to a minimum here.

For a city of its size, the sulfur dioxide problem of Los Angeles is small indeed. As little as 130 tons a day are emitted during the Rule 62 period (April 15 to Nov. 15) when steam power plants burn natural gas instead of fuel oil.

The other major primary pollutant is carbon monoxide. In this, Los Angeles is not so fortunate. Of the 8,580 tons of carbon monoxide poured daily into the Los Angeles air lake, 8,115 tons come from the automobile; it is a unique source of carbon monoxide pollution.

Odorless Gas

Carbon monoxide is an invisible and odorless gas which doesn't sting the eyes. For these reasons, it may turn out to be the most treacherous of all pollutants. Since it comes out of auto exhaust directly, it differs from most other components of Los Angeles air pollution in that it is present whether the sun is shining or not. It is a potential menace both day and night.

Carbon monoxide is a sneaky poisonous gas. It combines with hemoglobin, the material in our blood stream responsible for carrying vitally needed oxygen to our body cells.

Once the hemoglobin takes on carbon monoxide it becomes very difficult for oxygen to "cut in" to take its place. A carbon monoxide-poisoned individual dies from lack of internal oxygen.

Serious Level Set

Safety experts feel that an individual will not begin to experience ill effects until 10% of his hemoglobin is tied up with carbon monoxide. The California Department of Public Health, therefore, has set one-half of this figure (5% of hemoglobin disability) as the serious level for carbon monoxide in our air. This value comes to about 30 parts per million (ppm) over an 8-hour period.

On several occasions, the air lakes of both Los Angeles and Sacramento have exceeded this standard. Some days it has run as high as 45 ppm. The highest value recorded, thus far, was in Los Angeles: 78 ppm over a one-hour period.

Effect on Smoker

Urban residents obviously suffer from a chronic low-level hemoglobin inefficiency. A heavy cigarettee smoker in Los Angeles on a high carbon monoxide day may cripple seriously his blood's ability to carry oxygen properly.

Secondary pollutants are substances which come out of auto exhausts and which are relatively harmless in themselves. Something further has to happen to them to change them into obnoxious materials.

It is this type of pollutant that distinguishes Los Angeles smog from that of London.

The major secondary pollutant in our urban areas are the hydrocarbons which come from gasoline — either directly from its production and marketing or as unburned fuel from the auto engine.

Undergo Change

In the presence of sunlight, hydrocarbons undergo photochemical change into a long list of obnoxious materials, among them the PANs and others responsible for eye irritation and reduced visibility.

Photochemical air pollution (PAP) is what we know as smog. It is particularly severe in Los Angeles and is slowly turning America into the Unbeautiful — its alabaster cities no longer gleam, and they are dimmed by human tears.

The important photochemical role of hydrocarbons in the production of Los Angeles smog was demonstrated as long as 12 years ago by the pioneering experiments of Dr. Arie J. Haagen-Smit of Caltech.

The third type of offensive material: the oxides of nitrogen which are both primary and secondary pollutants.

Nitrogen dioxide consists of one atom of nitrogen and two of oxygen. It is a reddish-brown colored gas with an objectionable odor. It is quite toxic. In this respect it is a primary pollutant. Its major sources are auto exhausts and steam power plants.

American industry only permits 5 ppm of nitrogen dioxide as a safe level. Over an 8-hour period, this amount of the gas temporarily will decrease the ability of the lungs of animals to function properly.

Usual concentrations of nitrogen dioxide in Los Angeles air run around .2 ppm. On about five occasions, the level has reached 1 ppm, and in 1960, Burbank recorded a level of 1.3 ppm of nitrogen oxides over a four hour period.

That is the state's most severe nitrogen dioxide exposure, thus far. The air above Burbank happens to be one of the most stagnant "air ponds" within the stagnant Los Angeles basin air lake.

Have No Effect

Two automobile exhaust controls, the "Blow-by" and the tailpipe devices, are scheduled to reduce the carbon monoxide and hydrocarbon emissions from cars. They will do nothing about reducing the torrent of nitrogen oxides, as much as 850 tons a day during the non-Rule 62 period.

In addition to being a toxic primary pollutant, the major difficulty with nitrogen dioxide is the role it also plays as a secondary pollutant.

It is the key actor in the drama which begins in the air around us each morning. In the presence of sunlight, nitrogen dioxide gives away one of its oxygen atoms to the oxygen in the air.

Oxygen in air is a duet of two oxygen atoms. The addition of a third oxygen atom changes it into a material known as ozone, an extremely reactive substance.

Ozone attacks — and cracks — rubber articles, such as the side walls of your tires. It combines with the hydrocarbons from gasoline to give materials which, in turn, reduce visibility, damage plants, and cause eye irritation.

Then, adding insult to injury, the nitrogen dioxide — having indirectly produced ozone, which kicked off these numerous photochemical changes — itself becomes part of one of the most vile components of smog, the PANs. Nitrogen dioxide is the triple villain of Los Angeles smog. It is toxic itself. It helps to make ozone, and is an important part of the PANs.

The Air Pollution Research Center (APRC) at the University of California at Riverside is the world's center for PAN-research. It has the know-how to make large amounts of these unusual chemicals whose very existence was unknown a decade ago.

The detection and identification of the PANs in Los Angeles smog is largely due to the trail-blazing research techniques of Dr. Edgar R. Stephens. He presently is associated both with the APRC and the Scott Research Laboratories, Inc. at San Bernardino.

Next — The latest research into PANS, the only pollutions in smog which both kill plants and cause eye irritation.

County Percodan Law Ruled Out by Counsel

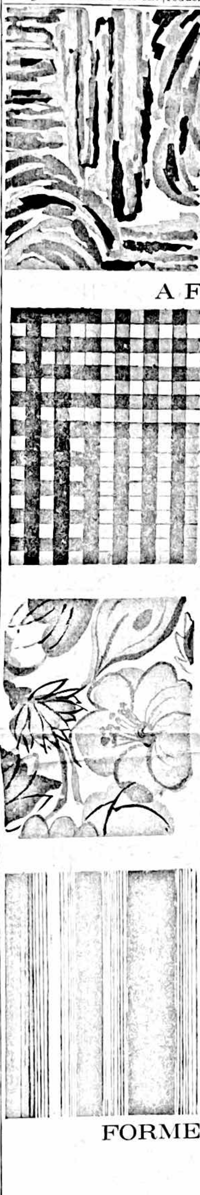
County Counsel Harold W. Kennedy ruled Monday that any county ordinance regulating the controversial drug Percodan would be in direct conflict with state law.

He also expressed belief that courts would hold the Legislature has already occupied the field of such drug control.

Supervisors chairman Warren M. Dorn, who had suggested a county law, said he will move today to urge Percodan control by amending other bills on dangerous drugs now pending before the State Legislature.

He said he will ask the county counsel, district attorney, county health officer and sheriff to push for such amendments.

He also will ask the same county officers to work with Los Angeles County Medical Assn. officers for a voluntary control of Percodan by doctors.



SMOG DAMAGE IN SOUTHLAND SOARS

Loss in State, Especially Among Leafy Vegetables, Placed at $12 Million a Year

BY IRVING S. BENGELSDORF, Times Science Editor

Smog first moved into the Los Angeles basin about 1942.

Along with reduced visibility, rubber cracking and eye irritation, there was damage to plants, especially to such leafy vegetables as spinach, Romaine lettuce, endive and pinto beans.

Dr. John T. Middleton, plant pathologist and director of the Air Pollution Research Center at the University of California at Riverside, first described this unusual agricultural damage in 1944.

Loss $12 Million a Year

He now estimates that California farmers lose about $12 million annually to smog. No agricultural area is immune to this gray "disease" of urban development.

From the Carolinas to Canada, the smoggy eastern seaboard of North America suffers about $20 million yearly crop damage. Tobacco in Connecticut, vegetables in New Jersey and spinach on Long Island all are its victims.

Cotton, alfalfa and grapes —California's three most important crops— are extremely sensitive to the photochemical air pollution we call smog. About 10 different kinds of vegetables grown in the Los Angeles basin in the 1940s no longer can be cultivated here. The last spinach farmer gave up in 1955.

Spinach now is grown in Ventura and San Diego Counties — but smog is spreading into these areas and spinach again will have to move.

Other Counties Affected

Ventura County, which incidentally has no Air Pollution Control District, suffered more than $100,000 agricultural damage last year. The San Luis Rey Valley near Oceanside also is closing up shop with respect to spinach; it no longer can be grown there.

Smog's damage to plants

Fourth of a Series

arises mainly from two materials; ozone and peroxyacylnitrates (PAN). Both in turn are "manufactured" in the sunshiny air around us from hydrocarbons (auto exhausts and gasoline production and marketing) and nitrogen oxides (auto exhausts and steam power plants).

Each affects plants differently. Ozone attacks the upper sides of older leaves while PAN goes after the bottom sides of young leaves. Ozone damage shows up as a mottled or spotted bleached pattern. PAN damage causes the leaf's underside to become glazed and to turn a bronzed or silvered, metallic color.

Struggle to Live

Smog sensitive plants which survive in a polluted atmosphere have to struggle to stay alive. They show reduced growth and weaker stem structure. And smog-stunted plants grow more slowly because of unknown subtle internal changes.

Dr. Ellis F. Darley, plant physiologist at APRC, has spent more than 12 years investigating smog damage to plants. He says: "There obviously are levels of smog which people do not complain about, but which seriously hinder plants without killing them."

Plants growing in smog cannot take carbon dioxide from the air, to make their food by photosynthesis, as fast as can a plant grown in filtered air. And their uptake of water from the soil also is decreased. All in all, a smog-afflicted plant has its branches full just trying to keep alive.

This has led Dr. Ruth Bobrov-Glater, botanist at UCLA, to advise home gardeners not to throw plants away if they don't grow well at first. Be patient. It may take them months to get going in polluted air.

Ponderosa pines in Southern California, in general, and in the San Bernardino mountain area, in particular, have been shedding their needles and dying prematurely; the mysterious malady is known as "Disease X". It now is known that the true killer of the pines is ozone in smog.

Ponderosa pines fumigated with ozone show the same type of premature needle drop as seen in nature. Eastern white pines, particularly those near TVA steam power plants in Tennessee, also show similar needle shedding damage.

Miniature Version

It is thought that in the presence of sunlight, nitrogen dioxide from the smokestacks of power plants combines with hydrocarbons (from the turpentine sap of the trees) to produce a miniaturized version of Los Angeles smog. Here is a case of photochemical air pollution in which the hydrocarbons, instead of coming from man's activities, are supplied directly by nature.

The biochemical details of how ozone and PAN attack and damage plants are being vigorously studied at UC Riverside.

Dr. Lawrence Ordin of the department of biochemistry has shown that either ozone or PAN can destroy a material known as indoleacetic acid, extremely important for proper plant growth.

In addition, he finds that fumigation of oat leaf sections with PAN seems to knock out the mechanisms the plant has for using

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SMOG DAMAGE

Continued from 8th Page

sugars to build its cell walls. No use of sugars, no cell walls, no proper growth.

Dr. Ordin's research suggests that PAN does its "dirsty work" by destroying or altering enzymes, those remarkable biochemical "supervisors" which keep the wheels of life turning. One other clue pointed in this direction.

Dr. W. M. Dugger Jr. and Dr. O. C. Taylor of APRC had observed that damage to plants was not as severe when intense smog occurred late in the day. This led to the surprising discovery that PAN damages plants only in sunlight. A plant fumigated with PAN in the dark is untouched.

It appeared that PAN was fouling up photosynthesis, the process through which the plant makes its food in the presence of sunlight. Again, this suggested interference with some enzyme.

Scientific Evidence

In a series of interesting experiments, Dr. J. Brian Mudd, biochemist with APRC, now has shown that PAN indeed does knock out enzymes. It particularly goes after an enzyme known technically as glucose-6-phosphate dehydrogenase (G-6-PD).

PAN specifically attacks a certain portion of this enzyme called a sulfhydryl group.

The evidence is good. The behavior of PAN in its attack on the enzyme is similar to that of other materials which are known to "poison" G-6-PD by alteration of the latter's sulfhydryl group.

Dr. Mudd's experiments now have provided a clincher. There is an enzyme from the pancreas known as ribonuclease which is known not to contain any sulfhydryl group. If PAN is a biochemical villain because it attacks the sulfhydryl group of enzymes, then it should have no effect upon ribonuclease. It doesn't.

The above work represents the first clues in our understanding of the subtle possible biochemical changes brought about by smog pollutants. We are woefully in need of more information.

Disturbing Feature

The disturbing feature about Dr. Mudd's research is that enzymes such as G-6-PD are universally distributed throughout nature. They occur in spinach, tigers and in man. They are an important part of living creatures.

If PAN brings about plant damage by tampering with enzymes, what effect does it have on man? We don't know—but we continue to breathe it in smoggy air.

We don't even know its effect upon other animals. Dr. L. Otis Emik, U.S. Public Health officer and professor of biology in residence at UC Riverside, is to investigate the effects of PAN upon mice. Preliminary results, using PAN concentrations higher than those found in Los Angeles air, indicate extensive lung damage to the mice. Dr. Emik's research has just gotten underway.

At the Allan Hancock Foundation at USC, Dr. Ruth Bass-Weg is to conduct a research program on the effects of smoggy air upon the G-6-PD and other enzyme levels in animals exposed to Los Angeles air pollution. Both animal programs obviously are of great interest.

Other Experiments

Experiments involving the inhalation of PAN by humans will be carried out this summer by Drs. Leon Smith and Ellis F. Darley of APRC. Young men, nonsmokers and in good physical condition, have volunteered to exercise on an experimental unicycle. Records of their heart rate, breathing, and lung capacity will be made while they breathe "pure" air and while they inhale PAN in amounts found in air on smoggy days.

The PAN-human experiments point up an interesting aspect of the Southern California smog problem. Dr. Smith wants to observe the behavior of human subjects when breathing PAN as compared to their performance when breathing "pure" air. The problem is: where in Southern California can one find "pure" air? One can't. Even at UC Riverside air is impossible to clean up—even with multiple filters.

So, Dr. Smith will "manufacture" his "pure" air as needed.

Next: The medical aspects of smog.

New Tourist Folder Extols Southland

A new foreign tourist folder describing the wonders of the Southland, and printed in French, Italian, Spanish, German and English, was issued Tuesday by the All-Year Club of Southern California.

The folder was introduced at the spring meeting of the All-Year Club board of directors in the Biltmore by Don Thomas, managing director.

Thomas reported that between Sept. 1 and March 1 almost 2.2 million persons visited Southern California, slightly more than in the same period the year before.

During the entire 12 months, he said, a record total of 5.2 million tourists came here and spent $743 million.

Last month the club asked the county for $884,357 to finance its 1963-64 national advertising campaign.

Julie London

SMOG CONTROL UP TO AUTO MAKERS

Crankcase Devices to Become Compulsory Jan. 1 Are Only Partial Answer to Problem

BY IRVING S. BENGELSDORF, Times Science Editor

We have nothing to replace it with now, but at some point in the future the automobile engine as we know it must be drastically changed if we are to eliminate smog.

Sixth in a Series

This is the almost unanimous opinion of California scientists and engineers, who feel the present day auto, so vital to our way of life, is posing a serious problem to our mushrooming population.

Photochemical air pollution, or smog, is the "gray plague" of civilization in general and the crowded masses of people in cities in particular. The greater the urban population, the greater the number of cars, the more severe the smog.

Under Lakes of Air

Each city in the world lies submerged under a lake of air, some lakes more stagnant than others.

On any given day weather conditions may permit greater than usual amounts of pollutants to accumulate. This can result in reduced visibility, plant damage and eye irritation.

For Los Angeles, the delicate balance between the ability of its air lake to hold and get rid of pollutants, and the ability of its inhabitants to pump more of them into the air, was reached and surpassed in 1942. The Los Angeles air lake will never be the same—at least in the foreseeable future.

May Never Return

The anticipated growth of the population of the Los Angeles basin to approximately 18 million poses the serious question of how long we can use gasoline-burning automobiles as we know them—no matter what devices are added.

Crankcase and muffler-type devices now being considered by the Motor Vehicle Pollution Control Board (MVPCB) to control auto exhausts will not get rid of smog. We will not return to the clean and pleasant Los Angeles air lake of 1940.

Dr. Philip A. Leighton, professor emeritus at Stanford University, has drawn a chart which shows how future population increases will wipe out any gains made by the use of control devices.

His figures, subject to change, of course, estimate that the Los Angeles air lake of 1970 will be polluted with the same amount of hydrocarbons as were in the basin's air lake of about 1947. From 1970 on, the amount of hydrocarbons in the air starts climbing again. As long as our primary means of locomotion is the internal combustion engine, in short, it looks very much as though we are in a losing battle.

Just Buying Time

At best, if all present cars were equipped with crank case and muffler devices, and they were operating properly, we would just be "buying time"—keeping our heads above water while we look for a new type of power plant to drive our cars.

At worst, the removal of a large portion of the hydrocarbons by the tailpipe devices possibly may change the nature of the photochemical pollutants. We may substitute one disagreeable evil for another.

The situation in Los Angeles is sufficiently acute, however, to leave little choice but to use devices. Every bit of pollution we keep out of the air will help.

Beginning this year, all new cars built in America are equipped with "blow-by" devices to reduce the loss of hydrocarbons from the engine crankcase.

Estimates of the amount of hydrocarbon reduction by these devices range from as high as 40% to as low as 20%. The higher value, claimed by Detroit manufacturers, may apply to a new car; the figure drops as the cars age.

Starting Jan. 1, 1964, everyone in California who owns a car, bus, or truck—new or used—will have to install a state-approved crankcase device.

The cost of the device and its installation will run between $15-18 if the mechanic knows what he is doing; it could run as high as $35. Failure to install the device will mean you cannot register the vehicle.

At present, there is no definite date set as to when the more expensive exhaust devices—if and when they are developed and approved—will be installed on new cars. They may never be approved for older cars; they can cost as much as, or more, than such cars are worth.

Two Types of Device

Exhaust devices to reduce hydrocarbons and carbon monoxide are of two types: catalytic and afterburner. The catalytic type contains a chemical material which will aid in the more complete burning of gasoline hydrocarbons coming from the exhaust. The afterburner will do this by ignition with a spark plug.

Both kinds of exhaust devices have advantages and disadvantages. Neither, however, will be of any use if a law is not passed to permit the state to inspect the devices at definite intervals.

Neither the blowby nor the exhaust device will cut down on the amounts of the emitted nitrogen oxides, the materials so important in photochemical air pollution. This is why the "nitrogen oxides line" in Dr. Leighton's chart keeps going straight up, without any dip seen for the hydrocarbons. Thus, there may be need for a future third device.

Hundreds of Schemes

Hundreds of schemes have been proposed to reduce emissions from the internal combustion engine. The fact that none has been adopted points to the serious engineering problems involved.

In view of this, Donald A. Jensen, executive officer of the MVPCB, and his staff are proceeding cautiously in the election of devices for state approval.

Up to now, automobiles have been manufactured for performance and economy, not smog-abatement. Some current Detroit research is in the direction of engines which produce reduced emissions. The "Stratified-charge" engine has the fuel injected in such a way that more of the gasoline is near the spark plug, and less elsewhere. This may result in more complete combustion.

Little detail is known about the turbine engines' exhaust with respect to potential smog formation.

Change of Fuel Tried

Some engineers have approached the pollution problem through change of the automobile fuel to liquefied petroleum gas (LPG). Preliminary tests indicate that engines burning such fuel still emit large amounts of olefins, the kind of hydrocarbons which are potent in photochemical air pollution. In addition, the fuel, kept in cylinders under pressure, could be extremely hazardous in the event of accidental collisions.

Nor are electric automobiles the answer—at present. In addition to poor performance, their use would demand the generation of more electrical power, which simply may shift the chief source of pollutions from the automobile to the steam power plants.

Problems Increasing

Electrical power from nuclear fission creates a new pollution problem—the disposal of large amounts of radioactive wastes.

California's population is expected to double by 1980. As long as we continue to live the way we do, our air pollution problems will become more and more severe. For in the final analysis, the smog woes of Los Angeles, or any other large technologically-based city, are due to the amazing population increase.

We desperately need sources of energy, such as solar, thermonuclear, or fuel cells, which emit little or no pollutants.

The harness of thermonuclear energy for relatively pollution-free power generation is the number one challenge to our society. It not only is an exciting scientific and technological challenge but is the hope of the future both for affluent America and the underdeveloped nations.

Sunday: What CAN we do about smog?

Times METROPOLITAN NEWS

Times Mirror Square, Los Angeles 53, Calif. MAdison 5-2345

Multiple Offensive Needed to End Smog

Solution to Big Problem of L.A. Air Pollution Will Be Slow, Costly

BY IRVING S. BENGELSDORF, Times Science Editor

There is no magic wand which, once waved, will rid Los Angeles, or any large metropolitan area, of air pollution. Scientists and engineers feel that the closest we can come to defeating smog by attacking on only a single front would be to replace or change drastically, the internal combustion engine of our present-day automobiles.

Last of a Series

Such magic lies in the distant future. With all its shortcomings as the major source of smog, the automobile is, and will be, very much with us.

We cannot, then, get rid of our "dragon" with one mighty stroke of a sword. Rather, we must hack away, here and there, keeping the dragon at bay, until our scientific "St. George" arrives with an engine that will not spill pollutants into the air.

Numerous suggestions have been made. All involve a price to pay—and the price may be high.

Small Cars Help

Los Angeles air pollution easily could be cut 60-70% if everyone drove a car small enough to get 35 miles of gasoline per gallon. There would be substantial corollary benefits: such cars also would be economical to operate and would ease the parking problem.

Detroit auto manufacturers could build such a car specifically for California, just as other manufacturers, in the past, have made specific products for this area. The car would not perform as well, be as comfortable, or carry as many passengers as present automobiles, but that would be part of the price one would have to pay to enjoy cleaner air.

Mass transportation, too, is intimately tied up with the smog problem. Fewer cars on clogged freeways would mean fewer pollutants spewed into the air.

But perhaps the most essential point to remember in this big and complex campaign is that clean air is everyone's responsibility every day of the year—not just during a severe smog period.

Just as we have signs reminding us not to be a litterbug, it is possible that we need signs to remind us continuously of our duties to keep air pollution to a minimum.

If every rush-hour driver shared-the-ride with one other fellow commuter, the number of cars on the freeway would decrease by half—a significant gain in the constant battle against smog.

Traffic Jamming

We must improve our flow of traffic. The purpose of the freeways is to keep traffic moving, although not necessarily at the 65 m.p.h. speed limit.

Traffic moves at high speed in the outlying districts, then slows to a snail's pace, often stopping, as one approaches downtown. These stop-and-go-crawls are the very conditions which

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Pilot Killed, 8 Escape in Plane Crash

Flier Drowns, Sky Divers Safe as Craft Falls in Lake

Los Angeles Times News Service

VENTURA—A veteran pilot drowned Saturday afternoon when his single-engine plane crashed in Lake Casitas and his pants leg got caught as he tried to scramble to safety, investigators said.

All eight sky divers he was carrying aloft managed to get out of the plane and make it to shore safely with the help of boaters.

The victim, Robert Reddick, 45, of Santa Paula, had taken off from a small airstrip beside the lake and climbed to about 500 ft. when his engine failed.

Hundreds See Fall

Hundreds of boaters on the lake heard the sputtering engine and saw the plane plunge toward the lake. The aircraft's landing gear apparently hit first, causing the plane to flip onto its back near shore.

Reddick, owner of the Piru Flying Service, was trapped in his seat and drowned. Sheriff's deputies said he apparently couldn't get his pants leg untangled as he struggled in the submerged cabin.

None of the sky divers was seriously injured. Tom Elson, 21, of 8106 Moonbeam Ave., Panorama City, suffered a cut chin, and Ladd Caine, 20, Santa Barbara, swallowed water and was given artificial respiration. Both were treated at Ojai Valley Hospital and released.

On First Flight

Caine was participating in his first sky diving flight.

The other passengers were Lester Flick, 30, Mint Canyon; Don Woerner, 26, Mint Canyon; Jerry Brooks, 23, of 13950 Remington St., Pacoima; A. L. Gonzalez, 30, Inglewood; B. J. McKinney, 24, a sailor stationed at Point Mugu, and Lane Smith, 22, of 911 14th St., Manhattan Beach.

Fishermen and boaters at the resort area 10 miles west of here used ropes to pull the fallen aircraft to shore.

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Inadequate Shelters Seen as Mass Graves

Perils Other Than Blast, Radiation Cited in Report Approved by Defense Experts

BY WALTER AMES

Public shelters constructed without careful consideration not only of blast and nuclear radiation but of heat, ventilation, flooding and noise will be a waste of money and, in effect, could become mass graves.

This is the warning contained in a 94-page report prepared for the City of La Mirada by eight engineers and released after screening by the U.S. Department of Defense.

It was made public as a House armed services subcommittee began prolonged civil defense hearings in Washington.

Some federal officials contend lives can be saved for $15 each, but critics charged before the House group that shelters might turn into death traps for millions.

The report may also have a bearing on plans by Joseph Quinn, Los Angeles City Civil Defense Director, for a voluntary stocking of 149 designated shelters in the city on June 8 and 15. These shelters, Quinn admits, have been surveyed for fallout protection only.

The La Mirada report was submitted to the Department of Defense under the signatures of R. L. Danson, La Mirada mayor; Hilton Fabre, W. T. Long and N. W. Wilson of Nortronics Corp; and four Hughes Aircraft engineers, E. Oliveras, M. Johnson, F. J. Fabre and D. Wendland.

Fabre, who originated the

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FLOWERS, CARDS AT CRYPT

Marilyn Monroe's Birthday Observed

Marilyn Monroe had a birthday Saturday. It did not go unremembered.

More than a dozen floral remembrances and cards were placed in front of her crypt in Westwood Memorial Park.

The movie beauty, killed by an overdose of sleeping pills last August, was born in Los Angeles on June 1, 1926. She would have been 37 Saturday.

A caretaker said visitors had not appeared in large numbers. "They've been drifting by in ones and twos the last several days," he said.

One large bouquet bore a pink ribbon with gold lettering that spelled out "Happy Birthday."

Attached to another cluster of flowers was a card that read, "Happy birthday, Marilyn Monroe, from Kay Carr."

A cemetery spokesman said Kay Carr was a little girl in Deerfield, Ill., and that she had sent $2 for flowers for Marilyn.

There were two dozen red roses with the message, "In memory of your birthday, never to be forgotten, Sgt. R. L. Workman."

Another bouquet carried these words, "Happy birth-

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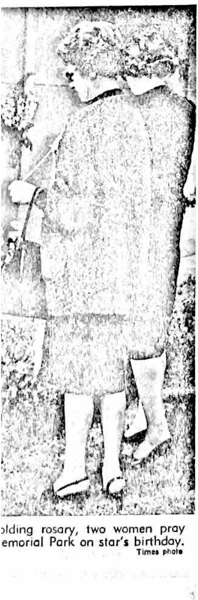

olding rosary, two women pray
emorial Park on star's birthday.
Times photo

Smog-Control Seepage

California's Problems With Auto Devices Suggest Rough Road for Nationwide Plan

By PAUL E. STEIGER
Staff Reporter of THE WALL STREET JOURNAL

LOS ANGELES—Despite some early success, California's automobile smog-control program is producing some disquieting evidence that new antismog devices aren't all they're cracked up to be.

Statistics gathered to date are hardly conclusive, but studies suggest the costly new exhaust-control systems, which supplement older crankcase devices, lose some of their effectiveness as cars accumulate mileage. Also, car owners are complaining that the new systems are causing engine problems—enough so that the year-old cars without the systems appear to run better than newer models with them.

Then there's the problem of what to do about cars built prior to 1963, when smog-control legislation became effective. Some 2 million of the state's 8.5 million cars don't even have the simple crankcase device, which any licensed mechanic can install for about $14. And this is four years after the devices were originally approved, in 1962. The far more complex systems that control exhaust are so far being required only on new cars, and there's no answer in sight as to how to get them onto older vehicles at reasonable cost.

All three problems suggest a stretch of rough road lies ahead for the nationwide auto smog-control program, which goes into effect next summer. Most other cities don't face so severe a smog condition as Los Angeles—which had 100 smog days last year compared with 14 for Denver, its closest rival—so even slower-than-expected success against car-produced pollution may be sufficient to keep other cities from catching up with the Los Angeles smog rate. But prospects for rapid improvement may be more cloudy than some experts had hoped.

Smogtown, U.S.A.

Los Angeles' dubious distinction as Smogtown, U.S.A., results largely from the fact that for much of the year, it and other coastal California population centers are covered by low-hanging "inversion layers"—caps of warm air that keep the lower layers from rising and dissipating their toxicants in the upper skies.

Brief tastes of this phenomenon had New York City gasping over the Thanksgiving holiday. When domed by the inversion cap, New Yorkers had to breathe varieties of aerial garbage that have been largely eliminated in California. Facing up to the challenge of its climate, California has rooted out and curbed pollution from such stationary sources as oil heaters and generators, backyard incinerators, open dump fires and petroleum refineries.

In California, motor vehicle toxicants are what remain; they now constitute 90% of the state's air pollution. In New York, by contrast, the percentage is considered substantially lower, much of which is normally wafted safely away by prevailing winds.

By getting various pollution controls put on some 6.5 million vehicles, the California Motor Vehicle Air Pollution Control Board has been able to halt the rise in the quantity of toxicants spewed daily by cars into the state's atmosphere. Indeed, by the board's estimates the hydrocarbon pollution rate in Los Angeles County has begun to decrease from its recent level of about 2,000 tons a day. Nevertheless, the number of cars keeps increasing, and even if all goes precisely as hoped, the board doesn't expect to get the rate down to the "acceptable" level of some 700 hundred tons a day until after 1980.

One big reason: Older cars. The devices the board approved in 1962 to shut off pollution from the crankcase—source of 25% of the hydrocarbons emitted by an uncontrolled vehicle—have been required on new cars starting with 1963 models. But the most the state has been able to do about autos of pre-1963 vintage is to require that they be equipped with a crankcase device when they're sold, or brought from out-of-sate, into one of 10 urban California counties. According to Miles Brubacher, chief engineer for the state Pollution Control Board, it usually takes about 12 years for 95% of the cars from a given model year to reach the scrap heap.

Peskier Source

In trying to limit pollution from another source, the exhaust, California smog fighters are apparently depending on attrition even more heavily than in their battle against the crankcase.

The exhaust is the source of about 65% of the hydrocarbons and all the carbon monoxide discharged by an unmuzzled vehicle. Partly because of California's urging, auto makers developed systems to eliminate much of this pollution in time for the 1966 model year. The state has required such systems to be factory-installed on most new cars sold within its borders, and beginning with the 1968s, the Federal Government is imposing a similar requirement nationwide.

But meantime, the California board concedes its hopes of ever getting exhaust-emission control on used cars have dwindled. There are technical problems: The new-car systems, for example, involve engine modifications difficult to make outside the factory, and the systems can't simply be installed on used autos as can the crankcase devices. Also, as each year's contingent of new vehicles arrives already equipped with exhaust control, the potential market for a used-car device shrinks, and so does the incentive for someone to spend time and money trying to develop one, says Eric Grant, the Pollution Control Board's executive officer.

The California experience to date indicates that more than a decade may well have to elapse after each new device to control auto pollution is first developed, before its full benefits can be enjoyed.

The next such device on the horizon may be the one Esso Research & Engineering Co., Linden, N.J., a subsidiary of Standard Oil Co. (New Jersey), says it has developed. The research company says its device "appears to largely eliminate" the hydrocarbons discharged into the air by evaporation of gasoline from the fuel tank and the carburetor. Evaporative losses contribute about 10% of the hydrocabrons emitted by an uncontrolled automobile.

Esso Research won't make details of its device public until Jan. 13, when it will present them at a meeting of the Society of Automotive Engineers in Detroit. But even if Detroit's response is immediately enthusiastic, a California official confides there's little chance such a device can be ready for required installation on 1969 models, not to mention the 1968s.

Disputed Tests

Wearied by the frustrating slowness with which various emission-control systems have been taking effect, California smog battlers let loose some salvos last month when results of tests conducted in the state suggested that exhaust-purifying systems already installed on 1966 model cars might be deteriorating as the vehicles accumulate mileage. Letters were fired off to Washington and Detroit, but experts later agreed only that the evidence was inconclusive.

Tests run by the state this year on 212 emission-controlled cars with between 2,500 and 5,000 miles on their odometers showed an average of 240 parts per million (ppm) of hydrocarbons in their exhausts, well within the 275-ppm state standard for the exhaust-control systems. But 84 cars tested with about 10,000 miles emitted an average of approximately 290 ppm, and 16 cars with about 20,000 miles gave off an average of over 300 ppm.

To Louis J. Fuller, Los Angeles County air pollution control officer, and others, such evidence indicated a clear trend toward deterioration in the antismog devices. But auto maker spokesmen contend, and Pollution Control Board chief engineer Brubacher concedes, that the evidence isn't statistically significant and may be misleading.

A statement to the state board's November meeting in San Diego by the Automobile Manufacturers Association, an industry group, said in effect that the test samples had been biased. The statement suggested that many of the high mileage cars in the California test results were from the early part of the model run. Most cars don't accumulate 20,000 miles until they're well over a year old. The manufacturers insisted they made significant improvements in the smog-control systems during the early months of 1966 model production, and claimed the board's tests didn't accurately reflect improved anti-smog performance of newer, lower-mileage cars.

The auto makers also claimed it's likely that many of the higher mileage cars tested were driven unusually hard. Of the six vehicles with more than 24,000 miles tested by the state, for example, two were taxis and one a police cruiser.

Auto makers base their assurances of a control system's durability on results of their own 50,000-mile tests. Although they accept these results, California smog experts tend to discount them, saying tests provide evidence of what emission-control systems can do under "jewel box" conditions, not necessarily of how well they will perform on privately owned cars. "They pack a mechanic in the trunk of every one of those test-track cars," says a Los Angeles County pollution control officer, only half in jest.

Problem of Servicing

In addition to developing a surer method of testing whether exhaust-control devices are deteriorating, California smog battlers face the problem of finding some method to guarantee that vehicles receive any servicing needed to insure smog device efficiency. One member of the state board contends that some mechanics' solution for a malfunctioning smog control unit is to ask the car owner if he just wants it disconnected. Indeed, many a motorist will admit to having had his crankcase device disconnected at his mechanic's recommendation.

Partly in an effort to upgrade servicing of smog-abatement systems, auto makers say they're conducting campaigns to improve the training of increased numbers of service personnel. Ford Motor Co., for example, embarked this September on a two-year, $8 million training center expansion, according to Robert C. Graham, service research and operations manager. The program will boost to 80,000 student-hours a year from 20,000 the company's teaching capacity in Los Angeles; it also will triple the capacity in San Francisco, Mr. Graham adds.

To make sure that all cars receive improved service as it becomes available, the state may eventually have to undertake some regular inspection of all vehicles. A method enabling a quick, simple check is necessary first, however. The current official test procedure requires cars to be left overnight at a test center, hardly the sort of thing voters generally would be willing to put up with.

The aim of inspection would be to catch the worst offenders, Mr. Brubacher says. California tests show that the worst cars often emit five times as much pollution as those on which controls are working best. "We'd be after the elephants, not the nits," he explains.

One ominous problem remains—the possibility that the new control systems, themselves, make cars perform badly. To test the relative driveability of vehicles with exhaust pollution-abatement systems against those without them, the board surveyed owners of 1966 model cars (with the systems) and 1965s (without). The results: On balance, the 1965s fared better, despite their extra year's mileage. On four out of the six driveability characteristics tested (such as starting cold, stalling, smoothness of idle) drivers rated the 1965s as slightly better.

The results of this survey are viewed as tentative, and the board has designed a more thorough and objective testing program to be performed on the 1967s. But fear that vehicles with smog control systems might be regarded as poorer-handling than those without such systems has caused some concern in Detroit, particularly with the advent of the 1968 model year, when exhaust controls go on all cars nationwide.

Industry sources note that manufacturers are still experimenting with different approaches to exhaust-emission abatement, and any general inclination among motorists to put off buying new cars for a year or so to await perfection of these systems would have an unwelcome effect on the market.

Avnet Says It Ended Negotiations to Acquire Valley Electronics Inc.

By a WALL STREET JOURNAL *Staff Reporter*

NEW YORK—Avnet Inc. said it terminated negotiations to acquire Valley Electronics Inc. of Baltimore.

By mutual agreement the companies decided not to continue efforts to resolve differences in contractual discussions at the present time, Lester Avnet, president and chairman of Avnet, said.

Avnet announced in early October it would acquire Valley for Avnet common, the total amount depending on future results. Valley is a distributor of electronic components.

Avnet also said the amount of its revolving credit agreement with Chemical Bank New York Trust Co. and other participating banks has been increased to $8 million from $5 million.

This was done to provide for the company's continuing expansion program, Mr. Avnet said. No further financing is planned in the foreseeable future, he added.

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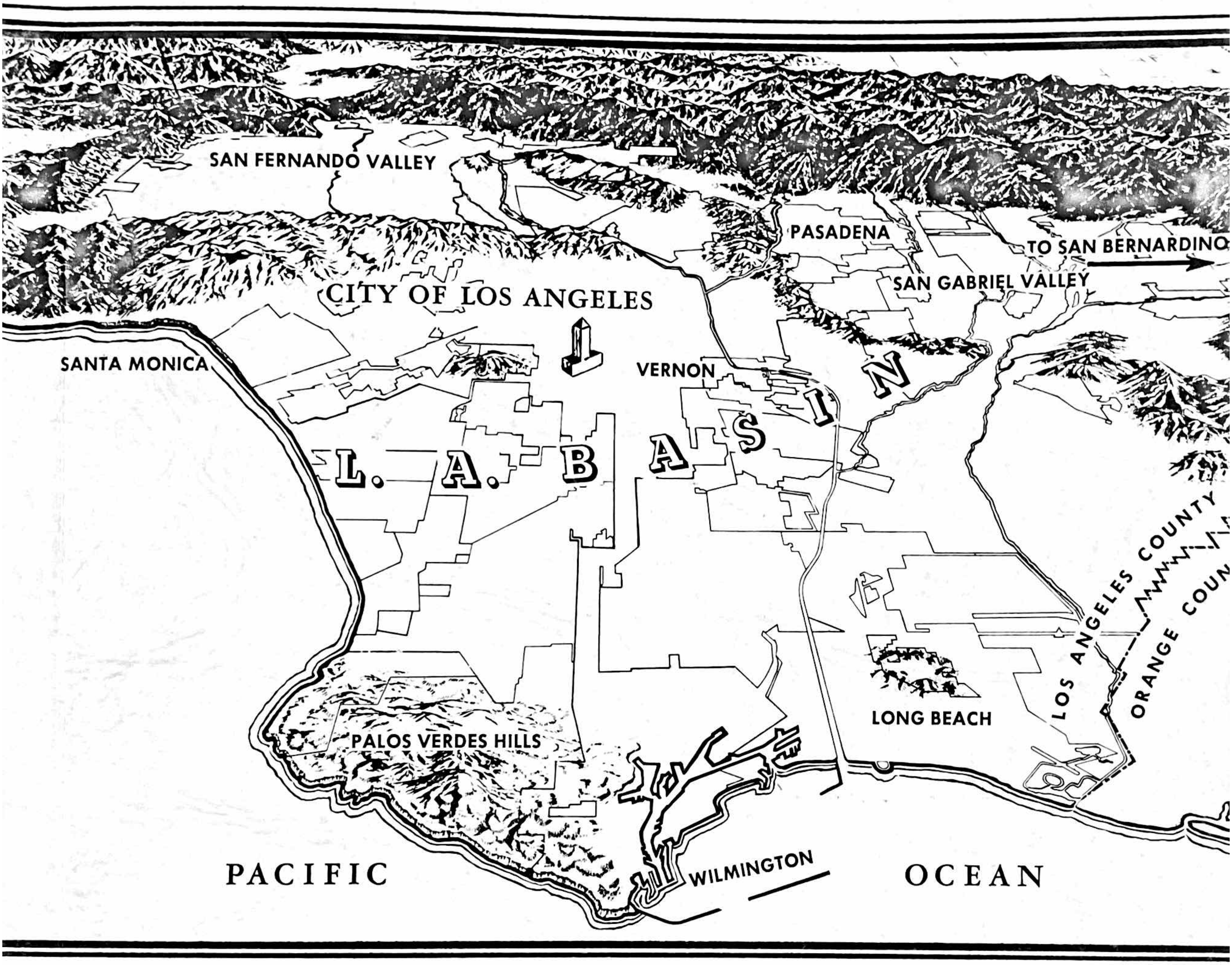
N. A. Renzetti

Report No. 4

FIRST TECHNICAL PROGRESS REPORT



Volume 1
Number 4

AIR POLLUTION FOUNDATION

Los Angeles, California

"Dedicated to the solution of the smog problem"

THE AIR POLLUTION FOUNDATION BELIEVES

That the answers to the smog problem will be found; that eye irritation and air pollution can be conquered; that it will take time.

That the evaluation of existing research and the conduct of new research projects will make possible the control of smog and shorten the time required for its elimination.

That impartial fact-finding, without fear or favor, is now, and will continue to be, the object of our Scientific Team.

The Foundation's Scientific Team

DR. LAUREN B. HITCHCOCK, *president and managing director*

DR. W. L. FAITH, *vice president and chief engineer*

DR. MORRIS NEIBURGER, *senior meteorologist*

DR. NICHOLAS A. RENZETTI, *senior physicist*

DR. LEWIS H. ROGERS, *senior chemist*

FIRST TECHNICAL PROGRESS REPORT

Covering Work Done in 1954

Prepared by the

Scientific Staff of the

AIR POLLUTION FOUNDATION

W. L. Faith, L. B. Hitchcock, M. Neiburger,
N. A. Renzetti, L. H. Rogers

Helen G. Marcus
Editorial Assistant

March, 1955

FOREWORD

A PROGRESS report is a link in a chain of knowledge—a link between the known past and future hope. This report is based on what I believe to be a very painstaking and conscientious digest of all information available to us bearing on the Los Angeles air pollution problem as of late 1954. All of this was the work of others, which we began to collect and evaluate in February, 1954.

In addition, this report describes our own research and field work, which got underway in July and was steadily increasing through the following months. Only preliminary results from this initial, brief period are available as this is written. Even so, in conjunction with the summary of the findings of others, this report helps to bring the whole complex problem into a little better focus, to establish a better (though still inadequate) definition. When a problem can be clearly defined, it has been said that it is half solved. We are still far short of that.

Acknowledgment of the contributions of others to this report and to our first year's indoctrination here is our first duty and one we undertake with pleasure, though so many have helped directly and indirectly that it is impossible to mention them all or to attempt any fair measure of their assistance. We came here in 1954 not only as strangers to the community, but as newcomers to the field of air pollution.

The Los Angeles County Air Pollution Control District headed by Gordon P. Larson; Professor A. J. Haagen-Smit of the California Institute of Technology; Stanford Research Institute represented by Dr. Fred E. Littman, Dr. L. M. Richards, D. H. Hutchison, and Dr. A. M. Zarem; Professor Francis E. Blacet of the University of California at Los Angeles; Professor John T. Middleton of the University of California at Riverside; and Vance N. Jenkins for the Smoke and Fumes Committee of the American Petroleum Institute have given unsparingly of their time and knowledge. Dr. Arnold O. Beckman as an individual leader in air pollution work, and Dr. Ulrich B. Bray are representative of many public-spirited citizens who have assisted our Foundation group generously. The Board of Supervisors of Los Angeles County and Chief Administrative Officer Arthur J. Will have shown unfailing interest in our work and participated importantly in our program, as have A M Rawn and Francis R. Bowerman of the Sanitation Districts.

Our own Board of Trustees under the leadership of Dr. Fred D. Fagg, Jr., President of the University of Southern California, did everything conceivable during this first year to get us off to a flying start. This is not the appropriate place to recognize their individual contributions in overcoming the problems of establishing this

unique Foundation, but the Research Committee of the Board of Trustees under the chairmanship of Dr. Lee A. DuBridge, President of the California Institute of Technology, has the basic responsibility for the approval of our research projects and the appropriation of funds. Their counsel, and understanding of the uncertainties which surround the plotting of research into new territory, have been most helpful and reassuring. Their names are listed elsewhere in this report.

Between one hundred and two hundred other scientists and engineers from this country and abroad have given us freely many days of their time, individually and in conferences; they have come from the Bureau of Standards, the Bell Telephone Laboratories, The Kettering Laboratory of the University of Cincinnati, the Taft Laboratory of the U. S. Public Health Service, the Coordinating Research Council, and many others for conferences on ozone chemistry, photochemistry, hydrocarbons, motor vehicle combustion products, meteorology, and incineration and other methods of rubbish disposal. Their cooperation with us in the common cause of public service is deeply appreciated.

The U. S. Navy is part of this community too; they converted one of their blimps from the Santa Ana base into a flying laboratory to help us collect several hundred samples of Los Angeles polluted air and meteorological data under, in, and above the inversion layer over the Basin during the 1954 Aerometric Survey. Our thanks to Commanders Peeler and McCartney and the men of the Naval Reserve!

To my associates who have done most of the work of evaluation, followed by the planning, placing, and supervising of the research projects, I can only say it has never been my good fortune to work with a finer group of scientists, nor one more devoted to the cause. Their names appear with their respective chapters. The rest of our staff, unnamed here, have done all those countless tasks well, without which these results could never have reached you.

By the end of 1955, we may not have "cracked" the problem, but I am sure we will have still more interesting results to report.

LAUREN B. HITCHCOCK

March 1, 1955

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I. INTRODUCTION

THIS Foundation exists primarily to find the facts. It believes that the evaluation of existing research and conduct of new research will make possible the control of smog and shorten the time required for its elimination. It is committed to the prompt publication of its findings and recommendations, so that the efforts of all groups and individuals may be coordinated properly, so that the public may be informed, so that government may in its discretion implement such findings and recommendations through enforcement and control measures.

The organization, purposes, and general operation of the Foundation have recently been described in the President's Report.[1]

In submitting this First Technical Progress Report, an attempt is made to evaluate and summarize pertinent information collected from many sources, to describe our own projects started in 1954, and to give such preliminary findings as are possible at this time. Since the scientific staff was not completed until June, 1954, the period covered by this technical report is essentially July 1—December 31, 1954. Most of the projects are continuing actively and will eventuate in a series of more complete individual reports during 1955. The final report of the Aerometric Survey, with interpretation of results and conclusions, is due in April. In the near future, reports will appear on the Air Tracer Survey, Trends in Visibility 1930 - 1954, and Statistical Studies of the Los Angeles Basin with reference to sources of air pollution.

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[1]Presented November 16, 1954; copies available on request.

The principal contributions which we think the present report makes are (1) to define the Los Angeles air pollution problem so far as it is possible in our present state of knowledge; (2) to critically examine the status of our knowledge and research programs; and (3) to indicate what seem to us the most immediate goals.

The Los Angeles Air Pollution Problem in February, 1954

In early 1954 there was general scientific agreement that:

(1) Air pollution is one of the problems resulting from the growth of population and industry, whose combined miscellaneous emissions began during World War II to exceed the variable capacity of our natural ventilation, peculiarly limited in this area by local topographical and meteorological conditions, and which now exceed this capacity more and more frequently.

(2) The production of pollution is more or less constant, if not from hour to hour, at least from day to day or week to week, and growing from year to year in proportion to the expansion of the metropolitan area.

(3) The pollution acquires obnoxious characteristics called "smog" in proportion to its confinement by low temperature inversions, lack of wind, and exposure to sunlight.

(4) Smog cannot yet be identified as to its chemical or physical composition, but may be defined generally by its "fingerprints" which include at times one or more of these manifestations:

(a) eye irritation
(b) reduced visibility
(c) odor
(d) high "oxidant" value
(e) plant damage

(5) No specific gaseous pollutant nor mixture of gaseous pollutants *in the concentrations found in our atmosphere* has been proved to be responsible for eye irritation or reduced visibility; *however*, typical high oxidant values have been produced in the laboratory by:

(a) irradiation of hydrocarbons when NO_2 was added, both being at experienced concentrations,

(b) irradiation of auto exhaust (which contains NO_2) at experienced concentrations

and plant damage has been obtained in the laboratory by fumigating with auto exhaust and added ozone, but not with hydrocarbons and ozone, at experienced concentrations. The fact that plant damage has been obtained with hydrocarbons at concentrations as low as a few parts per million (though several times experienced concentrations), plus ozone at experienced concentrations, implicates hydrocarbons with respect to this one smog effect. Qualitative effects of eye irritation and reduced visibility have been noted, again at higher concentrations. In brief, the evidence, though circumstantial, justifies intensive studies of means for the material reduction of both hydrocarbons and auto exhaust.

(6) Smog, thus characterized, does not appear to originate *as such* from any known source.[2]

(7) Smog forms *from* man-made pollutants, but how may be explained so far, if at all, only in vague generalities. Thus:

Its occurrence is quite variable;

It is only roughly predictable at short range (24 to 48 hours);

From *which* pollutants it is formed, singly or in combination, is unknown (though partly suggested with respect to certain hydrocarbons, as will be described);

Its intensity is indicated largely by the subjective effects listed above, varying according to place, time, and pollution levels in ways understood not at all;

Eye irritation and high oxidant values are rarely, if ever, found at night.

(8) The great bulk of our air pollution consists of combustion products, including motor vehicle exhausts, stack gases from the burning of natural gas and fuel oil for heat, light, and power, and burning of rubbish; it consists of industrial emissions including hydrocarbons from the production, refining, and distribution of petroleum products, and miscellaneous dusts, gases, solvent vapors, and smokes associated primarily with manufacturing processes other than combustion.

(9) The chemical composition of these sources is at worst not known at all, and at best not reliably or fully known.

(10) The gross daily quantities of gas, oil, gasoline, and rubbish consumed have been estimated, and the daily production of pollutants therefrom calculated on the basis of available knowledge concerning the composition of specific sources. (See Tables I, II, and Fig. 1)

(11) Gross tonnages of pollutants are only a measure of contribution to air pollution; until we know which pollutants produce which smog effects, we cannot directly relate sources and tonnages to smog; it is entirely possible that certain pollutants have importance as smog-formers out of all proportion to the quantity of the sources in which they occur, or to their concentrations.

(12) The information on the concentrations of specific pollutants in the Los Angeles atmosphere, especially during periods of low temperature inversion, is entirely spotty and inadequate; such data as exist for carbon monoxide, hydrocarbons, and oxides of nitrogen and sulfur agree qualitatively with values calculated from

[2]except for the synthetic rubber plant in Los Angeles operated during World War II and shut down in 1947; and except for very limited, highly localized brief emissions from some motor vehicles presumably in improper operating condition, and then only in high concentrations found close to such vehicles or in very confined spaces or tunnels.

CHAPTER I — TABLE I

DAILY EMISSIONS, COMBUSTION AND EVAPORATION — 1953*

Not including Particulates, Metallurgical Operations, CO, and Miscellaneous, for Los Angeles County in Tons per Day

Material Burned	COMBUSTION Tons/Day	Ald.	NH_3	NO_2	SO_2	Acids	Orgs.	Tons/Day Total Pollutants
General Public:								
Gas**	8640	8.5	—	60	—	11	12	
Oil	2370	3	—	32	71	32	11	
Gasoline	14380	40	5	177	40	4	1016	
Trash	5060	9	4	1	2	2	414	
Total	30450	60.5	9	270	113	49	1453	1955
Petroleum Industry:								
Gas**	9890	11	5	75	103	13	16	
Oil	2820	3	—	38	84	38	12	
Total	12710	14	5	113	187	51	28	398
Other Industries:								
Gas**	12873	12	—	88	—	17	20	
Oil	3640	4	—	49	111	50	17	
Refuse	2500	3	0.1	2	0.2	0.6	29	
Total	19013	19	0.1	139	111.2	67.6	66	402.9
Grand Totals	62173	93.5	14.1	522	411.2	167.6	1547	2756

EVAPORATION		
General Public (Autos and Service Stations)	Hydrocarbons	216
Petroleum Industry	"	251***
Total, Combustion and Evaporation	"	3223

TOTAL FUELS BURNED DAILY, TONS	
Gas	31403
Oil	8830
Gasoline	14380
Refuse	7560
Grand Total	62173

* *The Smog Problem in Los Angeles County*, Stanford Research Institute (January, 1954); Tables XLIV and XLVI; these figures are the best available as of April 1, 1955, but the Air Pollution Foundation has not as yet measured the composition or amounts of combustion effluents and cannot vouch for the accuracy of these data.

** Revision by Air Pollution Foundation as of December, 1954 based on data from the Southern California Gas Company for 1954.

***Air Pollution Foundation audit as of March, 1954.

the estimated quantities emitted, assuming reasonable dispersion over the metropolitan area under the inversion height existing at the time of the measurements. However, monitoring of presumably significant pollutants has not been done in a consistent and continuous manner. There are just enough data accumulated irregularly over recent years to permit differing interpretations of the origins and movement of polluted air masses, as well as the chemical and physical reactions taking place which cause observable smog manifestations. Concentrations of aldehydes, low as they are, appear to be significantly higher than can be accounted for from all known sources. The same is true of oxidants, especially ozone.

(13) Methods of analysis and instrumentation essential to reliable measurement of small fractions of a part per million of various gases, liquids, and solids are for the most part inadequate. No systematic, statistically significant techniques exist for the measurement of eye irritation or plant damage.

Scientific Conferences

That the foregoing general outline approximates the status of scientific opinion at this time is indicated not only by the consensus of published reports, but is more specifically evidenced by the minutes of conferences held in early 1954 (see Appendix). One of the first activities of the Foundation was to invite representatives of the principal scientific laboratories and agencies that had been working on the problem to meet in round-table sessions and exchange views. Participants included:

CHAPTER I — TABLE II

SUMMARY OF "IMPORTANT" POLLUTANTS, LOS ANGELES COUNTY — 1954*

Combustion and Evaporation Processes Only in Tons per Day

	General Public: Auto & Service Stations	General Public: Other	Petroleum Industry	Other Industries	Total	
Acids	4	45	51	67.6		167.6
Aldehydes	40	20	14	19		93
Olefins	26 (E)	—	16 (E)	—	42	
	292	—	—	—	292	334
Other Organics	190 (E)	—	28	—	218	
	724	437	235 (E)	66	1462	1680
Nitrogen Oxides	177	93	113	139		522
	1453	595				
Total	2048		457	291.6		2797

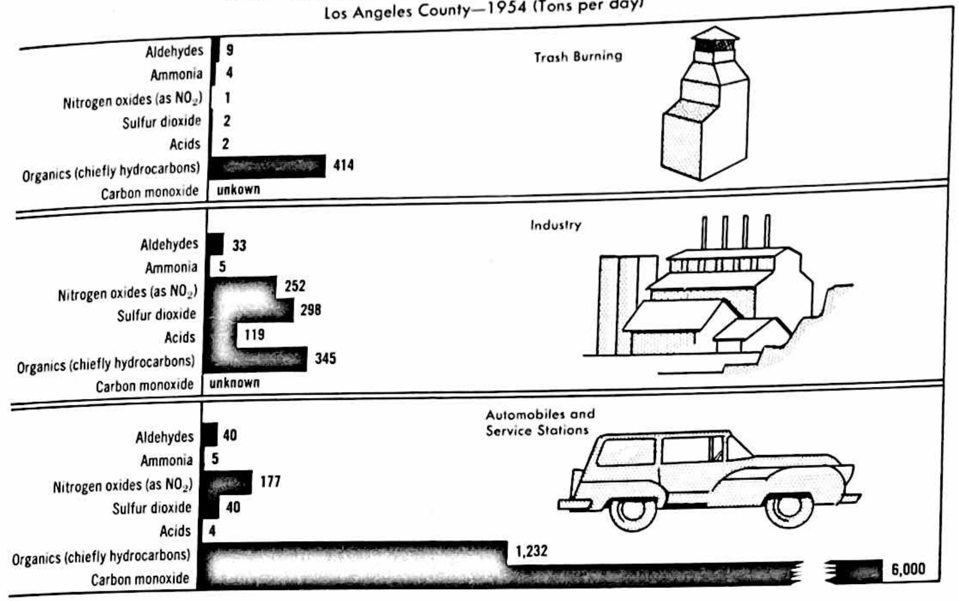
E—Evaporation

*Derived from Table I

CHAPTER I – FIG. 1 (derived from Table I)

DAILY GASEOUS EMISSIONS FROM SELECTED SOURCES

Los Angeles County—1954 (Tons per day)



Los Angeles County Air Pollution Control District: G. P. Larson, W. J. Hamming; Consultants to Air Pollution Control District: A. O. Beckman, U. B. Bray; Air Pollution Foundation: L. B. Hitchcock, L. H. Rogers; American Petroleum Institute: V. Jenkins; California Institute of Technology: A. J. Haagen-Smit; Stanford Research Institute: L. M. Richards, F. E. Littman; University of California, Los Angeles: F. E. Blacet.

Through conferences and correspondence over a period of about 60 days, the following conclusions were unanimously agreed to:

1. Hydrocarbons are present in the Los Angeles atmosphere.
2. Auto exhaust gases plus ozone, at realistic concentrations, give plant damage.
3. Auto exhaust gases alone are not damaging, nor do they of themselves cause eye irritation at realistic concentration.
4. Petroleum hydrocarbons (whether coming directly from refineries or gasoline, or coming from auto exhaust pipes) plus reaction products of the internal-combustion engine, of themselves will not cause smog; some further oxidative process must take place.
5. Hydrocarbons, etc., in auto exhaust fumes plus NO_2 plus ozone give plant damage.
6. Some petroleum hydrocarbon unsaturates may cause eye irritation when irradiated with some oxidant.

7. We believe that at least some petroleum hydrocarbons may enter into reactions in a significant way to produce what we call "smog." There are some hydrocarbons emitted into the atmosphere along the line from the oil well up to the input of the automobile which may enter into smog-producing reactions; more specifically, certain olefins which may react with ozone.
8. Petroleum hydrocarbons and/or their derivatives produced in the internal-combustion engine may be a significant contributor to smog, but we cannot yet completely and satisfactorily establish this significance; we agree that some of the more reactive hydrocarbons and/or their derivatives may contribute to smog by a mechanism or mechanisms not yet fully understood, although much progress has been made.
9. Ozone formation appears to be sufficiently significant in the conversion of certain hydrocarbons to smog to warrant further study.
10. Some petroleum hydrocarbons may contribute to smog through some oxidative process.
11. Ozone may participate in some way not yet fully understood in the oxidative process but the evidence is still inconclusive as to whether ozone is itself a reactant or a reaction product.
12. A photochemical reaction or reactions seem to be involved in the formation of ozone and in the reaction of NO_2 and some organic materials.
13. Ozone may also be produced by a separate reaction at the same time that smog is being formed.

In addition to these conferences many others were held with scientists invited from all over the country. The extent of their agreement turned out to be much more substantial than was generally anticipated. But since the scientific workers in general had not correlated their findings to any appreciable extent and indeed seemed to have been emphasizing their points of disagreement, it is not surprising that the general public had no perspective on the problem.

Actually, this scientific disagreement was typical of pioneering in a new field which we know now to be one of great complexity. The analogy was made to the three blind men who for the first time grasped different parts of an elephant, and each described a different animal. But the man in the street, at times severely annoyed by smog, was inclined to attribute the inability of the scientist to stop smog to stupidity, bias, or worse, and found little satisfaction or hope of relief in what he heard or read. Under these conditions it is not surprising that it was difficult to distinguish between fact and fancy, between numerous theories and speculative remedies.

Areas of Disagreement

Definite disagreement existed as to the extent to which available data proved that certain smog effects were caused by specific sources of specific pollutants in those sources. For example, whether:

(1) Hydrocarbons reacted photochemically in the presence of oxides of nitrogen and air to form both oxygen complexes and ozone.

(2) These oxygen complexes caused eye irritation as well as plant damage, the latter distinguishable from damage caused by ozone, or sulfur dioxide and other pollutants.

(3) Cracking of rubber by ozone and by organic peroxides or free radicals was distinguishable.

(4) Concentrations at which some smog effects were simulated in the laboratory were "realistic," or produced effects equivalent to those experienced in the Los Angeles atmosphere.

(5) Fumigations with mixtures of selected pollutants (such as selected hydrocarbons or auto exhaust) and ozone, or oxides of nitrogen and sunlight or artificial radiation, were significant. Wall effects, residence time, wave length and intensity of light source, and other experimental difficulties were typical of pioneering scientific research.

There was disagreement, consequently, not only as to the approximate magnitudes of our principal sources of pollution, but as to their relative importance smog-wise. For example, total emissions of incinerators in the Basin were estimated variously from 90 tons per day of "harmless smoke" to 500 tons per day of ash, smoke, and largely invisible organic compounds. Particulate matter and ordinary smoke were described by some as remarkably low in Los Angeles, while others claimed it was one of the dirtier cities in the country. Again, this disagreement was due largely to the great variability in such pollutants as to time and place, and the lack of adequate data.

Dual Approach to the Air Pollution Problem

In these chapters prepared by our scientists the situation will be described substantially as it existed at the end of 1954. We approached the air pollution problem with two dominant philosophies:

(1) that certain pollutants may be largely responsible for smog effects and these substances can be identified and means found for their elimination;

(2) that all pollution is undesirable, and means must be found for reducing the amount to tolerable levels and maintaining these in a growing metropolitan area. We assume polluted air is unhealthy.

We do not know yet which approach will bring relief sooner. We doubt if anyone else does. Both are quite likely to be productive. Both require research, based on continuous study and review of all available information from all quarters. Both require development of new or greatly improved methods of analysis and control.

Identification of principal sources of pollution does not tell us how to abate them. The magnitude of motor vehicle exhaust as a contributor to modern urban air pollution has only lately begun to be appreciated. No workable control remedy has been devised so far, although the automobile manufacturers, the Coordinating Research Council, the Foundation, and others are doing everything they know to find practicable remedies at the earliest possible date.

An independent audit of hydrocarbon losses from the production and refining of petroleum products was conducted by the Foundation, indicating as of March 1, 1954, a total of about 250 tons per day, a substantial reduction from the losses estimated two years ago. The oil industry in the Basin anticipates further significant reduction upon the completion of controls under Rule 56 by May 1, 1955. They are also working on devices for collecting vapors presently lost in filling tank trucks and controlling other emissions even though no control regulations have been issued.

But we do not have to wait until all information is in on all sources before acting. We, like others, are reporting our findings as rapidly as possible. For example, there seems to be adequate evidence that incineration of rubbish in the Los Angeles Basin creates a serious nuisance, and consensus of authorities over the country recommends discontinuance of all present-day incinerators, domestic or municipal, in view of the local conditions. But prohibition by edict must, at the same time, offer a workable alternative, so the "bury-and-cover" method is recommended in a thorough technical report just published by the Foundation.[3] Copies are being furnished to all Los Angeles County and municipal officials, as well as to our contributors and others to whom it may be helpful.

Duplication of the work of either our contemporaries or our predecessors is something for which we have neither time nor money. We have too many urgent new projects waiting for manpower. *Additional* work is often necessary on an important subject which has only been opened up by prior workers.

How long it will take to find the causes and subsequent controls for our air pollution problem, and when the remedies for the principal sources will be developed, are, of course, of the greatest concern to all of us. The impatience of the public is equalled only by the impatience of the workers on the problem, whose whole satisfaction and fulfillment in life can come in no other way than by finding the solution at the earliest possible time.

[3] Report No. 3, "Incineration, Rubbish Disposal, and Air Pollution," January, 1955.

II. METEOROLOGICAL ASPECTS

DEFICIENCIES IN DATA AVAILABLE AS OF APRIL 1, 1954

IN order to make readily accessible existing knowledge on the meteorological conditions in the Los Angeles area as they affect the occurrence of atmospheric pollution, the Foundation commissioned the writer to prepare a summary. In collaboration with Dr. James G. Edinger the material was published as Report No. 1, "Meteorology of the Los Angeles Basin."[1]

This report pointed to the need for certain types of additional meteorological investigations. In the first place, the representativeness of the wind observations was questioned. Surface wind observations were available from an extensive network of stations, but the exposure of the instruments and, in many cases, the quality of the instruments and observers were of doubtful reliability. In the case of upper air winds, measurements were made at only two points and additional stations were essential in order to complete the picture of the air flow over the Basin. It was suggested that tracer studies be carried out to check how accurately the air trajectories, i.e. the paths of polluted air, could be determined from surface wind observations.

The use of meteorological data in evaluating improvement due to control measures was discussed in the report. An example was given in which the Air Pollution Control District showed that the monthly average visibility for a given wind speed has had some tendency to increase in downtown Los Angeles since control of the emission of particulate matter was put into effect, even though the average heights of the inversion for corresponding months were stated to be approximately the same. A need was indicated for further studies of the trend in visibility during periods of increasing pollution, while testing the effectiveness of control measures.

It was pointed out that systematic measurements of pollution concentrations and effects were sorely lacking in correlating meteorological conditions and smog. In particular, the lack of controlled reports of eye irritation and plant damage prevented a quantitative estimate of smog intensity to which meteorological variables as well as chemical analyses might be related.

Based on this report and on additional discussions and conferences, the decision was made to undertake two meteorological investigations during 1954: (1) an air tracer study to test the reliability of trajectories computed from surface wind reports, and (2) an analysis of past visibility records to see how much visibility had been reduced by pollution, as well as to examine any evidence of improvement due to control measures. The decision to conduct the air tracer study and various points about the way to conduct it were greatly influenced by a conference with leading meteorologists, including among others Dr. O. G. Sutton, director of the Meteorological Service of the British Air Ministry, Dr. Harry Wexler, chief of the Scientific Services Division of the U. S. Weather Bureau, and Dr. E. Wendell Hewson, professor of meteorology at the University of Michigan.

[1]M. Neiburger and J. G. Edinger, "Summary Report on Meteorology of the Los Angeles Basin With Particular Respect to the 'Smog' Problem." Air Pollution Foundation, April, 1954.

AIR TRACER STUDY[2]

The design of the air tracer experiment had as its principal purpose a test of the accuracy of trajectories computed from surface winds. A secondary purpose was to see whether discrepancies, if they occurred, could be accounted for adequately on the basis of winds at upper levels, and for this purpose special upper wind stations were established at four points in addition to the regular stations at Long Beach and Burbank. The four special stations and the Air Force Station at Long Beach took winds-aloft observations every two hours during the tracer tests.

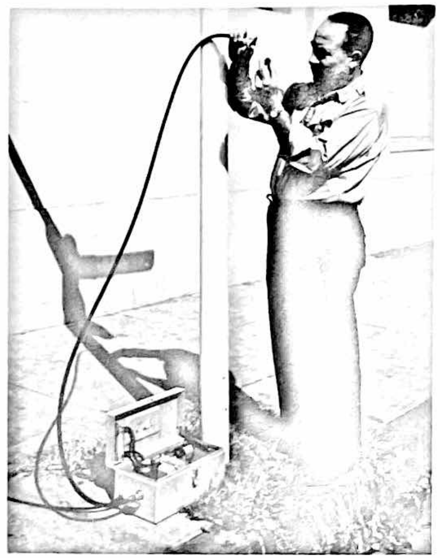
As a tracer material a fluorescent pigment, zinc-cadmium sulfide powder, was selected. This powder consists of fairly uniform-sized particles having a mean "diameter" of less than two microns, so that once dispersed into the air, they fall very slowly and move with the air currents almost as gaseous molecules (Fig. 1). They are collected on millipore filters through which the air is passed. The retained pigment particles glow under ultraviolet light with a characteristic yellow-gold color quite different from naturally occurring dust and haze particles, so that they may be distinguished and counted easily.

Wind observations appeared more likely to give a good indication of the movement of pollutants during the afternoon sea breeze than during the light, variable land breezes at night and in the early morning. It was decided, therefore, to make the tests in such a fashion as to release the tracer material early in the morning and to have the sampling network far enough away so that the tracer cloud would reach the sampling stations only after the sea breeze

[2]This work was supported by the Los Angeles County Air Pollution Control District through a research contract with the Air Pollution Foundation.

CHAPTER II – FIG. 1 *Courtesy of The Ralph M. Parsons Co.*

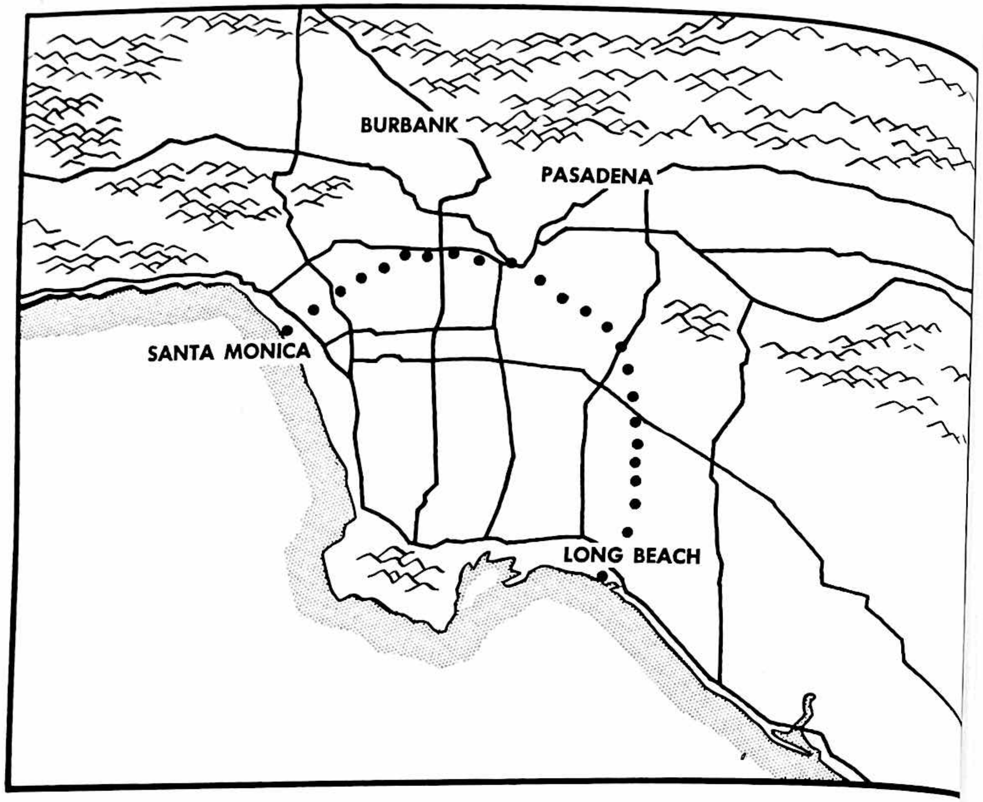
Dispersal of fluorescent particles for tracer tests



CHAPTER II – FIG. 2

Changing filter in air sampler for sampling fluorescent particles in tracer tests

Chapter II – Fig. 3
Air tracer sampling stations



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The dispersal and sampling was carried out by The Ralph M. Parsons Co., with personnel provided by the Los Angeles County Air Pollution Control District to man the sampling stations.

The dispersal took place during one hour, and it was computed that the cloud would spread during the movement to the sampling network into a volume about six miles in diameter extending from the ground to the inversion base.

It was decided that five or six tests should provide a sample of enough meteorologically different situations for an adequate indication of the extent to which the trajectories computed from wind observations represent the path traveled by pollutants.

As is the case in many such experiments, the behavior of the experiment varied considerably from expectations. Modifications were made in an effort to improve the results as the series of trials progressed, and whether or not it was due to these changes, the last two tests resulted in particle counts of the order anticipated, whereas in the first four the counts were very much smaller.

Chapter II – Table I

Operational Conditions during Tracer Tests

Test No.	1	2	3	4	5	6
Date	8/4	8/18	8/31	9/3	9/21	10/15
Inversion Base Heights (ft.) 1900 PST Prev. Day					280	
" 0100 PST	2550	80	Sfc	Sfc		Sfc
" 0700 PST	4200	1850	600	1600	950	390
" 1300 PST	2650	1450	1100	920		950
" 1900 PST	2800	1100	340	885	Sfc	Sfc
Place of Dispersal	Shell Chem. Co.	Shell Chem. Co.	Shell Chem. Co.	Shell Chem. Co.	Compton Airport	Compton Airport
Height of Dispersal above Ground, ft.	15	45	45	45	25	25
Time of Dispersal	0300-0400	0300-0400	0300-0400	0415-0515	0500-0600	0500-0600
Weather at Dispersal	Cloudy	Clear	Clear	Dense Fog	Moderately Dense fog	
Visibility at Dispersal	Good					
Wind at Dispersal	SE		ESE-E 3-6 NE-N 2-1	E-N 1.5-2.5 mph	NNW-N 1-2 mph	WNW-NW 2-4 mph
Amt. of F.P. Dispersed (grams)	1200	2400	2400	3000	2400	2400

CHAPTER II – TABLE II

Summary of Sampling Results in Tracer Tests

Test No.	1	2	3	4	5	6	
Sampling Network	Outer	Outer	Outer	Outer	Outer	Inner	Outer*
Period of Sampling PST	06-16	06-16	06-16	06-16	06-16	05-13	06-16
Sampling Rate (liters/hr)	600	600	600	600	600	600	600
Maximum Particle Count	10	11	104	7	2848	70512	315
Stations with Significant Counts (5 particles or more)	1+2	1-5	1	12+13	16-23	33-36+38	15-25
Stations Expected from Surface Trajectories computed by Vance	1+2	1-11	1-3	23-25	14-18	34-38	17
Above Computed by Graham		1-12	1-3	14-16	23-25	35-38	17-21
Above Computed by Neiburger						32-36	15-17
Stations Expected from Trajectories Surface and Aloft with Mixing between Levels	1+2	1-15	1-3	5-25	13-25	34-38	17-25
Observed Time of Significant Counts (PST)	07-08	08-12	07-08	12-13	09-12	05-11	07-13
Time Computed from Surface Trajectories by Vance	08-09	11-13	09-12	11	13-14	07-12	13-14
Time Computed from Surface Trajectories by Graham	08-09	11-14	08-11	13-14	09-10	06-12	12-13
Time Computed from Surface Trajectories by Neiburger						07-12	13
Time Computed from Mixed Trajectories	06-09	08-14	09-12	10-14	10-14		11-15

*Odd numbered stations only.

In the sixth test, in addition to the outer sampling net, an inner circle of sampling stations with a radius of four miles was established.

Table I gives a summary of the operational conditions during the tests, and Table II gives the sampling results, comparing them with the results expected from the trajectory computations. Table III gives more details concerning the stations and hours at which the highest numbers of particles were found in each test. In the case of Test No. 6, there was double maximum at both the inner and outer sampling station circles.

Surface wind trajectories were computed for all the tests independently by William Vance, a UCLA meteorology student with considerable experience in the Air Force weather service, and by Roderick D. Graham, research forecaster for the United States Weather Bureau. In addition, for Test No. 6, the writer computed a surface trajectory. Besides the surface trajectories, Mr. Vance computed the trajectories of the air moving at 500 ft., 1000 ft., etc., up to the base of the inversion in each case, and also the development of the cloud on the assumption that at each point the air was mixed vertically from the ground to the inversion base. All trajectories were computed with no knowledge of the sampling results. As an example, the surface trajectories for Tests 2 and 5 are shown in Fig. 4. Sampling stations which had filter counts greater than four particles in any hour are enclosed in shaded areas.

It will be seen from Table II and Fig. 4 that the surface wind trajectories are generally consistent with each other and give a reasonable approximation of the region where the fluorescent particles were found, but in some cases (Tests 4 and 5) the trajectories computed by the two analysts were rather far apart, and in almost every case the times at which the particles were observed were earlier than the computed times. In general, the computation assuming mixing at all levels resulted in movement which carried the fluorescent cloud to all stations where they were actually observed, but in addition to many other stations where no particle count was observed. The hypothesis of this mode of development and movement of the cloud of tracer material predicted times of cloud arrival at the stations closer to those observed than the trajectories using surface winds alone.

A detailed analysis of the results is reserved for the final report of the tracer project, which

CHAPTER II – TABLE III

Stations and Times of Maximum Particle Count

Test No.	1	2	3	4	5	6			
Max. Count.						Inner		Outer *	
No.	10	11	104	7	2848	70512	4773	315	157
Sta.	1	4	1	12	18	36	36	23	15
Time	07-08	10-11	07-08	12-13	10-11	06-07	08-09	07-08	11-12

*Odd numbered stations only.

(a) eye irritation
(b) reduced visibility
(c) odor
(d) high "oxidant" value
(e) plant damage

(5) No specific gaseous pollutant nor mixture of gaseous pollutants *in the concentrations found in our atmosphere* has been proved to be responsible for eye irritation or reduced visibility; *however*, typical high oxidant values have been produced in the laboratory by:

(a) irradiation of hydrocarbons when NO_2 was added, both being at experienced concentrations,

(b) irradiation of auto exhaust (which contains NO_2) at experienced concentrations

and plant damage has been obtained in the laboratory by fumigating with auto exhaust and added ozone, but not with hydrocarbons and ozone, at experienced concentrations. The fact that plant damage has been obtained with hydrocarbons at concentrations as low as a few parts per million (though several times experienced concentrations), plus ozone at experienced concentrations, implicates hydrocarbons with respect to this one smog effect. Qualitative effects of eye irritation and reduced visibility have been noted, again at higher concentrations. In brief, the evidence, though circumstantial, justifies intensive studies of means for the material reduction of both hydrocarbons and auto exhaust.

(6) Smog, thus characterized, does not appear to originate *as such* from any known source.[2]

(7) Smog forms *from* man-made pollutants, but how may be explained so far, if at all, only in vague generalities. Thus:

Its occurrence is quite variable;

It is only roughly predictable at short range (24 to 48 hours);

From *which* pollutants it is formed, singly or in combination, is unknown (though partly suggested with respect to certain hydrocarbons, as will be described);

Its intensity is indicated largely by the subjective effects listed above, varying according to place, time, and pollution levels in ways understood not at all;

Eye irritation and high oxidant values are rarely, if ever, found at night.

(8) The great bulk of our air pollution consists of combustion products, including motor vehicle exhausts, stack gases from the burning of natural gas and fuel oil for heat, light, and power, and burning of rubbish; it consists of industrial emissions including hydrocarbons from the production, refining, and distribution of petroleum products, and miscellaneous dusts, gases, solvent vapors, and smokes associated primarily with manufacturing processes other than combustion.

(9) The chemical composition of these sources is at worst not known at all, and at best not reliably or fully known.

(10) The gross daily quantities of gas, oil, gasoline, and rubbish consumed have been estimated, and the daily production of pollutants therefrom calculated on the basis of available knowledge concerning the composition of specific sources. (See Tables I, II, and Fig. 1)

(11) Gross tonnages of pollutants are only a measure of contribution to air pollution; until we know which pollutants produce which smog effects, we cannot directly relate sources and tonnages to smog; it is entirely possible that certain pollutants have importance as smog-formers out of all proportion to the quantity of the sources in which they occur, or to their concentrations.

(12) The information on the concentrations of specific pollutants in the Los Angeles atmosphere, especially during periods of low temperature inversion, is generally spotty and inadequate; such data as exist for carbon monoxide, hydrocarbons, and oxides of nitrogen and sulfur agree qualitatively with values calculated from

[2]except for the synthetic rubber plant in Los Angeles operated during World War II and shut down in 1947; and except for very limited, highly localized brief emissions from some motor vehicles presumably in improper operating condition, and then only in high concentrations found close to such vehicles or in very confined spaces or tunnels.

CHAPTER I — TABLE I

DAILY EMISSIONS, COMBUSTION AND EVAPORATION — 1953*

Not including Particulates, Metallurgical Operations, CO, and Miscellaneous, for Los Angeles County in Tons per Day

	COMBUSTION							
Material Burned	Tons/Day	Ald.	NH_3	NO_2	SO_2	Acids	Orgs.	Tons/Day Total Pollutants
General Public:								
Gas**	8640	8.5	—	60	—	11	12	
Oil	2370	3	—	32	71	32	11	
Gasoline	14380	40	5	177	40	4	1016	
Trash	5060	9	4	1	2	2	414	
Total	30450	60.5	9	270	113	49	1453	1955
Petroleum Industry:								
Gas**	9890	11	5	75	103	13	16	
Oil	2820	3	—	38	84	38	12	
Total	12710	14	5	113	187	51	28	398
Other Industries:								
Gas**	12873	12	—	88	—	17	20	
Oil	3640	4	—	49	111	50	17	
Refuse	2500	3	0.1	2	0.2	0.6	29	
Total	19013	19	0.1	139	111.2	67.6	66	402.9
Grand Totals	62173	93.5	14.1	522	411.2	167.6	1547	2756

EVAPORATION		
General Public (Autos and Service Stations)	Hydrocarbons	216
Petroleum Industry	"	251***
Total, Combustion and Evaporation	"	3223

TOTAL FUELS BURNED DAILY, TONS	
Gas	31403
Oil	8830
Gasoline	14380
Refuse	7560
Grand Total	62173

* *The Smog Problem in Los Angeles County*, Stanford Research Institute (January, 1954); Tables XLIV and XLVI; these figures are the best available as of April 1, 1955, but the Air Pollution Foundation has not as yet measured the composition or amounts of combustion effluents and cannot vouch for the accuracy of these data.

** Revision by Air Pollution Foundation as of December, 1954 based on data from the Southern California Gas Company for 1954.

***Air Pollution Foundation audit as of March, 1954.

the estimated quantities emitted, assuming reasonable dispersion over the metropolitan area under the inversion height existing at the time of the measurements. However, monitoring of presumably significant pollutants has not been done in a consistent and continuous manner. There are just enough data accumulated irregularly over recent years to permit differing interpretations of the origins and movement of polluted air masses, as well as the chemical and physical reactions taking place which cause observable smog manifestations. Concentrations of aldehydes, low as they are, appear to be significantly higher than can be accounted for from all known sources. The same is true of oxidants, especially ozone.

(13) Methods of analysis and instrumentation essential to reliable measurement of small fractions of a part per million of various gases, liquids, and solids are for the most part inadequate. No systematic, statistically significant techniques exist for the measurement of eye irritation or plant damage.

Scientific Conferences

That the foregoing general outline approximates the status of scientific opinion at this time is indicated not only by the consensus of published reports, but is more specifically evidenced by the minutes of conferences held in early 1954 (see Appendix). One of the first activities of the Foundation was to invite representatives of the principal scientific laboratories and agencies that had been working on the problem to meet in round-table sessions and exchange views. Participants included:

CHAPTER I — TABLE II

SUMMARY OF "IMPORTANT" POLLUTANTS, LOS ANGELES COUNTY — 1954*

Combustion and Evaporation Processes Only in Tons per Day

	General Public: Auto & Service Stations	General Public: Other	Petroleum Industry	Other Industries	Total	
Acids	4	45	51	67.6		167.6
Aldehydes	40	20	14	19		93
Olefins	26 (E)	—	16 (E)	—	42	
	292	—	—	—	292	334
Other Organics	190 (E)	—	28	—	218	
	724	437	235 (E)	66	1462	1680
Nitrogen Oxides	177	93	113	139		522
Total	1453	595				
	2048		457	291.6		2797

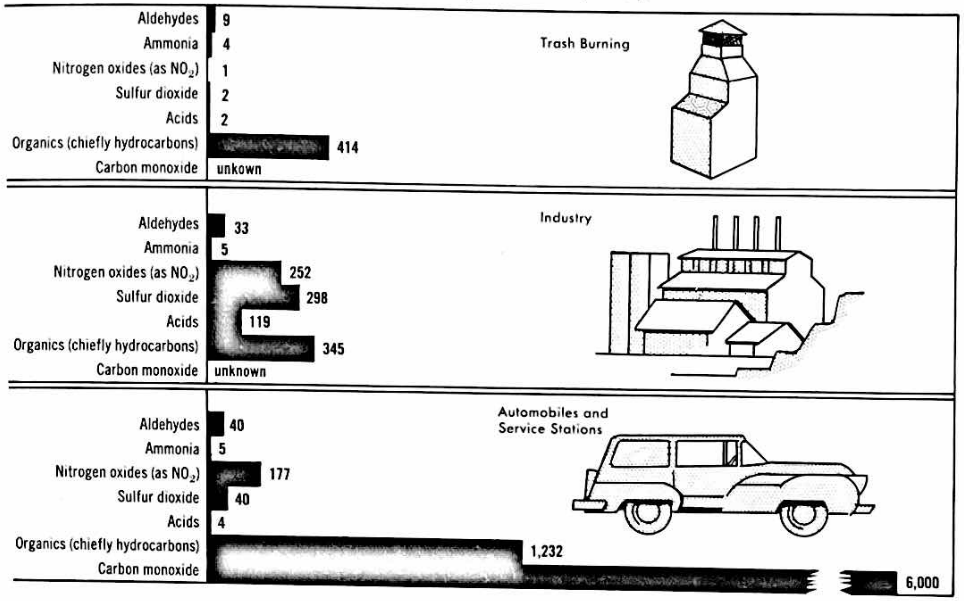
E—Evaporation

*Derived from Table I

CHAPTER I – FIG. 1 (derived from Table I)

DAILY GASEOUS EMISSIONS FROM SELECTED SOURCES

Los Angeles County—1954 (Tons per day)



Los Angeles County Air Pollution Control District: G. P. Larson, W. J. Hamming; Consultants to Air Pollution Control District: A. O. Beckman, U. B. Bray; Air Pollution Foundation: L. B. Hitchcock, L. H. Rogers; American Petroleum Institute: V. Jenkins; California Institute of Technology: A. J. Haagen-Smit; Stanford Research Institute: L. M. Richards, F. E. Littman; University of California, Los Angeles: F. E. Blacet.

Through conferences and correspondence over a period of about 60 days, the following conclusions were unanimously agreed to:

1. Hydrocarbons are present in the Los Angeles atmosphere.
2. Auto exhaust gases plus ozone, at realistic concentrations, give plant damage.
3. Auto exhaust gases alone are not damaging, nor do they of themselves cause eye irritation at realistic concentration.
4. Petroleum hydrocarbons (whether coming directly from refineries or gasoline, or coming from auto exhaust pipes) plus reaction products of the internal-combustion engine, of themselves will not cause smog; some further oxidative process must take place.
5. Hydrocarbons, etc., in auto exhaust fumes plus NO_2 plus ozone give plant damage.
6. Some petroleum hydrocarbon unsaturates may cause eye irritation when irradiated with some oxidant.

7. We believe that at least some petroleum hydrocarbons may enter into reactions in a significant way to produce what we call "smog." There are some hydrocarbons emitted into the atmosphere along the line from the oil well up to the input of the automobile which may enter into smog-producing reactions; more specifically, certain olefins which may react with ozone.
8. Petroleum hydrocarbons and/or their derivatives produced in the internal-combustion engine may be a significant contributor to smog, but we cannot yet completely and satisfactorily establish this significance; we agree that some of the more reactive hydrocarbons and/or their derivatives may contribute to smog by a mechanism or mechanisms not yet fully understood, although much progress has been made.
9. Ozone formation appears to be sufficiently significant in the conversion of certain hydrocarbons to smog to warrant further study.
10. Some petroleum hydrocarbons may contribute to smog through some oxidative process.
11. Ozone may participate in some way not yet fully understood in the oxidative process but the evidence is still inconclusive as to whether ozone is itself a reactant or a reaction product.
12. A photochemical reaction or reactions seem to be involved in the formation of ozone and in the reaction of NO_2 and some organic materials.
13. Ozone may also be produced by a separate reaction at the same time that smog is being formed.

In addition to these conferences many others were held with scientists invited from all over the country. The extent of their agreement turned out to be much more substantial than was generally anticipated. But since the scientific workers in general had not correlated their findings to any appreciable extent and indeed seemed to have been emphasizing their points of disagreement, it is not surprising that the general public had no perspective on the problem.

Actually, this scientific disagreement was typical of pioneering in a new field which we know now to be one of great complexity. The analogy was made to the three blind men who for the first time grasped different parts of an elephant, and each described a different animal. But the man in the street, at times severely annoyed by smog, was inclined to attribute the inability of the scientist to stop smog to stupidity, bias, or worse, and found little satisfaction or hope of relief in what he heard or read. Under these conditions it is not surprising that it was difficult to distinguish between fact and fancy, between numerous theories and speculative remedies.

Areas of Disagreement

Definite disagreement existed as to the extent to which available data proved that certain smog effects were caused by specific sources of specific pollutants in those sources. For example, whether:

(1) Hydrocarbons reacted photochemically in the presence of oxides of nitrogen and air to form both oxygen complexes and ozone.

(2) These oxygen complexes caused eye irritation as well as plant damage, the latter distinguishable from damage caused by ozone, or sulfur dioxide and other pollutants.

(3) Cracking of rubber by ozone and by organic peroxides or free radicals was distinguishable.

(4) Concentrations at which some smog effects were simulated in the laboratory were "realistic," or produced effects equivalent to those experienced in the Los Angeles atmosphere.

(5) Fumigations with mixtures of selected pollutants (such as selected hydrocarbons or auto exhaust) and ozone, or oxides of nitrogen and sunlight or artificial radiation, were significant. Wall effects, residence time, wave length and intensity of light source, and other experimental difficulties were typical of pioneering scientific research.

There was disagreement, consequently, not only as to the approximate magnitudes of our principal sources of pollution, but as to their relative importance smog-wise. For example, total emissions of incinerators in the Basin were estimated variously from 90 tons per day of "harmless smoke" to 500 tons per day of ash, smoke, and largely invisible organic compounds. Particulate matter and ordinary smoke were described by some as remarkably low in Los Angeles, while others claimed it was one of the dirtier cities in the country. Again, this disagreement was due largely to the great variability in such pollutants as to time and place, and the lack of adequate data.

Dual Approach to the Air Pollution Problem

In these chapters prepared by our scientists the situation will be described substantially as it existed at the end of 1954. We approached the air pollution problem with two dominant philosophies:

(1) that certain pollutants may be largely responsible for smog effects and these substances can be identified and means found for their elimination;

(2) that all pollution is undesirable, and means must be found for reducing the amount to tolerable levels and maintaining these in a growing metropolitan area. We assume polluted air is unhealthy.

We do not know yet which approach will bring relief sooner. We doubt if anyone else does. Both are quite likely to be productive. Both require research, based on continuous study and review of all available information from all quarters. Both require development of new or greatly improved methods of analysis and control.

Identification of principal sources of pollution does not tell us how to abate them. The magnitude of motor vehicle exhaust as a contributor to modern urban air pollution has only lately begun to be appreciated. No workable control remedy has been devised so far, although the automobile manufacturers, the Coordinating Research Council, the Foundation, and others are doing everything they know to find practicable remedies at the earliest possible date.

An independent audit of hydrocarbon losses from the production and refining of petroleum products was conducted by the Foundation, indicating as of March 1, 1954, a total of about 250 tons per day, a substantial reduction from the losses estimated two years ago. The oil industry in the Basin anticipates further significant reduction upon the completion of controls under Rule 56 by May 1, 1955. They are also working on devices for collecting vapors presently lost in filling tank trucks and controlling other emissions even though no control regulations have been issued.

But we do not have to wait until all information is in on all sources before acting. We, like others, are reporting our findings as rapidly as possible. For example, there seems to be adequate evidence that incineration of rubbish in the Los Angeles Basin creates a serious nuisance, and consensus of authorities over the country recommends discontinuance of all present-day incinerators, domestic or municipal, in view of the local conditions. But prohibition by edict must, at the same time, offer a workable alternative, so the "bury-and-cover" method is recommended in a thorough technical report just published by the Foundation.[3] Copies are being furnished to all Los Angeles County and municipal officials, as well as to our contributors and others to whom it may be helpful.

Duplication of the work of either our contemporaries or our predecessors is something for which we have neither time nor money. We have too many urgent new projects waiting for manpower. *Additional* work is often necessary on an important subject which has only been opened up by prior workers.

How long it will take to find the causes and subsequent controls for our air pollution problem, and when the remedies for the principal sources will be developed, are, of course, of the greatest concern to all of us. The impatience of the public is equalled only by the impatience of the workers on the problem, whose whole satisfaction and fulfillment in life can come in no other way than by finding the solution at the earliest possible time.

[3]Report No. 3, "Incineration, Rubbish Disposal, and Air Pollution," January, 1955.

II. METEOROLOGICAL ASPECTS

DEFICIENCIES IN DATA AVAILABLE AS OF APRIL 1, 1954

IN order to make readily accessible existing knowledge on the meteorological conditions in the Los Angeles area as they affect the occurrence of atmospheric pollution, the Foundation commissioned the writer to prepare a summary. In collaboration with Dr. James G. Edinger the material was published as Report No. 1, "Meteorology of the Los Angeles Basin."[1]

This report pointed to the need for certain types of additional meteorological investigations. In the first place, the representativeness of the wind observations was questioned. Surface wind observations were available from an extensive network of stations, but the exposure of the instruments and, in many cases, the quality of the instruments and observers were of doubtful reliability. In the case of upper air winds, measurements were made at only two points and additional stations were essential in order to complete the picture of the air flow over the Basin. It was suggested that tracer studies be carried out to check how accurately the air trajectories, i.e. the paths of polluted air, could be determined from surface wind observations.

The use of meteorological data in evaluating improvement due to control measures was discussed in the report. An example was given in which the Air Pollution Control District showed that the monthly average visibility for a given wind speed has had some tendency to increase in downtown Los Angeles since control of the emission of particulate matter was put into effect, even though the average heights of the inversion for corresponding months were stated to be approximately the same. A need was indicated for further studies of the trend in visibility during periods of increasing pollution, while testing the effectiveness of control measures.

It was pointed out that systematic measurements of pollution concentrations and effects were sorely lacking in correlating meteorological conditions and smog. In particular, the lack of controlled reports of eye irritation and plant damage prevented a quantitative estimate of smog intensity to which meteorological variables as well as chemical analyses might be related.

Based on this report and on additional discussions and conferences, the decision was made to undertake two meteorological investigations during 1954: (1) an air tracer study to test the reliability of trajectories computed from surface wind reports, and (2) an analysis of past visibility records to see how much visibility had been reduced by pollution, as well as to examine any evidence of improvement due to control measures. The decision to conduct the air tracer study and various points about the way to conduct it were greatly influenced by a conference with leading meteorologists, including among others Dr. O. G. Sutton, director of the Meteorological Service of the British Air Ministry, Dr. Harry Wexler, chief of the Scientific Services Division of the U. S. Weather Bureau, and Dr. E. Wendell Hewson, professor of meteorology at the University of Michigan.

[1]M. Neiburger and J. G. Edinger, "Summary Report on Meteorology of the Los Angeles Basin With Particular Respect to the 'Smog' Problem." Air Pollution Foundation, April, 1954.

AIR TRACER STUDY[2]

The design of the air tracer experiment had as its principal purpose a test of the accuracy of trajectories computed from surface winds. A secondary purpose was to see whether discrepancies, if they occurred, could be accounted for adequately on the basis of winds at upper levels, and for this purpose special upper wind stations were established at four points in addition to the regular stations at Long Beach and Burbank. The four special stations and the Air Force Station at Long Beach took winds-aloft observations every two hours during the tracer tests.

As a tracer material a fluorescent pigment, zinc-cadmium sulfide powder, was selected. This powder consists of fairly uniform-sized particles having a mean "diameter" of less than two microns, so that once dispersed into the air, they fall very slowly and move with the air currents almost as gaseous molecules (Fig. 1). They are collected on millipore filters through which the air is passed. The retained pigment particles glow under ultraviolet light with a characteristic yellow-gold color quite different from naturally occurring dust and haze particles, so that they may be distinguished and counted easily.

Wind observations appeared more likely to give a good indication of the movement of pollutants during the afternoon sea breeze than during the light, variable land breezes at night and in the early morning. It was decided, therefore, to make the tests in such a fashion as to release the tracer material early in the morning and to have the sampling network far enough away so that the tracer cloud would reach the sampling stations only after the sea breeze

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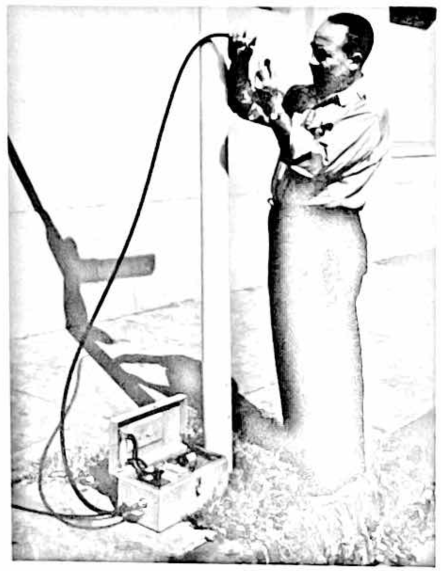
CHAPTER II – FIG. 1 *Courtesy of The Ralph M. Parsons Co.*

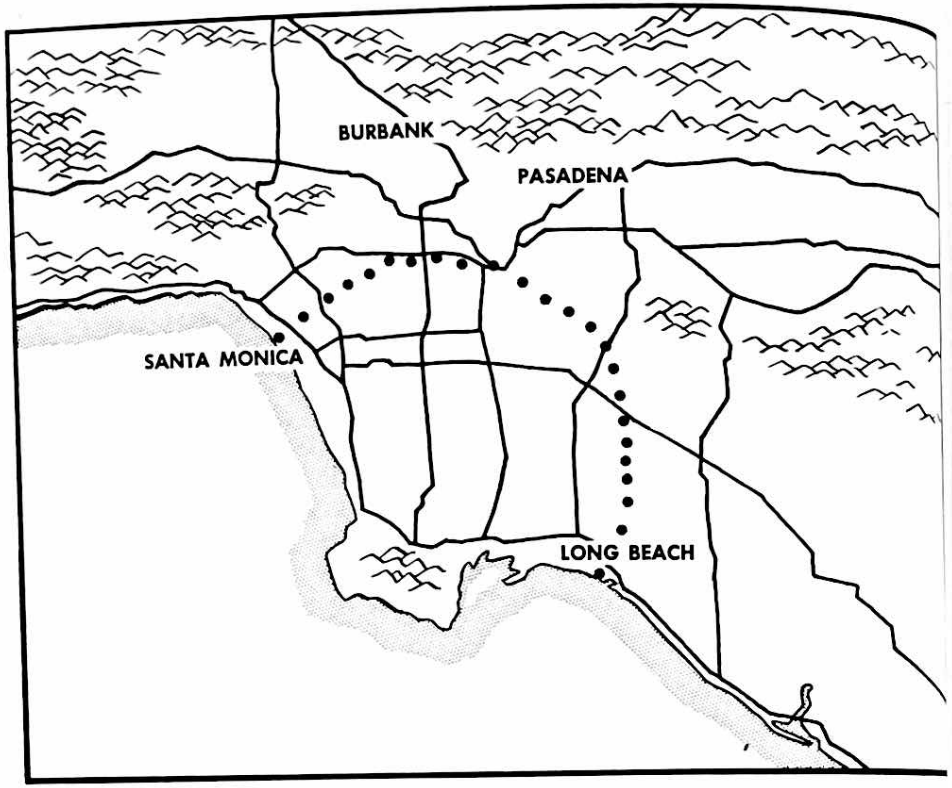
Dispersal of fluorescent particles for tracer tests



CHAPTER II – FIG. 2

Changing filter in air sampler for sampling fluorescent particles in tracer tests

Chapter II – Fig. 3
Air tracer sampling stations



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" 1900 PST	2800	1100	340	885	Sfc	Sfc
Place of Dispersal	Shell Chem. Co.	Shell Chem. Co.	Shell Chem. Co.	Shell Chem. Co.	Compton Airport	Compton Airport
Height of Dispersal above Ground, ft.	15	45	45	45	25	25
Time of Dispersal	0300-0400	0300-0400	0300-0400	0415-0515	0500-0600	0500-0600
Weather at Dispersal	Cloudy	Clear	Clear	Dense Fog	Moderately Dense fog	
Visibility at Dispersal	Good					
Wind at Dispersal	SE		ESE-E 3-6 NE-N 2-1	E-N 1.5-2.5 mph	NNW-N 1-2 mph	WNW-NW 2-4 mph
Amt. of F.P. Dispersed (grams)	1200	2400	2400	3000	2400	2400

Summary of Sampling Results in Tracer Tests

Test No.	1	2	3	4	5	6	
Sampling Network	Outer	Outer	Outer	Outer	Outer	Inner	Outer*
Period of Sampling PST	06-16	06-16	06-16	06-16	06-16	05-13	06-16
Sampling Rate (liters/hr)	600	600	600	600	600	600	600
Maximum Particle Count	10	11	104	7	2848	70512	315
Stations with Significant Counts (5 particles or more)	1+2	1-5	1	12+13	16-23	33-36+38	15-25
Stations Expected from Surface Trajectories computed by Vance	1+2	1-11	1-3	23-25	14-18	34-38	17
Above Computed by Graham		1-12	1-3	14-16	23-25	35-38	17-21
Above Computed by Neiburger						32-36	15-17
Stations Expected from Trajectories Surface and Aloft with Mixing between Levels	1+2	1-15	1-3	5-25	13-25	34-38	17-25
Observed Time of Significant Counts (PST)	07-08	08-12	07-08	12-13	09-12	05-11	07-13
Time Computed from Surface Trajectories by Vance	08-09	11-13	09-12	11	13-14	07-12	13-14
Time Computed from Surface Trajectories by Graham	08-09	11-14	08-11	13-14	09-10	06-12	12-13
Time Computed from Surface Trajectories by Neiburger						07-12	13
Time Computed from Mixed Trajectories	06-09	08-14	09-12	10-14	10-14		11-15

*Odd numbered stations only.

In the sixth test, in addition to the outer sampling net, an inner circle of sampling stations with a radius of four miles was established.

Table I gives a summary of the operational conditions during the tests, and Table II gives the sampling results, comparing them with the results expected from the trajectory computations. Table III gives more details concerning the stations and hours at which the highest numbers of particles were found in each test. In the case of Test No. 6, there was double maximum at both the inner and outer sampling station circles.

Surface wind trajectories were computed for all the tests independently by William Vance, a UCLA meteorology student with considerable experience in the Air Force weather service, and by Roderick D. Graham, research forecaster for the United States Weather Bureau. In addition, for Test No. 6, the writer computed a surface trajectory. Besides the surface trajectories, Mr. Vance computed the trajectories of the air moving at 500 ft., 1000 ft., etc., up to the base of the inversion in each case, and also the development of the cloud on the assumption that at each point the air was mixed vertically from the ground to the inversion base. All trajectories were computed with no knowledge of the sampling results. As an example, the surface trajectories for Tests 2 and 5 are shown in Fig. 4. Sampling stations which had filter counts greater than four particles in any hour are enclosed in shaded areas.

It will be seen from Table II and Fig. 4 that the surface wind trajectories are generally consistent with each other and give a reasonable approximation of the region where the fluorescent particles were found, but in some cases (Tests 4 and 5) the trajectories computed by the two analysts were rather far apart, and in almost every case the times at which the particles were observed were earlier than the computed times. In general, the computation assuming mixing at all levels resulted in movement which carried the fluorescent cloud to all stations where they were actually observed, but in addition to many other stations where no particle count was observed. The hypothesis of this mode of development and movement of the cloud of tracer material predicted times of cloud arrival at the stations closer to those observed than the trajectories using surface winds alone.

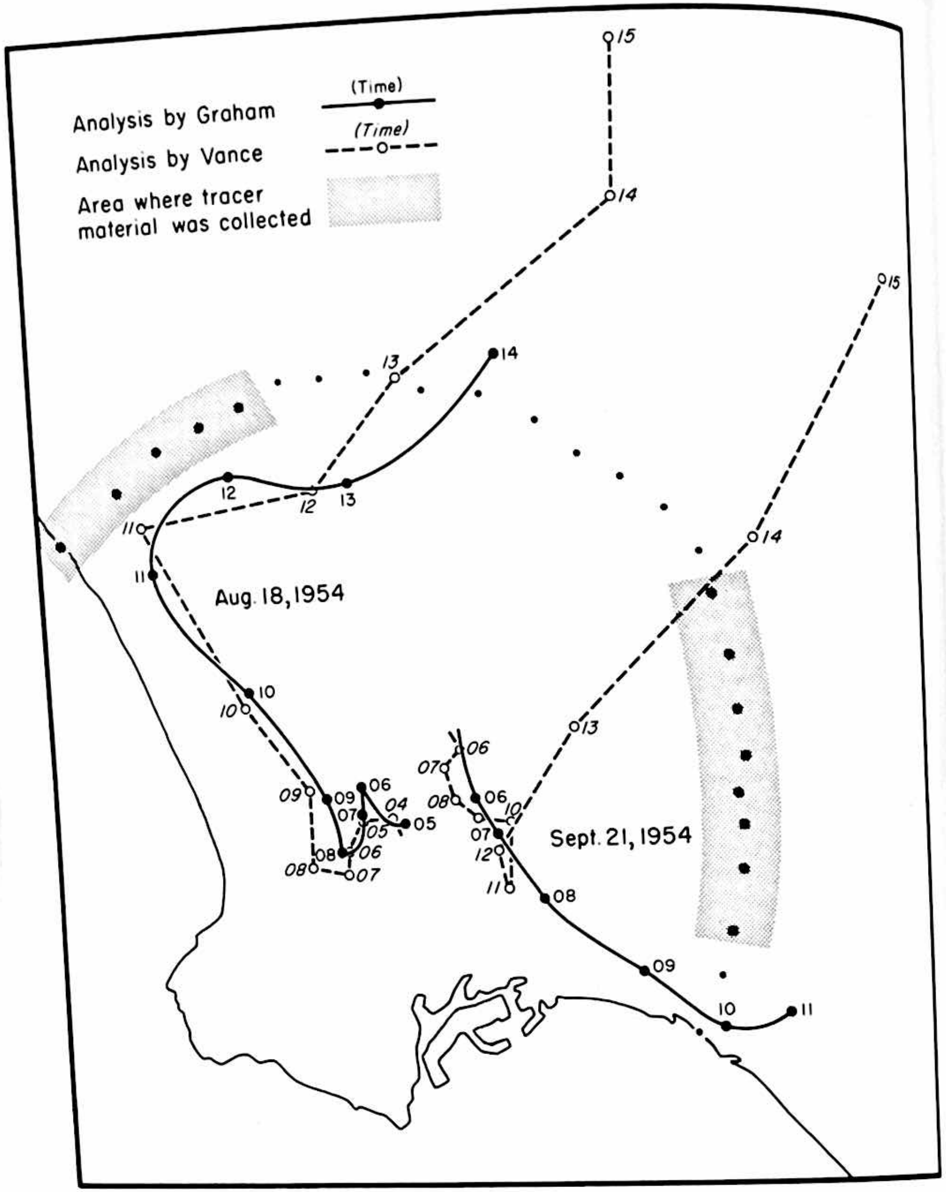
A detailed analysis of the results is reserved for the final report of the tracer project, which

CHAPTER II – TABLE III

Stations and Times of Maximum Particle Count

Test No.	1	2	3	4	5	6			
Max. Count.						Inner		Outer *	
No.	10	11	104	7	2848	70512	4773	315	157
Sta.	1	4	1	12	18	36	36	23	15
Time	07-08	10-11	07-08	12-13	10-11	06-07	08-09	07-08	11-12

*Odd numbered stations only.



Chapter II – Fig. 4
Computed trajectories in tracer tests 2 and 5

is now being prepared. For the present, the following tentative conclusions may be put forward:

(1) Trajectories from the surface winds computed independently by different analysts are usually nearly the same, but may differ markedly. This difference appears due to the existence of gaps in the wind station network, which permit varying interpolations of the wind pattern, particularly during a period of light winds.

(2) The trajectories computed from the surface winds are usually good indications of the general area of movement of the air, but may in some cases be fairly far from the real movement shown by the tracer material.

(3) The surface trajectories almost invariably indicate slower movement of the air than shown by the tracer material.

(4) The combination of surface and upper winds leads to an improvement in the areal designation, but also indicates too great a dispersion of the cloud; it leads to improvement of the speed of movement of the forward edge of the cloud, but also to too great a duration of cloud passage.

In summary, the tracer tests indicate that a fair amount of reliance may be placed on the surface wind trajectories, but that allowance must be made for errors with respect to timing. Since the errors appear to be present even when the inversion is low, it seems that variation of wind with height is not the only factor. Two measures seem desirable in seeking improvement: (1) certain large gaps in the surface wind station network should be filled by establishing new stations; and (2) the whole network should be calibrated by exposing standard wind instruments for a period of about one week at each of the stations, and a routine for checking and servicing the stations should be established. In addition, there is enough indication of the influence of upper winds to call for the establishment of additional upper wind stations for the purpose of micrometeorological and pollution studies.

STUDY OF VISIBILITY TREND

Systematic observations of visibility began only with the development of commercial aviation about 1930 and until very recently depended entirely on subjective estimates. The observer ascends to a place with a relatively unobstructed horizon and attempts to determine visually which of several pre-selected conspicuous structures he can just see well enough to recognize. This type of measurement varies somewhat from observer to observer, but the main differences in external conditions will be evident. Thus, if the statement were true that years ago Catalina Island was visible from Los Angeles every day both summer and winter, the early visibility records would show this fact.

In addition to the influence different observers might have on the records, conclusions from comparison of the visibility records from year to year are rendered difficult because visibility is influenced by many meteorological factors in addition to the increase in sources of pollution. Among them are inversion height and wind speed, which reflect the volume of air into which the pollution is diluted; wind direction, which indicates what pollution sources may have contributed to reducing the visibility; the general weather pattern which prevails; and the relative humidity, which indicates to what extent liquid water may have condensed on the particles present. In addition to these factors, there are the general flow pattern and the air mass structure, reflecting the source region and history of modification of the air as it has approached the area from long distances. In general, Los Angeles visibility is better in polar than in tropical air, in continental than in maritime air masses.

Measurements of the inversion height and other aspects of the upper air structure have been made for only a relatively small part of the period of visibility records. Correlation or sorting by general flow pattern would require development of typing procedures and the examination of the daily weather maps for the more than twenty years of record. It was decided therefore to attempt only to separate the observations according to locally measured factors, with the expectation or hope that the effects of the others would average out.

Of the factors which influence visibility, relative humidity and wind direction were selected as the two which might be most influential.

The stations in the Los Angeles Basin at which long visibility records are available are Burbank, International Airport, and downtown Los Angeles. Of these, the downtown station provides both the longest homogeneous record and the one most likely to reflect the effect of pollution. It suffers from the fact that the measurements were made on top of high office buildings, and thus do not give a good indication of the variations at street level.

The procedure used in the visibility study consisted of tabulating the observations at 4:30 a.m., 12 noon and 4:30 p.m. PST, and turning them over to the service department of International Business Machines, Inc., where they were punched on cards, sorted, and tabulated according to humidity and wind direction groups.

CHAPTER II — TABLE IV

Noon

Relative Humidity 41% - 70%

Percentage of Observations with Visibility less than 3 Miles

Years	Wind Direction Group 2 ESE - S			Wind Direction Group 3 SSW - W		
	Jan-Feb Nov-Dec	March-June	July-Oct	Jan-Feb Nov-Dec	March-June	July-Oct
1933-1935	33	24	43	25	13	27
1936-1939	24	26	22	34	11	15
1940-1943	26	28	39	6	20	31
1944-1947	22	37	65	40	22	43
1948-1951	30	25	36	57	17	28
1952-1954	21*	25	49	20*	20	36

Percentage of Observations with Visibility more than 12 Miles

Years	Wind Direction Group 2 ESE - S			Wind Direction Group 3 SSW - W		
	Jan-Feb Nov-Dec	March-June	July-Oct	Jan-Feb Nov-Dec	March-June	July-Oct
1933-1935	21	18	11	19	35	8
1936-1939	24	14	11	37	29	12
1940-1943	30	20	10	62	22	9
1944-1947	12	10	2	26	18	7
1948-1951	23	13	4	26	22	5
1952-1954	20*	21	3	44*	22	1

*Excluding December, 1954

The relative humidity groups used were (1) 1%-40%, (2) 41%-70%, (3) 71%-90%, (4) 91%-100%. The wind direction groups were (1) north-northeast to east, (2) east-southeast to south, (3) south-southwest to west, (4) west-northwest to north, (5) calm (speed less than 1.5 miles an hour). Observations with current precipitation were eliminated. In order to have a sufficient number of observations for a particular humidity and wind direction group, the data for groups of three or four years were lumped together. Altogether six such groups were used, covering the period 1933 to 1954.

Table IV gives an example of the type of results which can be obtained—the percentage of noon observations with visibility less than three miles and more than twelve miles, for relative humidity group 2 and wind direction groups 2 and 3.

It will be seen in the Table that, except for the winter season, the period 1944-1947 had a larger percentage of days with noon visibility less than three miles than any other period, as seen particularly in the July-October columns. This may be due to the fact that these months are the ones when the subsidence inversion is almost always present and is lowest, so that the influence of pollution is felt the most. The larger percentage of low visibilities for wind direction group 2 than for wind direction group 3 may reflect the distribution of heavy industry to the southeast of downtown Los Angeles.

The decrease in percentage of days with visibility less than three miles after 1947 suggests that the measures adopted to control the emission of particulates were effective.

Failure of the winter data for wind direction group 2 to show the same pattern as for the other seasons may indicate that in the unstable air masses of that season pollution is so rapidly diffused upward that it is not a major factor in the visibility variation.

In summer, noon visibilities greater than twelve miles occurred less than 12% of the time with these humidities and wind directions, even in the early 1930's when smog and its eye-irritating and plant-damaging effects were unheard of. At least for the summer period, and to some extent in other months, there has been a fairly consistent decrease through the years. In the case of high visibilities, the introduction of control measures in 1947 seems to have had no effect in stemming the decrease in the frequency of their occurrence.

As in the case of the tracer study, full presentation of these data and their discussion must be reserved for the separate report on the visibility study, now being prepared.

EVALUATION OF SPECULATIONS TO ELIMINATE SMOG BY METEOROLOGICAL EFFECTS

The meteorological staff of the Foundation has examined several proposals for the removal of smog by altering the temperature structure or flow pattern of the air over the Basin. In general, although several ingenious proposals have been put forward, we found that such proposals invariably ignore the vast amount of energy required to accomplish these purposes. There have also been suggestions that a search be made for some effect which will trigger natural forces adequate to achieve them. Until there is some indication that natural forces exist in latently unstable equilibrium, it remains the impression of the Foundation staff that such a search is not deserving of the investment of time and money. All the presently available meteorological information emphasizes the great stability of the situation.

As an example of the tremendous amounts of energy involved, the following computation may be of interest. It has been frequently suggested that a line of giant windmills be installed to blow the smog away. Neglecting the effect of the confining mountains, the opposing pressure forces which would be set up the moment the air began to move, or the turbulence which would be created, we computed the amount of energy required to maintain a wind against ground friction over the area (4000 km²) of the Los Angeles Basin.

The energy required is proportional to the cube of the velocity, the constant of proportionality depending on the roughness of the terrain. If the entire Los Angeles area were as smooth as a golf green, it would require about 400,000 kilowatts or 535,000 horse power to maintain a wind of 4½ miles per hour, and 3,200,000 kilowatts or 4,300,000 horse power to maintain a wind of nine miles per hour against surface friction. For the actual character of the terrain it seems reasonable to assume a roughness factor at least five times that for a close-cropped lawn. Thus, we have for the minimum likely values 2,000,000 kw (2,700,000 HP) for the 4½ mile-per-hour wind, and 16,000,000 kw (21,500,000 HP) for the 9 mile-per-hour wind.

Interpreted in terms of 5,000 HP engines operating fans at 100% efficiency in producing translational motion, at least 540 fans would be required to maintain a 4½ mile-per-hour wind, or 4,300 fans for a 9 mile-per-hour wind. An appreciation of the amount of energy involved can be had by comparison with the total installed capacity of electric generating plants in the United States, which was 82,000,000 kw at the end of 1952. Thus a minimum of 2½% of the total capacity of the U. S. would be required for maintaining a 4½ mile-per-hour wind, and 20% of it would be needed for maintaining a 9 mile-per-hour wind.

As stated earlier, this computation ignores the effects of confining mountains, opposing pressure forces, and turbulence generated by the fans. Since the energy requirement is prohibitively great even when these effects are neglected, no computation was undertaken with them taken into account.

FUTURE RESEARCH

(1) Of top priority in future meteorological investigations is the calibration of the existing network of wind stations, which was discussed briefly in the section on the tracer study. The tracer study indicated that the movement of air pollution over the Basin is faster than that indicated by the surface winds. While this may be to some extent due to its being carried at higher levels and mixed downward, there is evidence that in large part it is due to deficiencies of the wind speed measurements, particularly for low speeds.

It was learned that the Los Angeles County Air Pollution Control District, under whose efforts the network was established, has no program of checking or servicing the instruments. The monitoring is done only to call attention of the cooperating agency to any indication in the data that the equipment is not functioning properly. Since the plotting and analysis of the data by the APCD usually takes several months, these obvious defects can pass unnoticed for long periods. The Foundation will propose that the APCD establish a program of routine maintenance and service.

The Foundation intends to propose that four standard sensitive anemometers be purchased and operated for a week at each of the existing wind stations. In the course of a week, the variations of wind will enable comparison of the station observations with accurate wind measurements. The speeds at which the station anemometer and wind vane first begin to respond and a correction for all normally occuring wind speeds will be established. In the course of three or four months such comparisons can be made at all stations in the network.

(2) A second meteorological project which has been proposed, and may be carried out in the Department of Meteorology at the University of California at Los Angeles, is a study of the feasibility of computing wind trajectories on high-speed digital computing machines. For the interpretation of the measurements made in the Aerometric Survey (see Chapter V), it is desirable to compute thousands of trajectories. Computation of these by traditional methods would involve a tremendous expenditure of time

by skilled personnel. It is hoped that methods can be devised which will enable their computation by machine in much less time and with much less expense.

(3) Another meteorological project, which has been proposed for the Department of Meteorology at the University of California at Los Angeles, is entitled "Pollution Concentrations from Area Sources in the Los Angeles Basin." It is planned to assume reasonable models for the distribution of pollution source intensity as a function of space and time and to compute the resulting concentrations as a function of space and time, using observed patterns of wind and other meteorological data.

Both the above projects are dependent on appropriation of funds to the University by the State Legislature, or alternately on equivalent support from the National Science Foundation or other federal agencies.

(4) As part of the Aerometric Survey for 1955, it is planned to take temperature soundings by captive balloon at stations near downtown Los Angeles and in Pasadena. These, together with the regular radiosonde observations taken four times a day at Long Beach, will give information concerning the variation in height of the inversion over the Basin. This information will be valuable in interpreting the chemical, plant damage, and eye irritation data, as well as giving additional valuable meteorological statistics.

III. CHEMICAL ASPECTS

INTRODUCTION

THERE is reasonable agreement among workers on the air pollution problem in Los Angeles that a photochemical oxidation process is responsible for the plant-damaging and eye-irritating characteristics of Los Angeles smog. However, because of the extremely low concentration of most of the substances involved and the complex mixture of pollutants that arise from a rapidly growing industrialized area, the experimental problem of duplicating these reactions in the laboratory is quite formidable.

The reactants, with the possible exception of oxygen, are present in amounts no larger than one part per million parts of air. This has a profound effect on reaction rates.

There is uncertainty as to the starting compounds, intermediate and end products, mechanism and rates of reactions, and the intensity and wave lengths of light which produce the reactions.

Further study of these problems is imperative. Any solution to the smog problem should have as its goal a maximum allowable concentration of the reacting substances. Furthermore, the evaluation of possible control measures such as a "blocking" reaction, or increasing the rate of degradation of the smog-causing intermediates, or including a harmless side reaction, can only be carried out after the nature of the reactions is understood.

The work being carried on in this program includes a critical review of the literature of atmospheric chemistry, studies of smog-forming reactions using the Los Angeles atmosphere, and studies of photochemical reactions in the laboratory using synthetic gas mixtures.

REVIEW OF LITERATURE

A critical examination of the literature of atmospheric chemistry has been undertaken by Professor Philip A. Leighton and Professor William A. Perkins, both of the Chemistry Department at Stanford University. It is planned not only to evaluate critically the available published reports but also to discuss with the research workers their latest and unpublished findings.

At present, all available reports are being collected and digested. A compilation has been made of several dozen possible reactions of oxides of nitrogen, and the most probable reactions are being determined. This project is expected to take an additional six months or more.

SMOG-FORMING REACTIONS SCRUBBING EXPERIMENTS

This project is concerned with the mechanism of formation of smog utilizing the Los Angeles atmosphere directly, subjecting it to various treatments including the addition of ozone, irradiation with controlled intensity and wave lengths, and the subtraction of materials by scrubbing the air with various reagents. The contractor on this project is Stanford Research Institute.

From an experimental point of view, the problem resolves itself into the controlled formation of smog by reacting polluted but non-smoggy air with oxidizing agents such as ozone or the oxides of nitrogen under conditions comparable in time and concentration to those encountered in the atmosphere. There are two possible sources of polluted, non-smoggy air: (1) night air, or (2) daytime air treated to remove the plant-damaging agents without altering its composition otherwise. It has been shown previously that this may be possible by filtration of the air through a bed of crumbled foam rubber which removes ozone and the phytotoxic agents but not the organics. Ozone may then be added to polluted air in concentrations comparable to those found in the atmosphere, permitted to react for a period of time ranging from a few minutes to several hours, and the air can then be examined for smog. Ozone will also be formed *in situ* by irradiation of polluted air to determine if smog develops. Once the techniques of controlled formation of smog are available, constituents can be removed selectively to determine their effect on smog formation.

From this account some fundamental experimental problems become evident. The first is an analytical one, for it will be necessary to know when smog has been formed and to get a measure of its activity. Since smog is defined by its plant-damaging, eye-irritating, and visibility-reducing properties, these criteria will have to be applied. Of these, plant damage is experimentally the most easily accessible one, and indicator plants will be used as a criterion of smog formation. Once the experimental conditions are sufficiently narrowed, eye irritation studies will be incorporated. Measurements of visibility will supplement the other techniques.

The use of indicator plants for the detection of smog has been described previously.[1] As always, when dealing with biological assays, elaborate precautions have to be taken in order to obtain meaningful and reproducible results. As many variables as possible have to be controlled in the growing of plants to assure uniform material: temperature, relative humidity, light, composition of the nutrient solution, age of the test plants, and the particular variety of plants used.

Two rooms for the growing of plants under carefully controlled conditions have been constructed. These rooms provide control of light, temperature, moisture, filtration of outside air through charcoal filters, and careful control of the plant nutrient solution. In addition, a reaction chamber has been constructed of glass-lined steel of 500-cubic-foot capacity together with the necessary blowers, ducts, flow meters, and other control devices. Also two smaller exposure chambers of about ten cubic feet have been constructed from plate glass. These chambers are provided with adequate light, so that plants which are being exposed to various atmospheres will be growing under conditions which approximate daylight.

Several different varieties of the plants are being grown: pinto beans, Poa annua, spinach, and romaine lettuce. The results of a typical experiment, using statistical test planning, appear in Table I. In this experiment ozone was added to carbon-filtered night air to give an oxidant concentration of 25 pphm. Three species of plants of identical age were fumigated; plant damage was experienced by all three.

CHAPTER III — TABLE I
PLANT FUMIGATION WITH OZONE AND CARBON-FILTERED AIR

Time of fumigation:	5:00 P.M.—8:00 A.M.
Oxidant level in fumigation chamber:	25 pphm
Residence time of ozone and carbon-filtered air mixture before entering fumigation chamber:	1 min.

Species fumigated	Total No. of plants fumigated	Total No. of leaves on fumigated plants	Mean % of leaf area damage
Romaine lettuce	38	228	8
Spinach	12	72	47
Poa annua	62	312	12

Eight mercury arc lights have been installed on the outside of the 500-cubic-foot reaction chamber. With these eight lamps in operation, intensity of illumination at the center of the chamber was approximately one-third the intensity of noon illumination from the sun. With this intensity, oxidant values of 5 to 7 parts per hundred million were obtained using night air. Simultaneously, using outside air and a different experimental setup in which the intensity of artificial irradiation was approximately ten times that of noon sun, oxidant values of approximately 20 parts per hundred million were produced. Plants exposed to the air, which had been irradiated, showed no smog damage, even though it was known that the intensity of irradiation was not adequate to produce the maximum oxidant value of which it was capable. Additional mercury arc lights are now being installed.

Future Work

Irradiation of night air with appropriate intensity of light and exposure of plants will be undertaken, together with eye irritation studies and measurements of visibility. If the results from these studies indicate that smog manifestations are produced, the next phase of the program, selective removal of various constituents, will be undertaken.

PHOTOCHEMICAL REACTIONS

This project studies the mechanism of reaction between synthetic atmosphere under the influence of controlled radiation both as to intensity and wave length. The contractor is Armour Research Foundation, Chicago, Illinois.

It has been determined by a number of workers that the principal chemical characteristics of Los Angeles smog is the presence of extremely high oxidant concentrations during periods of high pollutant intensity. In an attempt both to duplicate the lachrymatory effects of smog and to identify a possible source of the oxidant, Haagen-Smit and his co-workers[2] investigated the photochemical reactions of a series of synthetic mixtures of nitrogen dioxide and hydrocarbons in both air and oxygen car-

[1] Haagen-Smit, A. J., Darley, E. F., Zaitlin, M., Hull H., and Noble, W. "Investigation on Injury to Plants from Air Pollution in the Los Angeles Area." *Plant Physiology 27*, 18-34 (Jan., 1952).

[2] Haagen-Smit, A. J., and Fox, M. M., "Photochemical Ozone Formation with Hydrocarbons and Automobile Exhaust," *Air Repair, 4*, No. 3 (November, 1954).

riers. In these systems, the oxidant was produced photochemically; the yield was extremely dependent on the hydrocarbon-nitrogen dioxide concentrations. Hydrocarbons containing four or more carbon atoms per molecule were found to have oxidant-forming tendencies when irradiated in the presence of nitrogen dioxide.

The most complete study made by Haagen-Smit was on the nitrogen dioxide-3-methyl-heptane system, with the resultant preparation of a three dimensional curve showing the interrelations between the reactant concentrations and resultant oxidant level. In this latter system, for example, the choice of 0.4 ppm nitrogen dioxide with 10 ppm 3-methyl heptane resulted in appreciable rubber cracking under the selected experimental conditions. However, if the hydrocarbon concentration chosen was zero or greater than one hundred ppm, no rubber cracking was observed under his experimental conditions. Other workers (unpublished work) repeated some of Haagen-Smit's work with respect to reactant concentrations but with different irradiation conditions and found that cracking occurred at 1170 ppm 3-methyl heptane in filtered air in the presence of 0.4 ppm nitrogen dioxide and also that cracking occurred in nitrogen dioxide alone.

It is important to resolve these and other discrepancies. The differences in the results mentioned may be due to the differences in wave-length distribution and intensity used in the radiation.

This project is in its construction phases. The ozone generator and the associated analytical gas train have been fabricated and are in operation. The photolysis system is nearly complete. The reactant chambers, dilution bulbs, gas inlet system, and the photolysis bulb are assembled. Other items, including a long absorption cell for observing ozone formation *in situ*, using its ultraviolet absorption band, the light system for the photolysis source, and electronic equipment are being assembled.

Future Work

When construction is complete, the nitrogen dioxide-hydrocarbon-irradiation system will be investigated under carefully fixed conditions of wave length, light intensity, and irradiation time to determine the important reaction parameters.

IV. STUDY OF COMBUSTION PRODUCTS

THE various gaseous pollutants entering the Los Angeles atmosphere result primarily from the combustion of organic material, e.g. gasoline, fuel oil, natural gas, and refuse. A great deal of the particulate matter (smoke) arises from the same sources. The other source of gaseous pollutants is evaporation of volatile solvents such as gasoline, paint solvents, and dry-cleaning fluids.

The exact contribution of the different pollutants to smog manifestations is not known. The Foundation has therefore initiated several research projects directed toward determining the relative importance of various components of combustion effluents in the formation of smog. Such information will be invaluable in the development of adequate control methods.

Data available at the time of the formation of the Foundation have been assembled and analyzed in Report No. 2[1] of the Foundation. On the basis of the report, further work was planned to reconcile differences among various investigators and to extend our knowledge of the field.

COMPOSITION OF AUTO EXHAUST
MIDWEST RESEARCH INSTITUTE
KANSAS CITY, MISSOURI

Background

Investigators have been able to produce smog damage to plants by subjecting them to the reaction products of ozone and various hydrocarbons, and also ozone and automobile exhaust. In all cases, the amount of hydrocarbons necessary has been higher than concentrations experienced in the Los Angeles atmosphere. On the other hand, damage has been produced with ozone and automobile exhaust in concentrations even lower than those often experienced in Los Angeles. This anomaly leads one to wonder if plant damage is a function of gross hydrocarbon concentration or if some individual constituent is responsible for the ease with which auto exhaust-ozone mixtures produce typical smog damage on plants.

General Plan

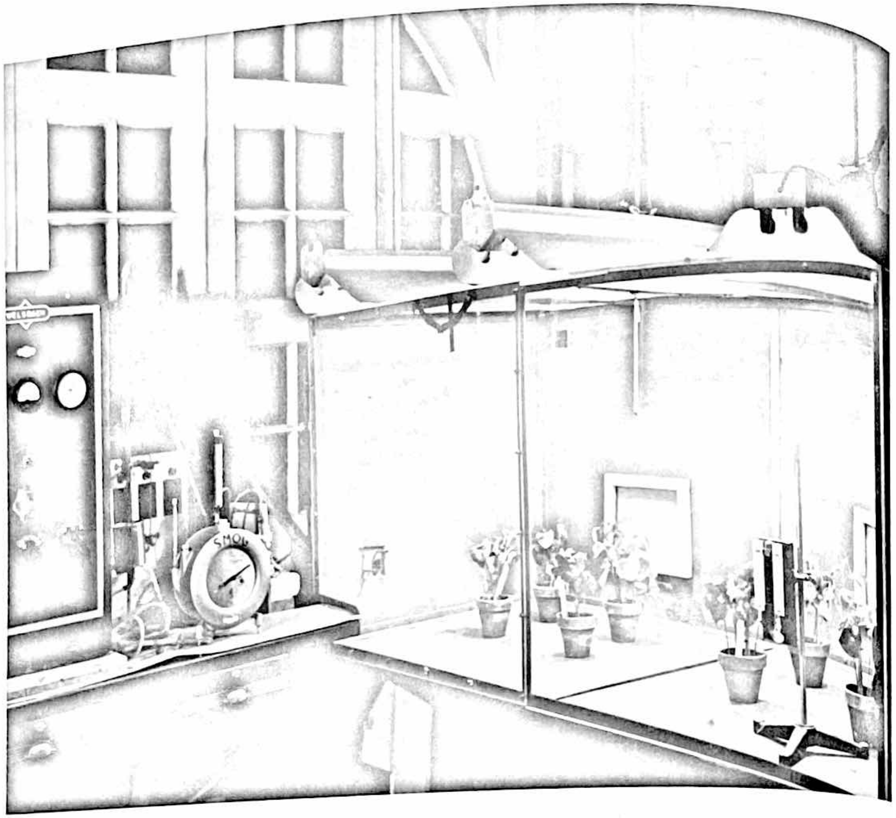
Equipment has been devised at Midwest Research Institute to freeze out the liquefiable portions of auto exhaust under various conditions of engine operation and use of fuels of different composition. These liquefiable products will then be separated into various fractions by both chemical and physical means, and the effect of each fraction on producing plant damage after being mixed with ozone will be tested. It is possible that one or more of the various fractions will produce plant damage much more readily than the others. In this event, further study will be directed toward the composition of the reactive fractions for the purpose of determining more exactly the material responsible for plant damage and, later, eye irritation.

Status

Facilities for testing the effect of mixtures of exhaust gases and ozone on pinto beans (the test

[1]Faith, W. L., "Combustion and Smog," *Air Pollution Foundation, Report No. 2*, September, 1954.

Chapter IV – Fig. 1
Pinto bean plants in fumigation chamber—Midwest Research Institute



plant) have been built (Fig. 1). Source of exhaust gas is a 1941 Cadillac which during idling emits an exhaust gas containing 0.15% hydrocarbons. The test chamber and the bean plants are currently being calibrated. Initial results indicate that considerable difficulty may be expected in using the pinto bean for more than a qualitative estimation of plant damage.

Concurrently with the above work, tests are also under way to determine the effect of addition of various amounts of ethyl alcohol to gasoline on the composition of exhaust gases. A 1952 Ford V-8 station wagon is being used for these tests which are just getting under way (Fig. 2). Initial analyses will be made with the Beckman IR-2 spectrophotometer.

COMPOSITION OF INCINERATOR GASES BATTELLE MEMORIAL INSTITUTE COLUMBUS, OHIO

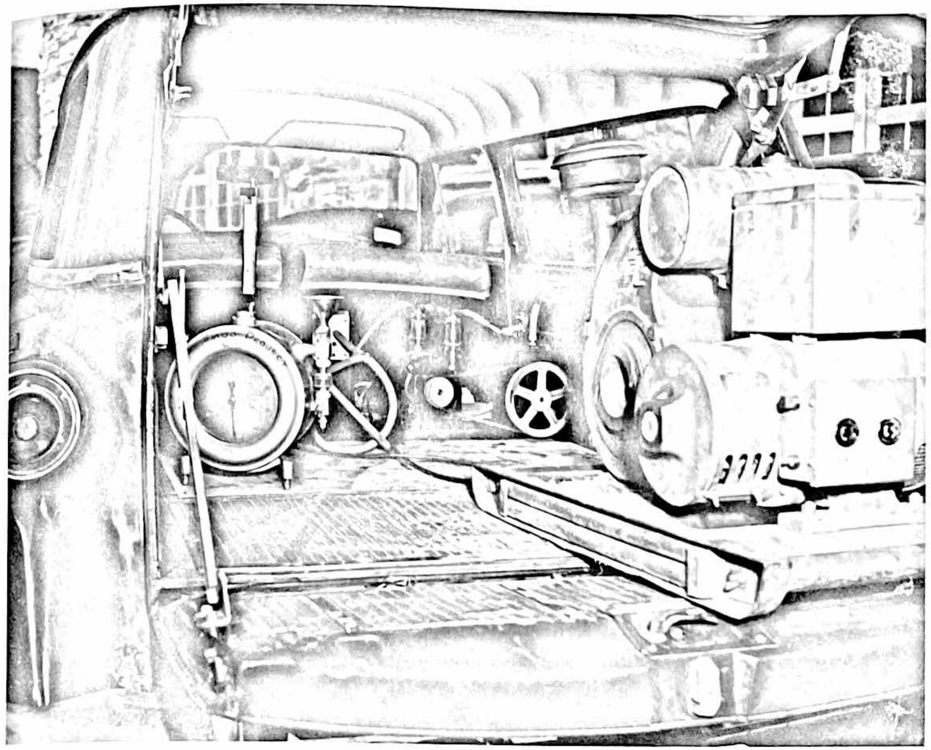
Background

Work by different investigators leading to information on the composition of effluent gases from backyard incinerators is fragmentary and conflicting. The Los Angeles County Air Pollution Control District[2] holds that the primary contribution of incinerator effluents to smog is the 100 tons of smoke which decreases visibility and adds to the haze. No effect on vegetation damage and eye irritation has been found.

On the other hand, Stanford Research Institute reports[3] that backyard incinerators in the Los Angeles Basin produce over 500 tons of invisible "organics" of undetermined nature. These materials could well be effective in damaging plants and causing eye irritation.

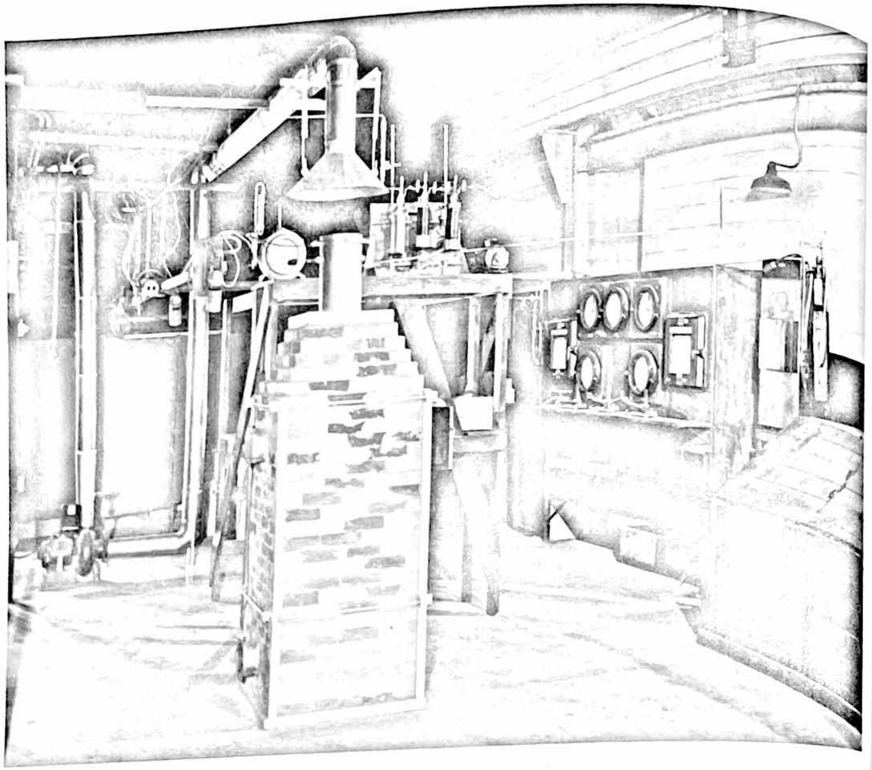
[2] "Smog–What Has Been Done–What Must Be Done." *Los Angeles County Air Pollution Control District,* April, 1954.

[3] "The Smog Problem in Los Angeles County," *Stanford Research Institute,* January, 1954.



Chapter IV – Fig. 2
Exhaust sampling equipment in Ford station wagon—Midwest Research Institute

CHAPTER IV – FIG. 3
"Backyard" incinerator and auxiliary equipment—Battelle Memorial Institute



General Plan

A typical backyard incinerator will be operated with the various types and ratios of refuse usually burned in the Los Angeles area. Under a variety of operating conditions, the effluent gases will be analyzed for types of gaseous materials in the effluent, using infrared, ultra-violet, and mass spectrometers as well as gas chromatography. Aerosols evolved will also be collected on a weight as well as a size and count basis, and analyzed.

Status

This project got under way on November 15, 1954. A backyard incinerator of six-cubic-foot capacity has been built and the necessary control and analytical equipment procured and assembled (Fig. 3). Tests started about January 20, 1955.

SMOG-FORMING POTENTIAL OF VARIOUS COMBUSTION EFFLUENTS

We propose to carry out large test chamber experiments, working with actual pollutants instead of synthetic mixtures, to study Los Angeles smog under conditions which can be controlled in this chamber. We should prefer to experiment with the entire Los Angeles Basin. This is impossible, as we cannot control the weather. In Operation Pilot Plant, we could control the temperature, wind, humidity, concentration of pollutants, the amount of light, etc. In a large chamber of special construction, perhaps as big as an airplane hangar, we could supply straight auto exhaust at one time, backyard incinerator smoke at another, hydrocarbons at another; then mixtures of two or more of these pollutants. We could find accurate answers to such questions as "does auto exhaust actually form smog?" or "what would be the effect of closing down the refineries, stopping all incinerators, or keeping all cars off the roads?" Two years with this operation, whatever the cost, would be time and money saved in trying futile experiments on the whole Basin itself. Operation Pilot Plant is a natural for the University of California; the main installation would probably be built at Riverside; experts from other faculties would be called in and perhaps some of the work might be assigned to other sections of the University of California. Because this work would increase understanding of air pollution problems in the San Francisco Bay Area, in San Diego, and other cities, it is a good state project. The University of California is interested in carrying out a project of this nature and is currently seeking funds from the state legislature to underwrite the project.

CONTROL OF AUTO EXHAUST

Even though the Foundation believes further information is necessary to pinpoint the actual constituents of combustion effluents responsible for various manifestations of smog, it would be remiss if some activity were not directed toward controlling the emission of auto exhaust. Two projects have accordingly been initiated in this area.

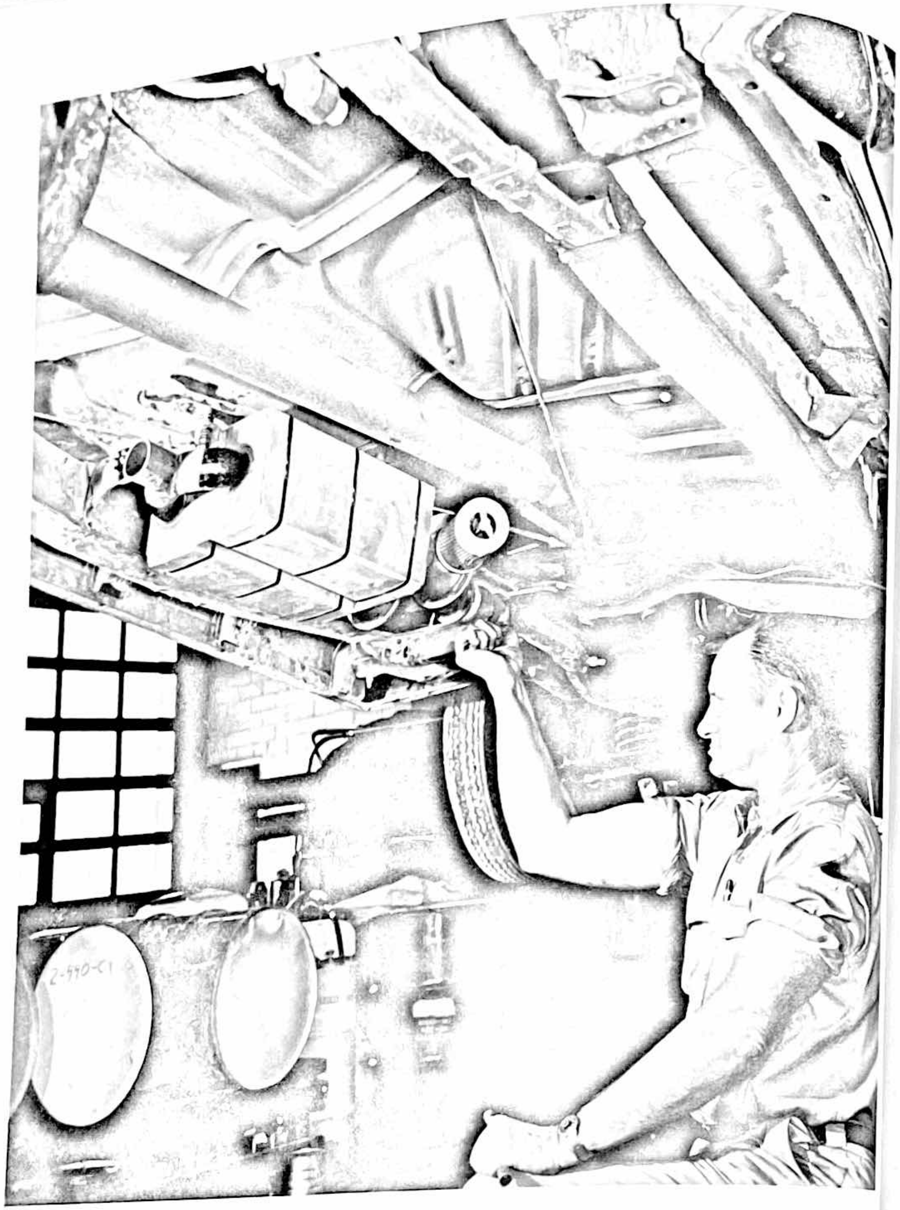
Evaluation of Control Devices for Automobile Exhaust
Southwest Research Institute, San Antonio, Texas

Background

Of the many proposed devices for controlling hydrocarbon emissions from automobile tailpipes, three general types are attractive: (1) exhaust oxidation devices, (2) fuel feed cutoff devices operating during deceleration, and (3) fuel injection devices.

The automobile industry is greatly interested in the fuel cutoff valves because they show promise of not only reducing hydrocarbon emissions but also of adding to fuel mileage. Several companies are working on the development of such devices, and the Foundation is keeping informed of progress. A device of this sort may be expected to reduce hydrocarbon emissions by 30% to 50%. Proposed fuel injection devices would involve major changes in engine design and, hence, many years of development. This approach does not appear to be sufficiently promising at an early enough date to warrant study at this time. The third possibility, the oxidation of exhaust hydrocarbons to carbon dioxide and water in a specially designed muffler, gives promise of application to both new and old cars, and possibly a 99% reduction in exhaust hydrocarbons.

The most promising device in this field is the Houdry catalytic muffler for use with leaded gasoline. Preliminary tests made by both Oxy-Catalyst, Inc. and the Los Angeles County Air Pollution Control District showed that the device has merit. It therefore appeared necessary to submit the muffler to road tests under various conditions of operation, terrain, weather, etc. A contract was therefore made with Southwest Research Institute to carry out these tests in its laboratory in San Antonio, Texas, under the supervision of its Department of Engines, Fuels and Lubricants Research.



CHAPTER IV – FIG. 4
Houdry catalytic muffler being installed on automobile—Southwest Research Institute

General Plan

The plan is to carry out life tests of catalytic converters installed on several makes of automobiles. Four converters for use with leaded gasoline will be installed on a 1954 Ford V-8, 1954 DeSoto V-8, 1953 Buick V-8, and a 1953 Cadillac (Fig. 4). The individual cars will be run on a proposed 20,000-mile road test, during which time the operators will determine the effect of these converters on the operating characteristics of the automobile. At the end of each 1,000 miles, the car will be returned to the laboratory for an inspection and also for an analysis of the hydrocarbon content of the exhaust gases under different conditions of operation. At the end of the test, exhaust gas analyses will be checked by the Los Angeles County Air Pollution Control District. If the converters fail during the 20,000 mile road test, the catalyst will be reconditioned in the presence of a representative of Southwest Research Institute or the Air Pollution Foundation, and the converter put back on the car. It is possible that when these tests are completed other types of devices may also be subjected to life tests.

Status

Tests started on February 15, 1955. In addition to the tests using leaded gasoline, two converters designed for use with white (nonleaded) gasoline will be installed on 1954 Chevrolet Powerglides and evaluated in the same way as the leaded gasoline mufflers. Thus, if the latter type fails and the former does not, a stopgap method may be available to the area, provided sufficient white gasoline can be made available.

Economic Feasibility of Stopgap Methods Southwest Research Institute, San Antonio, Texas

Background

It is becoming apparent that the ultimate solution to the Los Angeles smog problem may require automotive or fuel changes which will not be effective in the Los Angeles area for perhaps ten years. As the population of the Los Angeles Basin increases, smog frequency may be expected to increase. To obtain relief at an early date, we may have to resort to stopgap procedures which are not economic in the long run. Many such stopgap procedures have been proposed, not only by the uninformed, but also by men of considerable stature in scientific, civic, and political affairs of Southern California. The facts concerning the technical and economic feasibility of these proposals have not been available either to community leaders or to the public.

Proposals for stopgap procedures include the following:

(a) The use of nonleaded gasoline and the OCM catalytic muffler. This proposal is based on the generally accepted supposition that the catalytic converter for nonleaded gasoline has been successfully developed.

(b) The use of the Houdry catalytic converter, which is supposedly effective in oxidizing the hydrocarbon constituents of leaded gasoline.

(c) The use of liquefied petroleum gases in place of gasoline in internal-combustion engines. This proposal is based on the theory that only hydrocarbons of four carbon atoms per molecule or above contribute to smog.

(d) Alcohol blends as automotive fuel. This is based on claims that alcohol improves the combustion of hydrocarbons in the cylinder.

(e) Fuel rationing. The supposed advantages of this proposal are obvious.

(f) Control of excessive fumes from "smokers." There is considerable opinion that automobiles which emit a blue trail of unburned lubricating oil droplets from the exhaust pipe not only contribute greatly to reduced visibility, but that they also emit much larger quantities of unburned gasoline than properly maintained and operated cars.

(g) Further control of hydrocarbon losses which accompany the distribution of automotive fuels. After present control methods are adopted by the petroleum refining industry, the largest contributions to hydrocarbon emissions as such will be from filling tanks at bulk storage terminals, tank trucks, filling station delivery tanks, and automobile fuel tanks. The costs involved in further control of these emissions must be determined.

General Plan

It is proposed to study *all* of the factors involved in making any of the above changes, either in whole, or in part, or in combination one with another. Most of the data will be secured by conversations with experts in the petroleum and automotive fields. In a few cases, some preliminary test work may have to be carried out; but in general, the proposals will be evaluated both on the basis of current knowledge of the effectiveness of the method under consideration and also on the assumption that partially developed methods may be made 100% effective. It is obvious to many technical men that many of these proposals will require such far-reaching expenditure of funds and changes in our way of life that it might be easier to move the city than to impose the suggested remedies on the Los Angeles public. It is important, however, that these facts be clearly pointed out and made available to the public.

Status

Studies are in progress and only partial answers are therefore available. However, one design of an afterburner has been unearthed which shows considrable promise in the bus field. Arrangements are being made to test the device. Preliminary results also indicate that up to 50% elimination of hydrocarbon emissions would result from proper maintenance of automobiles, and particularly, proper adjustment of air/fuel ratios. A further dividend from the latter adjustment would be improved gasoline mileage.

FUTURE RESEARCH

Basic Design Data for Exhaust Converters

Background

Many attempts have been made to design a device in which the hydrocarbon content of auto exhaust gases could be oxidized completely to carbon dioxide and water. It is obvious, however, that one cannot design a piece of equipment until the process requirements are known.

General Plan

It is proposed to initiate a laboratory study to determine the effects of time, temperature, pressure, catalyst, and concentration variables on the oxidation of the hydrocarbons present in exhaust gases. This information will then be made available to any and all persons interested in the design of equipment to carry out this reaction.

Status

A proposal is being prepared by a well-known research laboratory.

V. AEROMETRIC SURVEY[1]

INTRODUCTION

A REVIEW of reports and data available to anyone concerned with the smog problem in February, 1954 revealed the following questions and gaps in the status of knowledge:

1. Sufficient data had not been obtained to permit any sound conclusion to be drawn with respect to the possible movement of smog or smog-producing substances.

2. What was the relationship between oxidant value and manifestations of smog, namely eye irritation, plant damage, and reduced visibility?

3. How were the manifestations of smog distributed in severity and time throughout the entire Basin?

With the above factors in mind it was reasoned that a continuous monitoring of the Los Angeles atmosphere during the period of highest incidence of smog was appropriate. Accordingly, with the best meteorological data available, a network of ten sampling stations was established (Fig. 1) and one monitoring station outside the Los Angeles Basin was also set up. The stations were chosen to lie along typical surface wind trajectories for the period in question, namely: August 1 to December 1, 1954. One series of trajectories involved stations in Venice, Wilshire District, downtown Los Angeles, Pasadena, Azusa; another involved Venice, Wilshire District, downtown Los Angeles, and Burbank; another involved Dominguez, downtown Los Angeles and either Pasadena, Azusa or Burbank; another series extended from Artesia, Rivera to Bassett and Azusa. Finally, it was decided that data should be obtained on a continuous basis when at all feasible, twenty-four hours a day throughout the period.

DESCRIPTION OF STATIONS

With the cooperative support of the Los Angeles County Air Pollution Control District, Los Angeles County Department of Charities, California Institute of Technology, American Cyanamid Company in Azusa, and various Los Angeles City and County departments, sites were inspected during June and July, 1954. Final selections were made in the middle of July as follows:

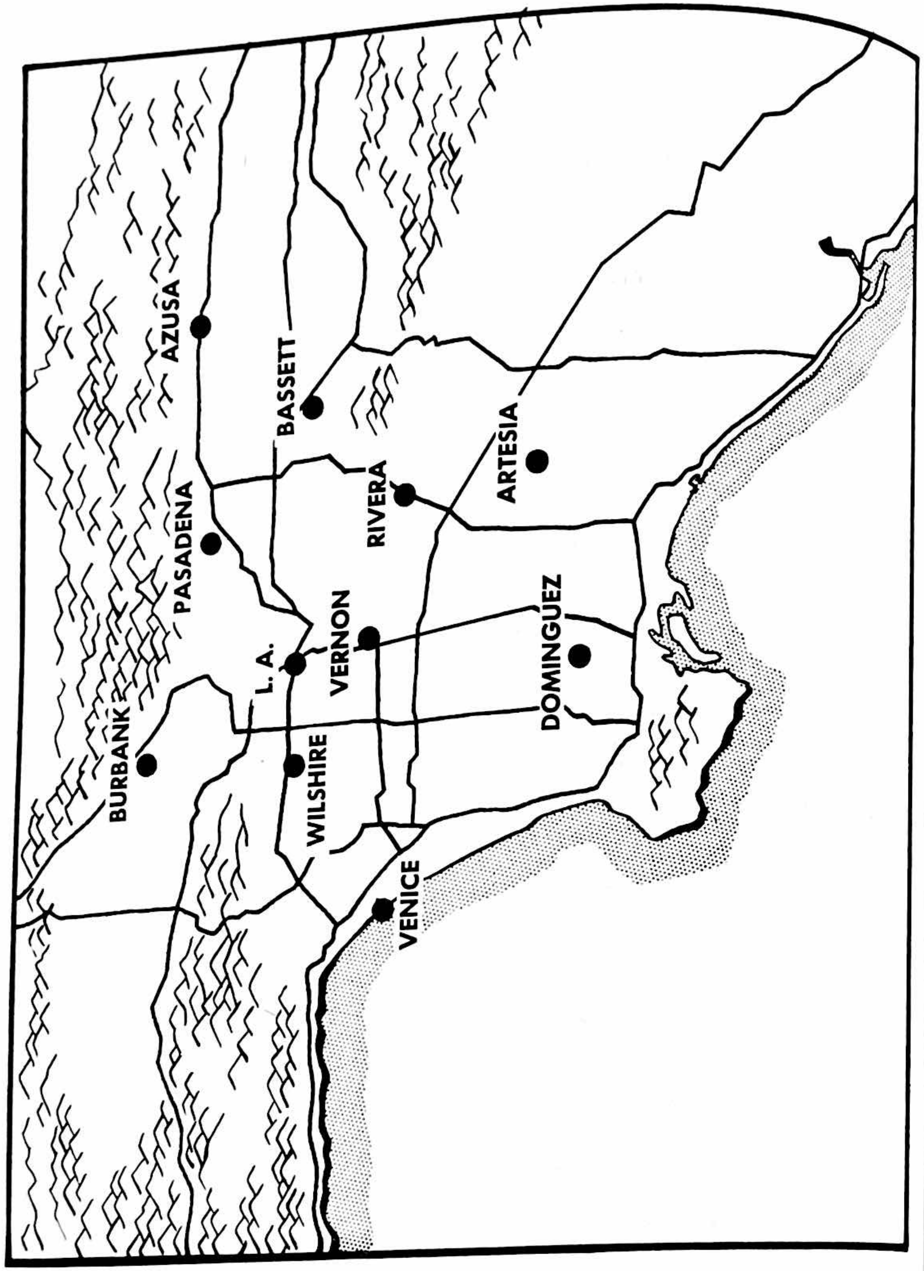
Station 1—Venice

This sampling site was at the shore of the Pacific Ocean in a recreational, residential-type area with some commercial activity. Here were installed an oxidant recorder; oxides of nitrogen sampler, and surface wind anemometer.

Station 2—Wilshire District

This sampling site was on the third floor of the Los Angeles High School; the area is primarily residential. The site was used both by the Air Pollution Control District and the Foun-

[1]The major part of this survey was supported by the Los Angeles County Air Pollution Control District through a research contract with the Air Pollution Foundation.



Chapter V - Fig. 2
View from Fidelity Building

dation. Equipment was installed in a room 9′ x 12′ whose windows overlooked an inside court large enough to be considered in equilibrium with the general atmosphere of the area. The Foundation installed an oxidant recorder; a plant damage test chamber; a hygrothermograph, and a transmissometer on the roof of the main building. The District operated a sulfur dioxide recorder and sampled for hydrocarbons, carbon monoxide, aldehydes, and oxides of nitrogen.

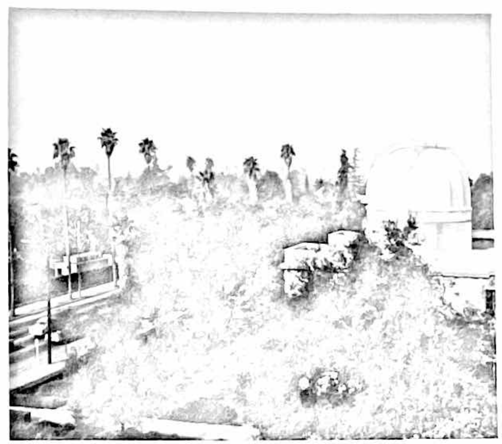
Station 3—Downtown Los Angeles

This station (Fig. 2) was in an office on the fourth floor of the Fidelity Building at Sixth and Spring Streets, overlooking a clear expanse immediately below which is a parking lot to the north; this sampling site is obviously in the heavy commercial and industrial area. The Foundation installed here an oxidant recorder; sulfur dioxide recorder; oxides of nitrogen sampler; plant test chamber; hygrothermograph; equipment for sampling hydrocarbons, aldehydes, carbon monoxide; AISI hourly particulate sampler, and a high volume particulate sampler.

Station 4—Pasadena

This sampling site (Fig. 3) was located on the fourth-floor roof of a California Institute of Technology building in a residential area. The

Chapter V - Fig. 3
California Institute of Technology
View from roof of physics building



Foundation installed an oxidant recorder; oxides of nitrogen sampler; plant test chamber; hygrothermograph; equipment for sampling hydrocarbons, aldehydes, and carbon monoxide; AISI hourly particulate sampler; high volume twenty-four (24) hourly particulate sampler, and a transmissometer.

Station 5—Burbank

This sampling site was located on a ground floor room of a school building overlooking a recreational area in a commercial district. The Foundation installed an oxidant recorder and an oxides of nitrogen sampler in an unused anteroom, with sampling tubes from the equipment through a window to the outside.

Station 6—Dominguez

This station located in the oil refinery area was in the backyard of a fire station alongside the parked mobile laboratory of the Los Angeles County Air Pollution Control District. It consisted of two plywood shacks, one to house the oxidant recorder and recorder for the transmissometer, the other to house the plant test chamber and hygrothermograph. The transmissometer transmitter was located on the roof of a cafe approximately 500 feet east of the receiver which was on the fire station roof proper.

Station 7—Artesia

This sampling site was in a commercial area on the ground floor of the school district office building. The Foundation installed an oxidant recorder in this room and ran a sampling tube out the window.

Station 8—Rivera

This station was on the ground floor of the Insectary of the County Agricultural Commission Building, which for practical purposes was open to the atmosphere. The Foundation installed here an oxidant recorder and plant test chamber with hygrothermograph. The station was in an open space between light industrial areas.

Station 9—Bassett

This sampling site was located in the recreation building of a park. The Foundation installed an oxidant recorder with sampling tube out through a window and the plant test chamber with hygrothermograph outside the building near some bushes. This station was in an agricultural area.

Station 10—Azusa

This station was in a little used building on the grounds of the American Cyanamid Company, an industrial area. The Foundation installed an oxidant recorder on the ground floor with sampling tube through the window.

Station 12—Santa Barbara

This station was near the Santa Barbara Airport, about 100 miles northwest of Los Angeles. The Foundation installed an oxidant recorder. Station 12 was considered a monitoring point for the Los Angeles Basin, remote from human activity, but under similar meteorological influences and conditions.

In addition to the above stations, oxidant recorder data were available from the District headquarters in Vernon, a heavy industrial area, and from the Riverside Campus of the University of California. In the downtown Los Angeles area, Hall of Records ninth floor, the Los Angeles County Air Pollution Control District had equipment for sampling hydrocarbon, aldehydes, carbon monoxide, and oxides of nitrogen; across the street, data from a particulate sampler and sulfur dioxide recorder on the roof (18th floor) of the Federal Building were available, as well as transmissometer data on the sixth floor level. The latter sites were labelled Stations 13 and 13a.

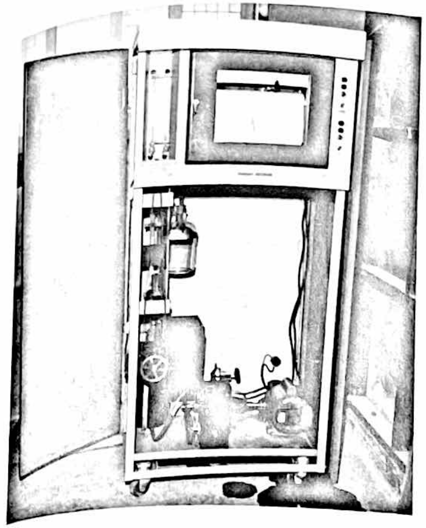
Instrumentation

(1) Oxidant Recorder

Twelve recording instruments for this survey based on the design of Littman and Benoliel[2] were constructed by Beckman Instruments, Inc. at Fullerton, California. These recorders (Fig. 4) consist of two functional parts: a recording colorimeter and a continuous counter current gas scrubber. A glass column packed with single turn

[2]Littman, F. E. and Benoliel, R. W., "Continuous Oxidant Recorder." *Analytical Chem.*, *25*, 1480-1483 (1953).

CHAPTER V – FIG. 4
Oxidant recorder



glass helices was used as the absorbing device and neutral potassium iodide solution as the reactant. The output of the colorimeter was recorded on a Brown recorder calibrated in parts per hundred million expressed as ozone.

Ten of these recorders were located at Stations 1 to 10 described previously; an eleventh instrument was located at Santa Barbara, and a twelfth instrument was located at the Los Angeles County Air Pollution Control District headquarters at 5201 South Santa Fe Avenue. The instruments at Stations 1 to 10 were operated from early August, 1954 to November 30, 1954.

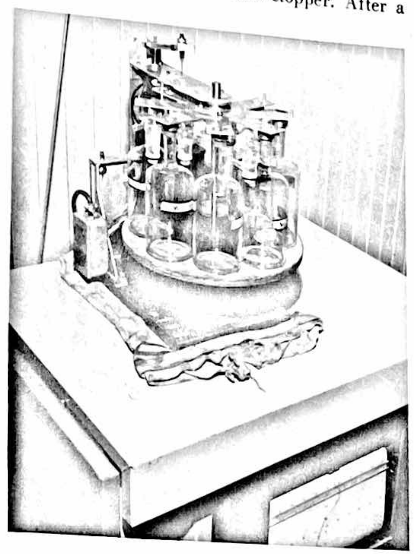
The instruments required frequent servicing in the early phases of the operation. Several of the instruments required daily service, others were serviced every other day. After September 15, 1954 servicing had become routine, the instruments then requiring attention every second or third day. Various minor instrumental difficulties were gradually discovered and eliminated.

(2) Oxides of Nitrogen Sampler

Four special oxides of nitrogen samplers were designed and constructed for use in this survey by A. L. Chaney and Kenneth Johnson (Fig. 5). These samplers consisted of a turntable holding eight 500 ml. evacuated sample bottles. This turntable was designed to rotate either at the rate of one revolution in twenty-four hours or one revolution in eight hours, depending upon the gear train used.

Each sample bottle was closed with a serum stopper and evacuated through a side arm which could be sealed off either with a stopcock or with a piece of plastic tubing and a short piece of glass rod. The eight bottles were held firmly on the rotating turntable.

As each bottle passed a fixed point, a pin actuated a microswitch. This operated a solenoid which forced a hypodermic needle on a lever arm down through the serum stopper. After a



CHAPTER V – FIG. 5
Chaney-Johnson nitrogen oxide sampler

period of approximately two minutes, during which time a sample of air was drawn into the evacuated bottle, the solenoid was switched off and the hypodermic needle was withdrawn by a spring. The four samplers were located at Stations 1, 3, 4, and 5.

The procedure for analysis was modified from that of B. F. Rider and M. G. Mellon.[3] The sample flasks were prepared in the laboratory by stoppering each bottle with the serum stopper and evacuated to twenty-five inches of mercury. A measured quantity of 0.05 normal sodium hydroxide was added with a hypodermic needle pushed through the serum stopper. Eight sample bottles and two blank bottles were prepared for each sampling machine. These bottles were placed in the sampler each day and replaced the following day with another set.

After the samples were collected, 0.5 ml. of reagent solution containing sulfanilic acid and hydrochloric acid were added to each sample for diazotization of sulfanilic acid by any nitrous acid absorbed in the sodium hydroxide. After standing five minutes, 0.5 ml. of a coupling reagent containing N-(1-naphthyl)-ethylenediamine dihydrochloride was added. This was allowed to stand for five minutes; then a measured quantity was placed in a spectrophotometer cell, and the color was read at 540 millimicrons. The results were reported as oxides of nitrogen calculated as nitrogen dioxide.

(3) Hydrocarbon Sampler

Air samples for hydrocarbon analyses were collected by a freeze-out technique and determined by infrared absorption.[4] The freeze-out assembly consisted of a flow meter, an ascarite trap, a Shepherd trap immersed in a Dewar flask containing liquid oxygen, a vacuum gauge, and a vacuum pump. A flow rate of one liter of air per minute was used and samples were taken for a one-hour period. At the end of this time, the Shepherd trap was disconnected, stored in a Dewar flask filled with crushed ice, and returned to the laboratory. The use of crushed ice for storage of Shepherd traps containing freeze-out samples was discontinued on October 18, 1954. Instead, the traps were evacuated to 50 mm. of Hg absolute pressure while still at liquid oxygen temperature, then closed off and stored at room temperature until the time of analysis.

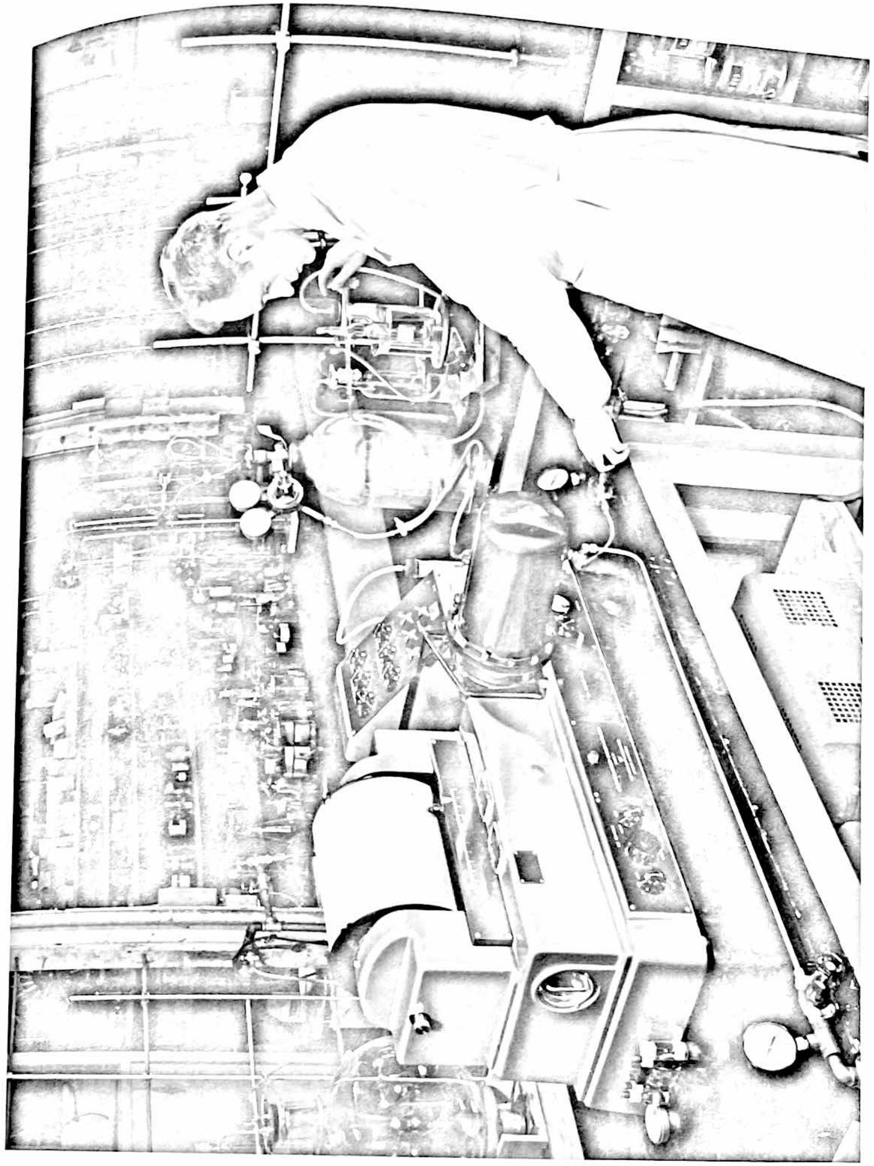
A Perkin-Elmer model 21 infrared spectrophotometer equipped with sodium chloride optics and a ten-meter multiple reflection gas cell was used for the analysis. The instrument was calibrated against hexane as a standard using the carbon-hydrogen absorption band at 3.45 microns. The trap containing a sample was connected to the gas cell by heating and flushing the trap with dry nitrogen gas. Dry nitrogen was used to bring the pressure in the gas cell to approximately one atmosphere absolute. A photograph of the Perkin-Elmer spectrophotometer and ten-meter gas cell appears as Fig. 6.

(4) Carbon Monoxide Indicator

Carbon monoxide was determined at Stations 3 and 4 on an hourly basis corresponding to the schedule for hydrocarbon samples. The Mine Safety Appliance carbon monoxide indicator tube was used for this determination. The squeeze bulb was replaced by a system consisting of a one-gallon bottle containing water which was siphoned out at a measured rate into a graduated cylinder. The indicator tube was connected to the air intake line to the bottle. Water was siphoned from the bottle into the graduate at a rate of approximately 65 ml. per minute until the color change in the indicator tube was very pronounced. The color thus produced was compared against the color scale provided by the Mine Safety Appliance Company. This value was recorded together with the volume of air sampled as measured by the water in the gradu-

[3]Rider, B. F. and Mellon, M. G. "Colorimetric Determination of Nitrites," *Ind. & Eng. Chem., 18,* 96 (1946).

[4]Mader, Paul, Heddon, M. W., Lofberg, R. T., Koehler, R., "Determination of Small Amounts of Hydrocarbons in the Atmosphere," *Analytical Chem., 24,* 1899 (1952).



Chapter V – Fig. 6
Perkin-Elmer spectro-photometer and ten meter gas cell

ate cylinder, and the carbon monoxide concentration was calculated in parts per million.

(5) Aldehyde Sampler

The method for determination of aldehyde was based on the addition reaction of bisulfite to aldehydes, liberation of the bisulfite and its estimation by iodometric titration.[5,6] Ten ml. of a one per cent sodium bisulfite solution was placed in each of three midget impingers placed in series. Air was drawn through these impingers at the rate of one-tenth cubic foot per minute for one hour. At the end of this time, the contents of the impingers were transferred to a flask. After various manipulations, the bisulfite which had been released was titrated with dilute iodine solution.

(6) AISI Particulate Sampler

Two of these instruments developed by Hemeon, Haines, and Ide[7] were used, one at Station 3 and the other at Station 4. This unit used filter paper tape, through which outside air was pumped at the rate of approximately 0.25 cubic feet per minute. These instruments were set to sample for a one-hour period, at the end of which time the filter paper tape was advanced and another sample of one-hour duration was taken. The spots thus obtained on the filter paper tape were approximately one inch in diameter. These filter paper samples were evaluated by measuring the transmission of light through them with a special densitometer. Hemeon has defined a special unit called a Coh unit as being equivalent to an optical density of 0.01. Thus a spot giving a light transmission value of 50% corresponds to an optical density of 0.301 or 30.1 Coh units.

In addition to the measurement of the light transmission of the spots, a total of approximately 1200 of the individual spots were cut from the paper tapes and their lead content determined by the dithizone method, as described by Cholak.[8]

(7) High Volume Sampler

Two Staplex high volume air samplers were used, one at Station 3 and the other at Station 4. These units consist of an air pump for sampling large volumes of air for particulate matter by means of filter media. These samplers were modified by constructing two aluminum filter heads to permit the use of a specially fired glass-fibre filter web. A rectangular filter, 8″ x 10″, was used, the filtering area being 63 square inches (7″ x 9″).

Air was pumped through these units at the rate of approximately 60 cubic feet per minute, so that a total of about 85,000 cubic feet of air was pumped in each twenty-four hour period. The total sample weight was determined and the weight of the particulate matter in micrograms per cubic meter was calculated. In addition, organic matter, polycyclic hydrocarbons and anions were determined chemically. Spectrochemical analyses were carried out for fourteen cations.

(8) Sulfur Dioxide Recorder

A single instrument for recording the sulfur dioxide content of the air was borrowed from the Kaiser Steel Corporation and operated at Station 3. This instrument is described by Thomas, Ivie, and Fitt,[9] and consists of a scrubbing device in which air and liquid move countercurrently. Air at the rate of 12 to 15 liters per minute is pumped up through the absorbing

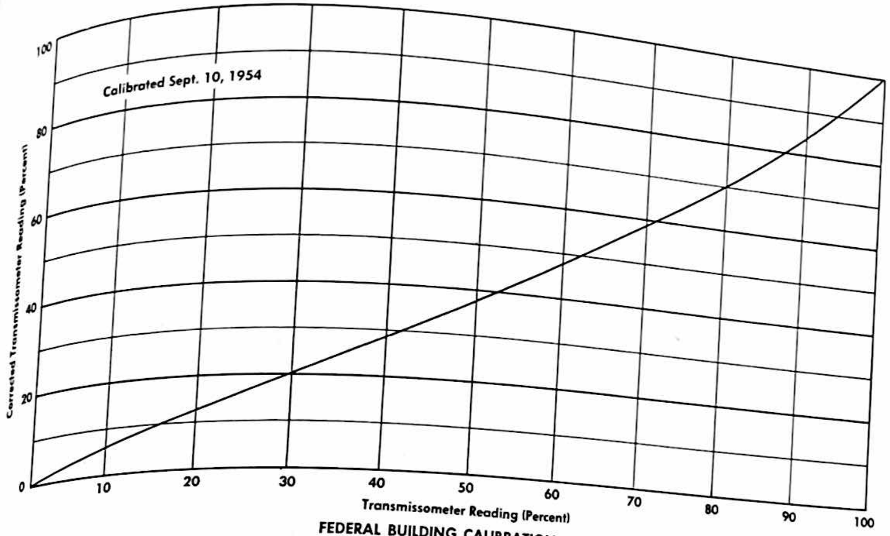
[5]"Los Angeles Air Pollution Control District Test Procedure and Methods in Air Pollution Control," page 35.

[6]Goldman, F. H. and Yagoda, Herman, "Collection and Estimation of Traces of Formaldehyde in the Air," *Industrial and Engineering Chem.*, Analytical Edition, *15*, 377 (1943).

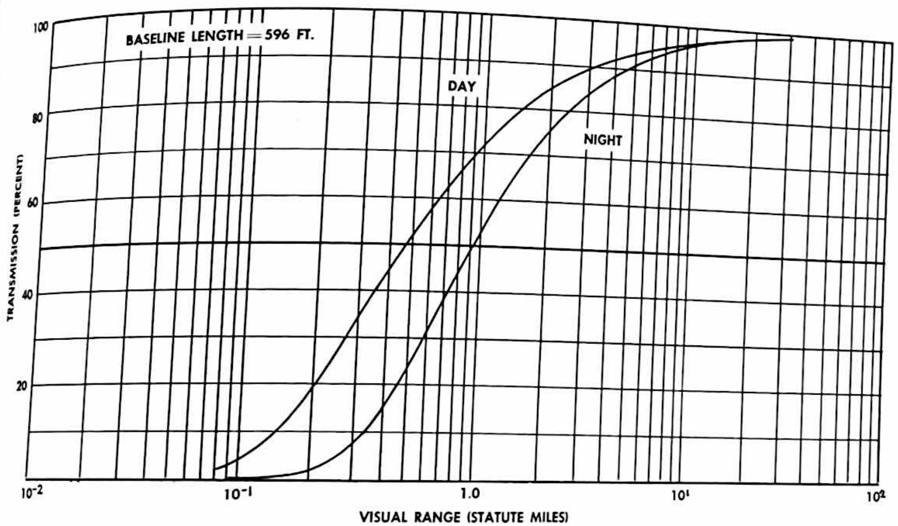
[7]Hemeon, W. C. L., Haines, George F. Jr., and Ide, Harold M., "Determination of Haze and Smoke Concentrations by Filter Paper Samplers," *Air Repair*, *3*, No. 1, 22-28 (August, 1953).

[8]Cholak, J., Hubbard, D. M., and Burkey, R. E., "Micro-determination of Lead in Biological Material with Dithizone Extraction at High pH," *Analytical Chem.*, *20*, 671 (1948).

[9]Thomas, Moyer D., Ivie, James O., and Fitt, T. Cleon, "Automatic Apparatus for Determination of Small Concentrations of Sulphur Dioxide in Air," *Industrial and Engineering Chem.*, Analytical Edition, *18*, 383-387 (1946).



FEDERAL BUILDING CALIBRATION CURVE



RELATION BETWEEN TRANSMISSION AND VISUAL RANGE — FEDERAL BUILDING

CHAPTER V – FIG. 7

column, and the absorbing solution containing hydrogen peroxide and dilute sulfuric acid flows down through the column. The solution with absorbed gases flows into a conductivity cell and the conductivity of the solution is automatically measured and recorded on a strip chart recorder.

Considerable difficulty was experienced with this unit when it was placed in operation; hence records were obtained only for a portion of the period from August 1 to November 30, 1954.

(9) Visual Range

It was considered necessary to the survey that not only eye irritation and plant damage be measured at certain stations but data be obtained on reduction of visibility as an important manifestation of smog. There are unfortunately few continuous recording-type instruments for getting such information. The only such instruments available to the Foundation for day and night readings were four Douglas (Bureau of Standards) transmissometers. These had been used by the Los Angeles International Airport in their studies on fog dispersal systems. They were *not* ideally suited for the survey but nevertheless they were put into service. The instrument is described in the reference below;[10] it consists basically of a light projector having an intensity of about 10^5 candles mounted solidly on a stand or post. A photocell receiving unit is mounted on a post and placed 500-1000 ft. away. Essentially, transmission readings were obtainable as a function of time and these were transformed to visual range determinations by curves shown in Fig. 7.

Considerable work was involved in getting the instruments in shape and calibrated. Particularly the projector lamps were short-lived and prone to drift in intensity despite good voltage regulation.

Data were presented on an Esterline Angus line recorder and each fifteen minutes the light was automatically turned off and a reading on background illumination was obtained.

[10]U. S. Dept. of Commerce, Civil Aeronautics Administration, Techn. Dev. Rep. No. 47.

PLANT TEST CHAMBER[11]

The two primary leaves of the pinto bean plant were used as the basis for assessing air pollution injury to plants. Pinto bean seed of a uniform lot was planted in four-inch clay pots, so that when the plants reached the proper maturity for testing there were three plants of a uniform size and age in each pot.

The plants reach the proper maturity when grown in a glasshouse from 10 to 15 days after seeding. Thus, from the time of initial seeding to exposure to the atmosphere, a time lapse of 10 to 15 days occurs. These plants were grown and protected from air pollution exposure in an especially built glasshouse located in West Covina. The glasshouse was of aluminum construction and measured 14′ x 18′10″. It was provided with a carbon filter and evaporative cooler, so that all of the air introduced into the house was cooled as well as passed through the activated charcoal to remove the naturally occurring phytotoxicants.

When the plants attained the proper age for their exposure, five pots containing three plants each, and each plant having two uniform, primary leaves, were set aside for each of the six aerometric sampling stations used in this survey. A station wagon was provided for the transport of these plants to the six stations. The rear portion of the station wagon was sealed and the only air inlet was passed through activated charcoal. A small, six volt, squirrel-cage fan provided the necessary air flow through the activated charcoal and into the body of the truck. Since it required about four hours to completely cover the survey route, the possibility of plants being exposed to natural air pollution while being transported about Los Angeles County was eliminated. Each group of plants at the individual stations was exposed for a 24-hour period.

The man in charge of changing the plants in the exposure boxes started his route about 3:30

[11]by John T. Middleton, Citrus Experiment Station, University of California, Riverside, California.

p.m. Pacific Standard Time. The first change was made at Station 6 in Dominguez.

At each of these stations the plants were placed in a plywood box measuring two feet on the base, three feet in height, and four feet in length. A transparent covering was provided on three sides of each box so that sufficient light was transmitted into the box. The rear end was enclosed with a plywood covering except for the opening where a small squirrel-cage fan with an operating capacity of about 146 cu. ft. per minute was placed in order to provide a constant air flow through each of the boxes. The front end of each box was covered with an open-mesh screen. One box was placed at each station, so that it did not receive direct sunlight. The five pots of plants were placed in each box at a predetermined location. Thus, pots numbered 1, 2, 3, 4, and 5 were placed at the same location in the box at each of the six stations. The plants were watered amply after placing them in the exposure boxes. A recording hygrothermograph was also present in each of the six plant exposure boxes (Fig. 8). The plants exposed the previous 24 hours to the change were placed in the air-filtered station wagon for transport back to the glasshouse at West Covina.

The second change was made at Station 2, Los Angeles High School; the third change at the Fidelity Building, Station 3; the fourth change at the California Institute of Technology, Station 4; the fifth change at the Los Angeles Insectary at Rivera, Station 8: the last change was made at Bassett Park, Station 9. This circuit was completed about 9:30 p.m. PST.

The exposed plants were allowed to remain in the glasshouse at West Covina for approximately 48 hours before they were assessed for plant damage. At the end of this time each individual

Chapter V – Fig. 8
Plant test chamber

leaf was examined and rated for the extent of tissue collapse on the lower side of the leaf. Ten classes of damage were provided in the rating. A leaf with no damage received a rating of 0; one in which there was a trace to 10% of the leaf area involved received a rating of 1; from 11% to 20% received a rating of 2; 21% to 30% received a rating of 3, etc., until the maximum was reached where 100% of the leaf area was involved in tissue collapse, and that received a rating of 10. A sum was taken of all the leaf ratings within a pot, and an average leaf damage rating was obtained by dividing by the number of leaves involved in this sum. If a mean value for leaf damage was desired for the station for a particular day, the five pot averages were summed and this sum was divided by five.

EYE IRRITATION MEASURE[12]

Part of the Aerometric Survey called for a measure of eye irritation, which would be as nearly correct as possible, and which could be used in computing correlations with atmospheric variables. Eye-irritating elements in smog had to be evaluated in their effects on people. Since individuals vary greatly in their sensitivity to smog, it was decided to determine measures of eye irritation for groups rather than for individuals. It was presupposed that the sources of variability in individuals could be made equivalent for a group from one situation to the next and that the composite effect of the sources of individual variability would be essentially the same on all situations.

The minimum size of the panel was ten individuals, drawn from office and/or factory workers near all ten of the station sites used for the survey. Investigators visited the site from which the panel was drawn, made sure that the office was not air conditioned, that ventilation was at least average, and that employee turnover was not too high. All individuals cooperating did so voluntarily; they were chosen on a basis of conscientiousness, good attendance records, and interest; high sensitivity to smog was not required.

Eye Irritation Scale

It was decided to use a form of graphic rating scale as shown in Fig. 9. The scale is a line 5½ inches long, on which the rater places a mark to show the degree of the factor being rated. The graphic rating is analyzed by measuring the linear distance from a reference point on the line to the rater's mark. The reference point is the left-hand end of the line, the unit of measurement is one-tenth of an inch.

Individual irritation amounts were averaged arithmetically to obtain the mean irritation for the entire panel, and the group value is referred to as the "station-day-mean." The standard deviation and standard error of the mean were then computed.

The standard deviation is a measure of the variability between the individuals composing the panel; the standard error of the mean is a measure of the variability of the mean value for the panel. A sample computation is given in Table I. Values of smog sensitivity as represented in numbers are shown in Table II.

[12]by Philip R. Merrifield and Floyd L. Ruch, Department of Psychology, University of Southern California.

SOUTHERN CALIFORNIA AIR POLLUTION FOUNDATION

"SMOG" SENSITIVITY SCALE

Name ______ Organization ______

Date ______ Time of Day ______ Hours since eating ______

Instructions: Please make a mark across each of the three lines below to show the amount of irritation from smog you feel today.

Amount of Irritation Today

None — Some — Moderate — Severe — Worst

EYES: ______

NOSE: ______

THROAT: ______

. . .

Instructions: Please make a mark across each of the three lines below to show how the amount of irritation today compares with the amount you felt yesterday.

Today Compared To Yesterday

More Today — About the Same — Less Today

EYES: ______

NOSE: ______

THROAT: ______

Please submit this form as arranged for your organization.

THANK YOU

Chapter V – Fig. 9
Eye irritation scale

Chapter V – Table I

A COMPUTATIONAL EXAMPLE

Assume that the scales for the twenty individuals composing this panel have been measured, and that the values listed below represent the distance, in tenths of inches, from the reference point to the observer's marks.

Obs.	E	PST	( )	Obs.	E	PST	( )
01	03	....	( )	11	21	1300	(5)
02	14	1600	(17)	12	25	1245	(4)
03	33	1400	(8)	13	26	1400	(9)
04	33	1530	(16)	14	34	1400	(10)
05	34	1230	(2)	15	15	1400	(11)
06	34	1655	(18)	16	25	1500	(15)
07	36	1230	(3)	17	28	1300	(6)
08	05	....	( )	18	35	1200	(1)
09	34	1500	(14)	19	26	1300	(7)
10	38	1425	(13)	20	14	1400	(12)

Notes: E refers in this example to reports of maximum irritation at the time specified in the next column, PST.

The numbers in ( ) to the right of certain of the times is the rank order from earliest to latest of the given times. There were 18 time values reported, so the median will divide these into two groups of nine time values each. The median value is taken as the arithmetic mean of the 9th and 19th values, in this example. It turns out that both of these are the same, 1400 PST, so this value is the median time.

The 95% confidence interval, for a set of this size, will be bounded by the 5th and 14th cases in serial order. These values are 1300 and 1500 PST. The 95% confidence interval is thus two hours, specifically, 1300-1500 PST.

$\Sigma E = 531$

$\Sigma E^2 = 15245$

$N = 20$

MEAN $= 25.65$

$\sigma_M^2 = 5.4909$

STANDARD ERROR OF THE MEAN, $\sigma_M = 2.35$

FORMULAS FOR COMPUTATION:

MEAN $M = \frac{\Sigma E}{N}$

$$\sigma_M^2 = \frac{N\Sigma E^2 - (\Sigma E)^2}{N^2 - (N-1)}$$

$$\sigma_M = \sqrt{\sigma_M^2}$$

MEAN VALUE = 25.65

CHAPTER V—TABLE II

Number	Cue word	Comment
05	None	A mean value, or an individual value of 20.5 may be interpreted as indicating an amount of irritation that is greater than "some" but less than "moderate."
15	Some	
25	Moderate	
35	Severe	
45	Worst	

Table III displays results obtained downtown Los Angeles for the month of August.

Two Methods of Reporting Eye Irritation

Eye irritation data were collected in *two phases:* one, a random sampling of days and a predetermined time of reporting, and the second, a selected sample of days with individuals reporting the maximum irritation experienced during the day and the time at which the maximum irritation occurred.

Phase I: Early in the survey investigators decided to sample smoggy as well as non-smoggy days. Routine reports were made on Tuesday and Friday of each week, and as conditions warranted, additional reports were requested. Each panel was assigned a time of day to observe and report irritation. Several panels were employed at each station and soon comments were received from individuals on different panels to the effect that irritation had been bad the previous day when no report was made. Therefore, Phase II was inaugurated.

Phase II: In this stage more emphasis was placed on investigating days with apparent irritation and some method was devised to measure the irritation at its peak. Observers were asked to report the greatest amount of irritation experienced and the time of day at which this maximum was noticed, and also whether they were indoors or outdoors. The selection of days for which to request reports depended on the

CHAPTER V – TABLE III

EYE IRRITATION SURVEY

Downtown Los Angeles, August 1954

Date	Mean Eye Irritation (01-55)	Median Time PST	Number in Panel	Standard Error of Mean
8/11	17.0	1025	19	2.37
8/17	22.0	1000	20	1.97
8/18	14.9	1030	17	2.17
8/20	14.9	1000	16	2.03
8/24	10.2	1000	21	1.44
8/27	16.6	1000	22	1.83
8/31	15.3	1000	23	1.68

irritation forecasts by the Air Pollution Control District. Instructions included specifically reporting maximum irritation "inside and outside." A statistical investigation was made to show the validity of the hypothesis that there is "no difference between inside and outside maximum irritation reports." Accordingly, "inside" and "outside" maximum values were pooled without correction. Maximum irritation is computed in the same way as "station-day-mean" and is called "mean-maximum." In order to determine the time of maximum irritation, a median of the reported times was decided on as furnishing the best estimate of the true time of occurrence of maximum irritation.

Expert Panel

As a contrast with the regular panels composed of people at random, one expert panel was selected at California Institute of Technology composed of Dr. A. J. Haagen-Smit and his co-workers. A comparison of mean values reported by this panel with those reported by a lay panel on the campus of California Institute of Technology shows that the expert panel reported means of about 5 units less. This is possibly due to the fact that the experts had a higher criterion for eye irritation since they were familiar with odors and irritants. Variability of the expert panel was comparable to the other panels, and reliability was estimated as 0.66 during a period when the variability of the daily means was relatively low.

Using Eye Irritation Measures

It was presupposed that each panel represented a random sample of the same people-in-general population, that one panel was equivalent to the next panel in reporting mean values of irritation, and that therefore it was possible to infer a different level of stimulus from different mean values of irritation thus reported. However, this presupposition seems somewhat questionable and can be tested in order to obtain a correction factor. Until this is done, the data from different panels should not be pooled.

Relationships developed within each panel may be compared to similar relationships developed by another panel at another station. Correlations between eye irritation and atmospheric variables, for instance, can be proved or disproved in this fashion. At this stage of the survey, the comparison between panels of obtained relationships was preferred to the pooling of basic data in an effort to find relationships applicable to all stations.

SUPPORTING METEOROLOGICAL OBSERVATIONS

Inversion Height

Inversion height data were determined from radiosonde observations taken at the Long Beach Municipal Airport by the Air Force Air Weather Service detachment. Observations were made four times daily: 1:00 a.m., 7:00 a.m., 1:00 p.m., 7:00 p.m., PST. The radiosonde consists essentially of an aneroid barometer, a resistance thermometer, and a hygrometer controlling the audio signal sent out by a radio transmitter. The radiosonde is carried aloft by means of a free balloon. The ground station receives radio signals representing the temperature, humidity, and pressure at the various levels of the atmosphere through which the radiosonde passes.

Radiation

Continuous radiation records were obtained using Eppley pyrheliometers at the U.S. Weather Bureau—Los Angeles City Office, U.S. Weather Bureau—Airport Station, University of California at Riverside, University of California at Los Angeles, and Mt. Wilson.

Total direct solar radiation and "sky" radiation, i.e. the short-wave radiation scattered toward the ground by the atmosphere, were recorded continuously by the Eppley pyrheliometer. The radiation falls on two concentric silver rings, of which one is painted with lamp black to absorb most of the radiation and the other (outer cold ring) is coated with magnesium oxide to form a reflecting surface. The difference in temperature between these two surfaces is measured by thermocouples which are in thermal contact alternately with the blackened and the whitened rings but are electrically insulated from the silver. Either 10 or 50 thermocouple junctions form the thermopile. The whole thermopile is mounted at the center of a three-inch glass bulb filled with dry air and sealed. Only radiation shorter than about 2.5 microns is transmitted by the glass. The 10 junction-type pyrheliometer has a sensitivity of about 2 millivolts per gram calorie per minute per centimeter squared and records on a millivolt recorder.

Wind Velocity

Surface wind speed and directions were observed hourly at about fifty-five stations throughout the Basin and surrounding hills. Various types of anemometers and wind vanes were used in making these measurements. The stations included the Weather Bureau, Air Force, Navy, and Marine stations, as well as equipment operated by public and private utility companies and various industrial concerns. These data were obtained and coordinated by the Los Angeles County Air Pollution Control District and made available to the Foundation.

Temperature and Relative Humidity

At six of the Aerometric Survey stations, temperature and relative humidity were recorded continuously by means of a hygrothermograph in the plant test chamber. A hair-type hygro-element and a Bourdon-type thermo-element actuated pens which plotted the relative humidity and temperature traces on a chart. The chart was mounted on a cylinder which revolved once a week. In addition, temperature and humidity records were available from the three Weather Bureau stations in the Basin and several other stations including those of the military.

OPERATIONS

Measurement Schedule

1. The survey got underway on July 30 when an oxidant recorder was put into operation at Station 3. As instruments became available and stations were readied, the recorders were put into operation so that all were going by August 6, except at Azusa where work started on August 16. Except for occasional breakdowns and troubles, the oxidant recorders were operating continuously until the end of the survey November 30, 1954. The Ralph M. Parsons Company, Research and Development Division, Pasadena, California, was given a contract to operate these recorders.

2. The sampling program for oxides of nitrogen got under way on a seven-day week as follows:

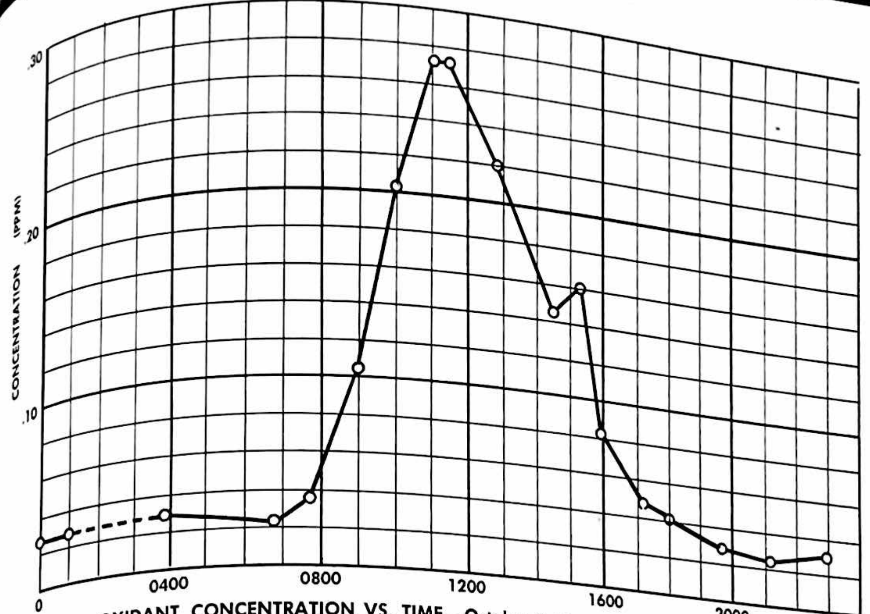
Station 3	8:00 a.m.	August 7
" 4	8:00 a.m.	August 8
" 5	8:00 a.m.	August 9
" 1	8:00 a.m.	August 9

Samples of air were obtained every three hours around the clock for each station until about September 30. Starting about October 1, hourly samples were obtained as follows:

Station	Time of Samples	Dates
1	6:00 a.m.-1:00 p.m.	10/1/54-11/30/54
3	6:00 a.m.-1:00 p.m.	10/4/54-11/30/54
4	6:00 a.m.-1:00 p.m.	10/2/54-11/30/54
5	6:00 a.m.-1:00 p.m.	10/4/54-11/30/54

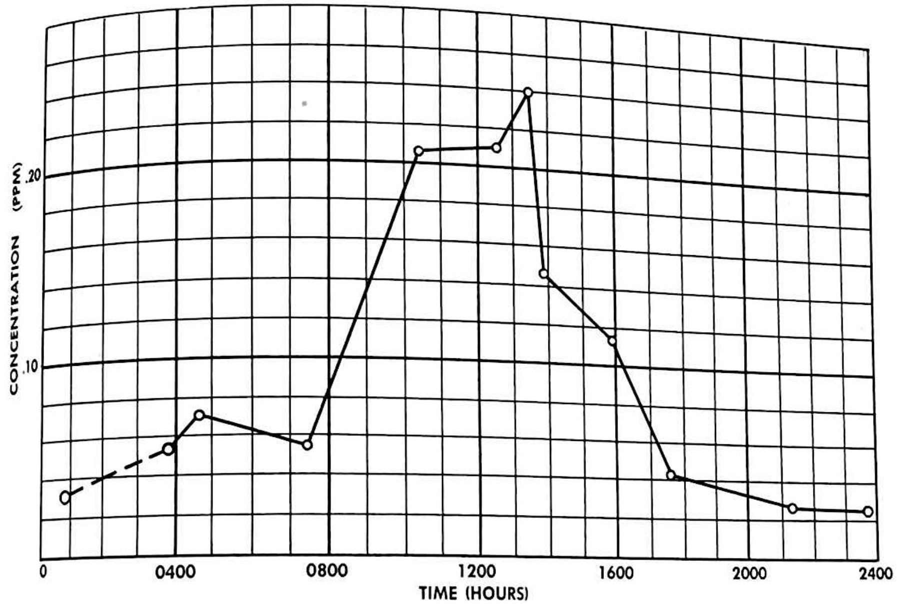
The operation and laboratory analyses were done under contract with the A. L. Chaney Laboratories, Glendale, California.

3. and 4. Hydrocarbon and carbon monoxide measurements were started on August 2 at Stations 3 and 4. Samples of freeze-out hydrocarbons were obtained on an hourly basis at Station 3 and Station 4, five days a week. On October 21, sampling was initiated for six days a week, Thursday through Tuesday, omitting Wednesday. At each station six samples were collected



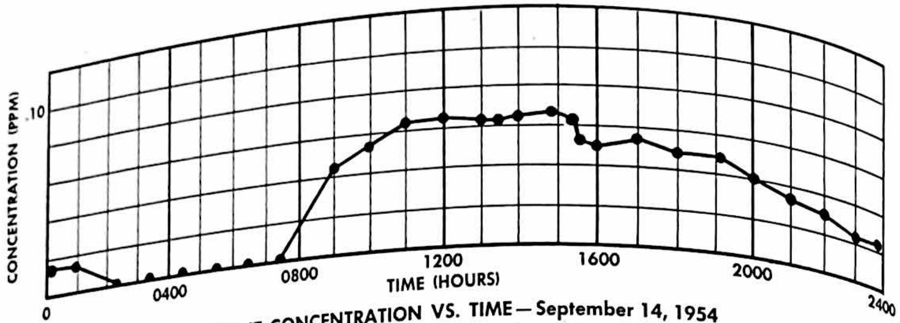
OXIDANT CONCENTRATION VS. TIME—October 8, 1954 STATION 4—PASADENA

CHAPTER V - FIG. 10a



OXIDANT CONCENTRATION VS. TIME—November 15, 1954 STATION 2—WILSHIRE DISTRICT

CHAPTER V - FIG. 10b



OXIDANT CONCENTRATION VS. TIME—September 14, 1954
STATION 12—SANTA BARBARA

CHAPTER V – FIG. 10c

on an hourly basis from 6:30 a.m. at Station 3, and at Station 4 from 10:30 a.m. until 4:30 p.m. As for oxides of nitrogen additional samples were obtained at selected low inversion periods.

5. Sampling for aldehyde analyses was not started until September 21 at Stations 3 and 4. Hourly samples were obtained on the same schedule as hydrocarbons. The above three operations were done under contract with the Truesdail Laboratories, Los Angeles, California.

6. The AISI automatic smoke filter equipment for particulate sampling was put into operation at Station 3, August 9, and hourly samples were obtained continuously to November 30, 1954. This was also done at Station 4, August 12 to November 30, 1954.

7. The Staplex high volume particulate samplers were put into operation at Stations 3 and 4 on August 9 and 10, and 24-hour samples were obtained seven days a week until November 30, 1954. The operation of the AISI and Staplex were under contract with The Kettering Laboratory, University of Cincinnati, Cincinnati, Ohio.

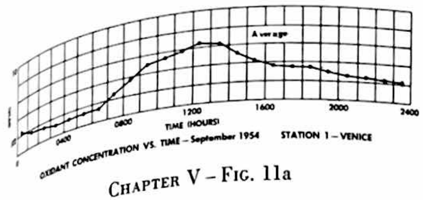
8. The sulfur dioxide recorder was operated continuously from September 4 to November 30 at Station 3, under contract with The Ralph M. Parsons Company.

9. The transmissometers were set in place during August, but because of difficulties of alignment and calibration, useful data were not obtained until September 10, 1954. From that date on, all four stations were operating continuously 24 hours a day until November 30, 1954, under contract with The Ralph M. Parsons Company.

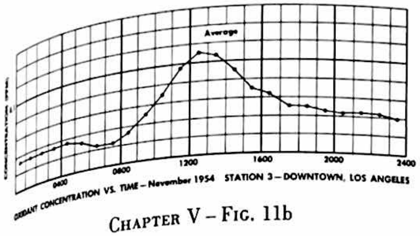
10. The plant test chambers were put at Stations 2, 3, 4, 6, 8, 9, August 4 and starting on August 5 pinto bean plants were put out almost every day until November 30. This operation was done by means of a research grant to the University of California, Riverside.

11. Eye irritation panels were set up during July and August, and initial reports were submitted from August 10 to August 31 for two or three days a week until the last week of November. During August and September surveys were run Tuesdays and Fridays plus usually one other day if smog was forecast; no data are available for Saturdays and Sundays. During November surveys were run only on the basis of a smog forecast by the Los Angeles County Air Pollution Control District.

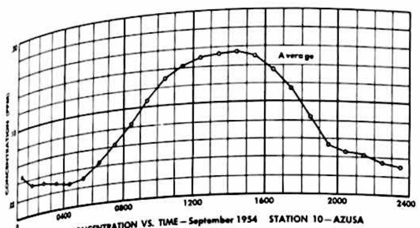
12. Radiosonde observations are made all year by the U. S. Air Force at Long Beach; therefore data for obtaining inversion characteristics were available for the entire period of the Aerometric Survey except for a few days late in September when helium supply was exhausted.



CHAPTER V – FIG. 11a



CHAPTER V – FIG. 11b



CHAPTER V – FIG. 11c

13. Solar radiation measurements are made all year at the Weather Bureau City Office and Airport Stations, and at the University of California at Riverside. The UCLA station was under way before August 1 on an all-year operation. The Mt. Wilson station was put into operation November 5 and was discontinued November 30.

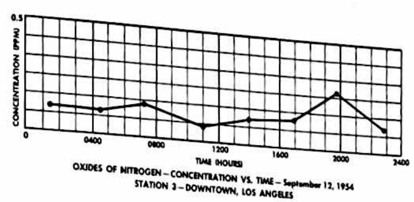
14. Wind velocity and direction data are obtained all year and therefore were available to the Foundation for the period of the survey through the Los Angeles County Air Pollution Control District.

15. Temperature and relative humidity measurements taken by hygrothermographs were put into operation in the plant test chambers on August 5 as part of the plant study with the University of California, Riverside.

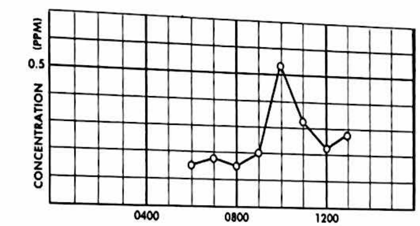
Preliminary Data

Information which has been compiled on this project is still being processed to determine averages, correlations of various measurements, maxima and minima, and other manipulations. To indicate the type of data assembled, examples of some of the measurements are described below.

1. *Oxidant.* In Fig. 10 (a, b, c) there are three curves showing the daily values of oxidant concentration vs. time for the Pasadena, Wilshire, and Santa Barbara stations. The particular dates are indicated. In Fig. 11 (a, b, c) there appear three curves showing the average oxidant value for the month of September for the Venice, downtown, and Azusa stations. All of these curves show the previously reported daily change in oxidant, with maxima appearing between 11:00 a.m. and 1:00 p.m.

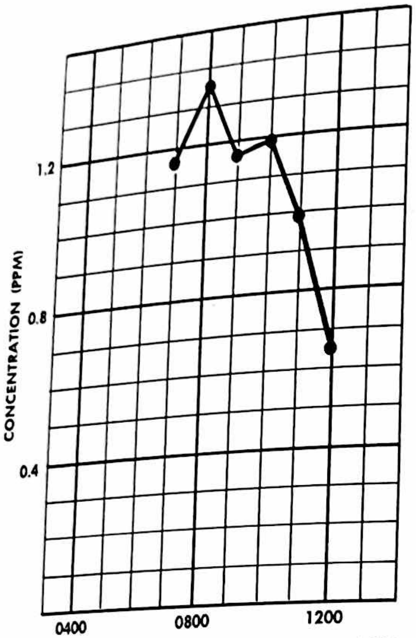


CHAPTER V – FIG. 12a



OXIDES OF NITROGEN CONCENTRATION VS. TIME—Oct 31, 1954
STATION 3—DOWNTOWN, LOS ANGELES

CHAPTER V – FIG. 12b



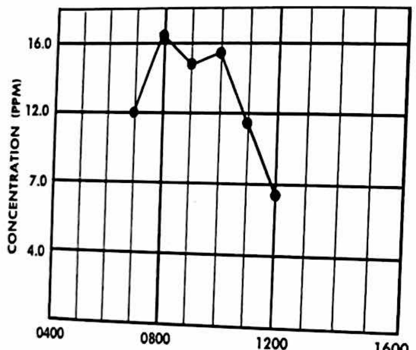
HC CONCENTRATION VS. TIME—Sept 24, 1954
STATION 3—DOWNTOWN, LOS ANGELES

CHAPTER V – FIG. 13a

2. *Oxides of nitrogen.* In Fig. 12 (a, b) two curves are shown, giving the concentration of oxides of nitrogen against time. In part (a) of this figure, the eight points on the curve represent samples which were taken three hours apart. In part (b) of the figure, the eight points shown were taken at hourly intervals. This change from three hour sampling to one hour sampling was made in an attempt to find whether a daily variation existed which was not being shown by the three hour sampling period.

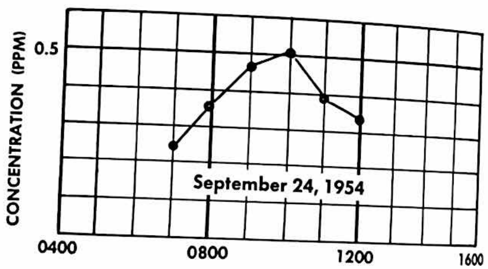
3. *Hydrocarbons, carbon monoxide, and aldehydes.* In Fig. 13 (a, b, c) there appear three curves showing hydrocarbon concentration, carbon monoxide concentration, and aldehyde concentration measured at the downtown station on September 24, 1954.

4. *Particulate matter.* Fig. 14 (a, b) shows a curve giving the variation in Coh units with time for September 24, 1954 and in addition a bar chart showing the average Coh units per thousand lineal feet of air averaged for each day for the month of September, 1954. A Coh unit is defined as that quantity of light scattering solids which produce an optical density of 0.01 when measured by light transmission of a circular spot on a filter paper through which has been drawn a measured quantity of air.



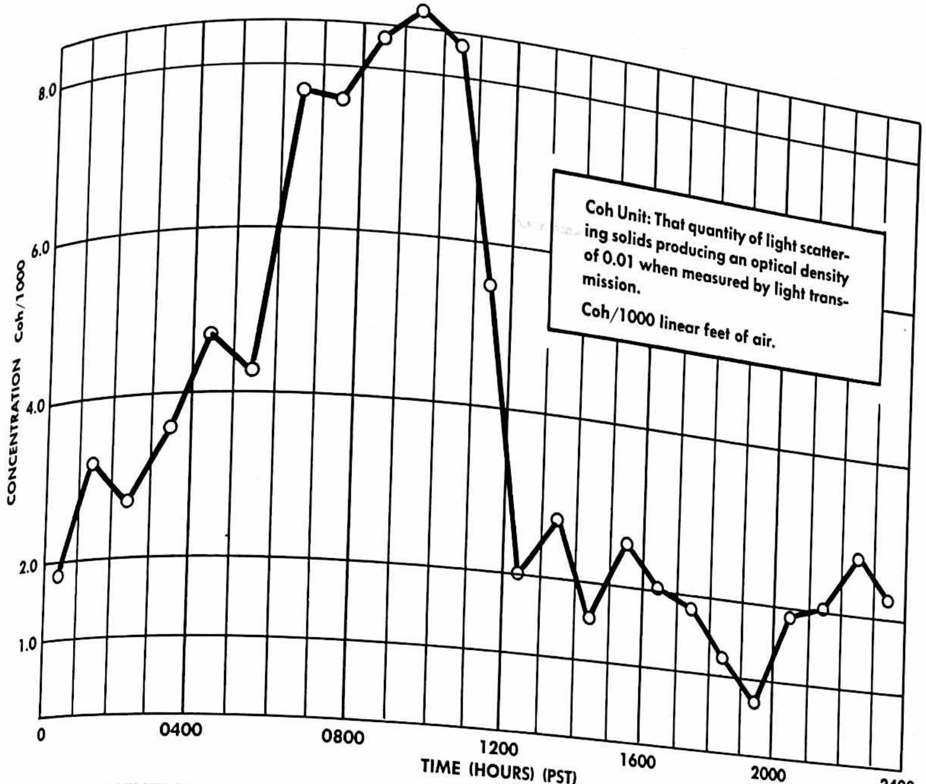
CO CONCENTRATION VS. TIME—Sept 24, 1954
STATION 3—DOWNTOWN, LOS ANGELES

CHAPTER V – FIG. 13b



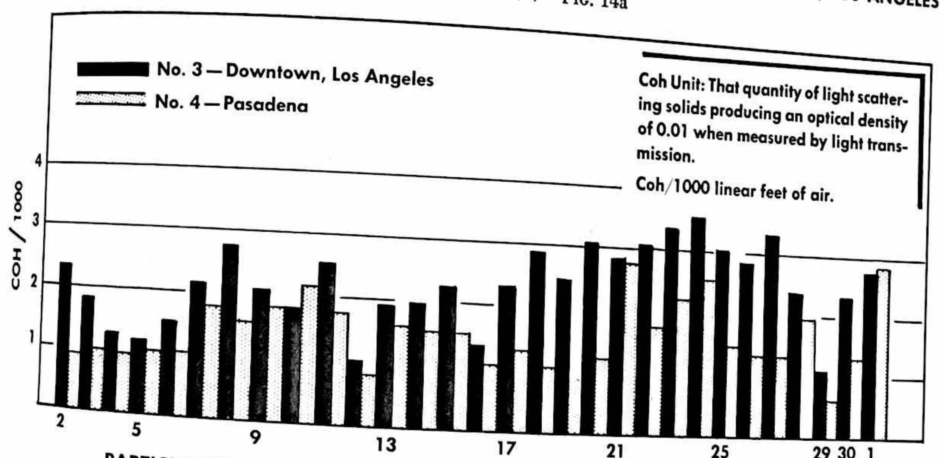
ALDEHYDES CONCENTRATION VS. TIME
STATION 3—DOWNTOWN LOS ANGELES

CHAPTER V – FIG. 13c



COH CONCENTRATION VS. TIME—September 24, 1954 STATION 3—DOWNTOWN, LOS ANGELES

CHAPTER V – FIG. 14a



PARTICULATE MATTER IN THE ATMOSPHERE (IN COH UNITS) September 1954

CHAPTER V – FIG. 14b

AIR POLLUTION SURVEY

Sampling Date: 9/23-24/54
2:00 P.M.

Sampling Station: No. 3
(Downtown, Los Angeles)
Sampling Time: 23 hrs. 55 min.

AIR VOLUME		SAMPLE WEIGHT			
Cu. ft.	Cu. M	Final	Initial	Wt. mg.	µg/cu.m
60,300	1700	4.152	3.245	907	534

ANALYTICAL DATA

ORGANIC MATTER			POLYCYCLIC HYDROCARBONS		
mg. Extracted	µg/cu.m	% of Sample	mg.	µg/cu.m	% of Sample
179.6	105.6	19.8	10.4	6.1	1.15

INORGANIC ANALYTICAL RESULTS

Metal, etc.	µg/M³	%	Metal, etc.	µg/M³	%
Mn	0.26	0.05	Mg	4.7	0.9
Pb	11.7	2.2	Na	7.3	1.4
Sn	0.01	0.01	K	5.0	0.9
Fe	7.4	1.4	Sr	0.18	0.03
Al	...	...	Be	0.0001	0.0001
Cu	0.21	0.04	As	nil	nil
Ag	0.0012	0.0002	F–	1.07	0.20
Ti	0.57	0.11	SO^{4-}	41.2	7.7
V	0.029	0.006	NO_3	22.5	4.2

CHAPTER V – FIG. 15

5. *Analysis of particulate matter.* Fig. 15 gives data for the analysis of the particulate matter collected on the high volume Staplex sampler for September 24, 1954. A total of 60,300 cubic feet of air was sampled on this particular day, and the total particulate matter collected was 4.15 grams or 534 micrograms per cubic meter.

6. In Fig. 16 there are data obtained from the *transmissometers* at the Federal Building on November 15, 1954 and at Pasadena on September 10, 1954.

7. Fig. 17 shows *plant damage data* for the months of August and September at Station 9 in Bassett.

8. Fig. 18 gives *eye irritation* data for the month of October for Station 6, Dominguez, and Station 4, Pasadena.

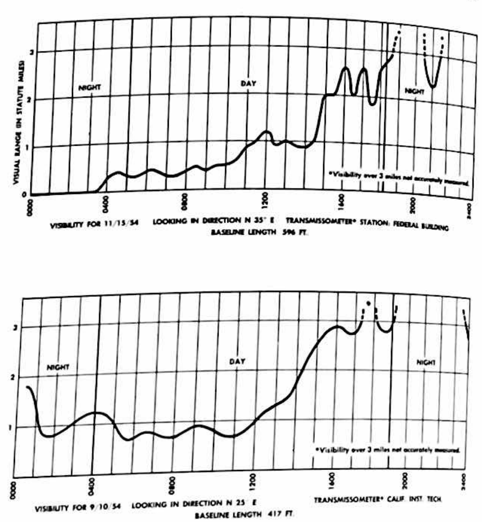
9. Fig. 19 is a plot of the height of the base of the inversion layer as measured by *radiosonde* at Long Beach for each day of October, 1954.

Measurements Aloft

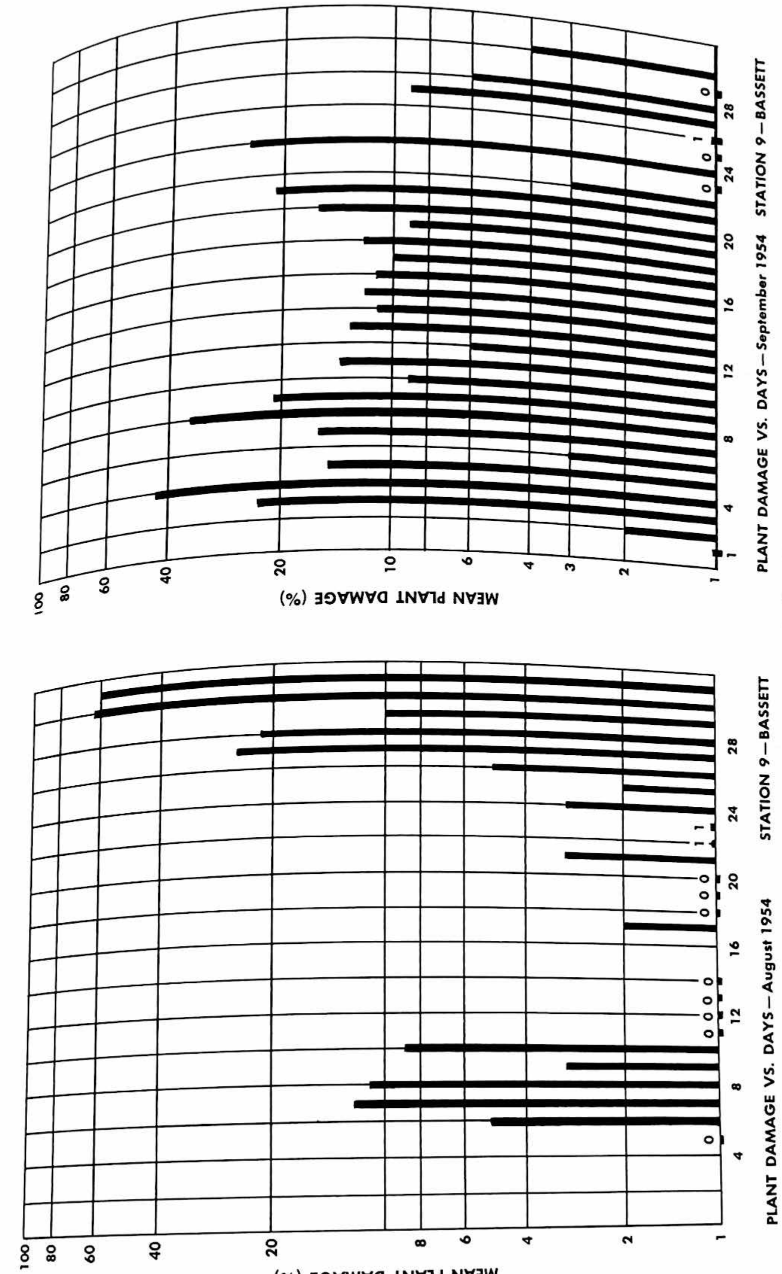
To study the dispersion of the contaminants at various altitudes above several of the ground stations, arrangements were made with the U. S. Navy Reserve Training Unit at Santa Ana and also with the Goodyear Aircraft Corporation to make a number of air sampling flights with a blimp. Thirteen flights were made in the Navy blimp and two flights were made in the Goodyear blimp. The cooperation of the U. S. Navy and the Goodyear Aircraft Corporation is highly appreciated.

Samples were taken as nearly as possible over existing ground stations. The pattern followed was to ask the pilot of the blimp to execute a tight turn for a period of several minutes at altitudes (a) as low as possible, (b) at 1,000 feet, and (c) as high as possible.

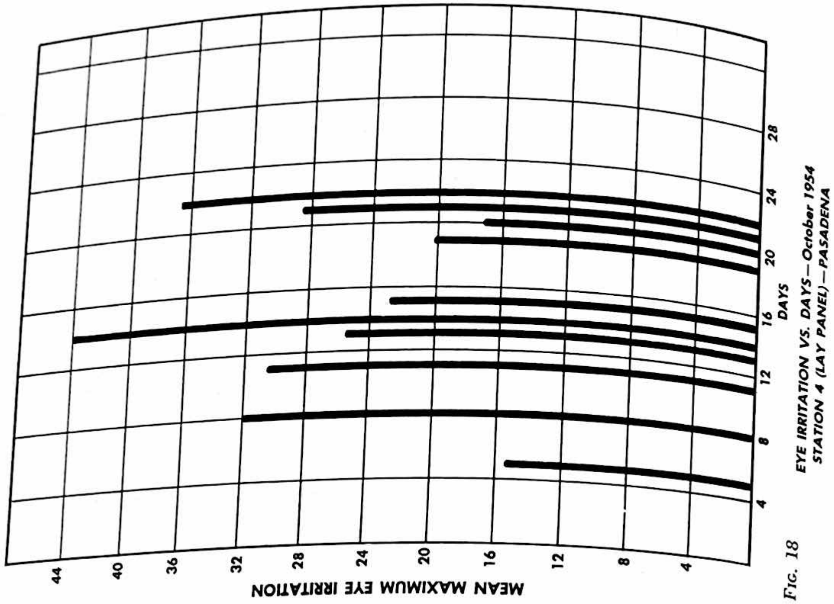
Certain limitations of the blimp became apparent. It was not possible to hover at a fixed point, but instead it was necessary to circle in order to obtain an adequate volume of air for a sample. Furthermore, due to the manner in which



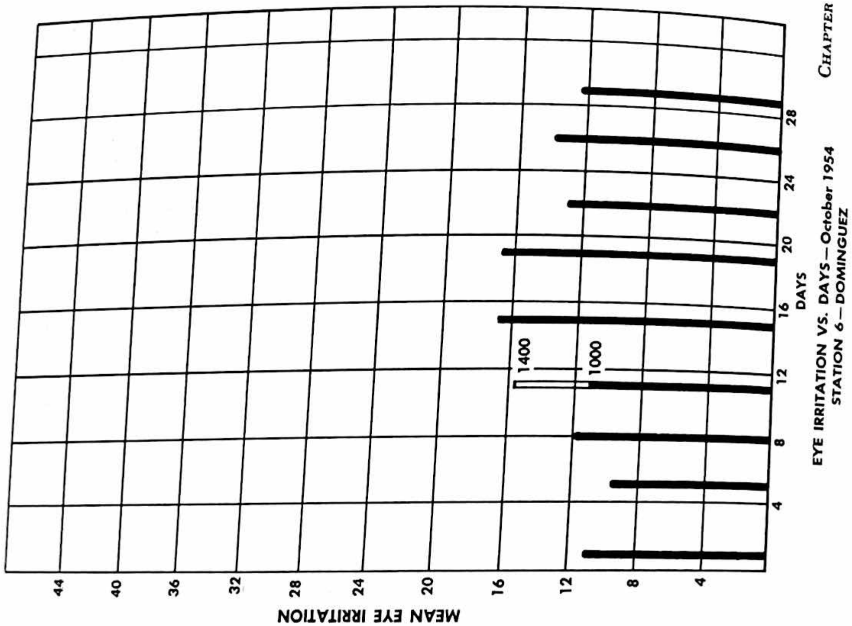
CHAPTER V – FIG. 16



CHAPTER V – FIG. 17

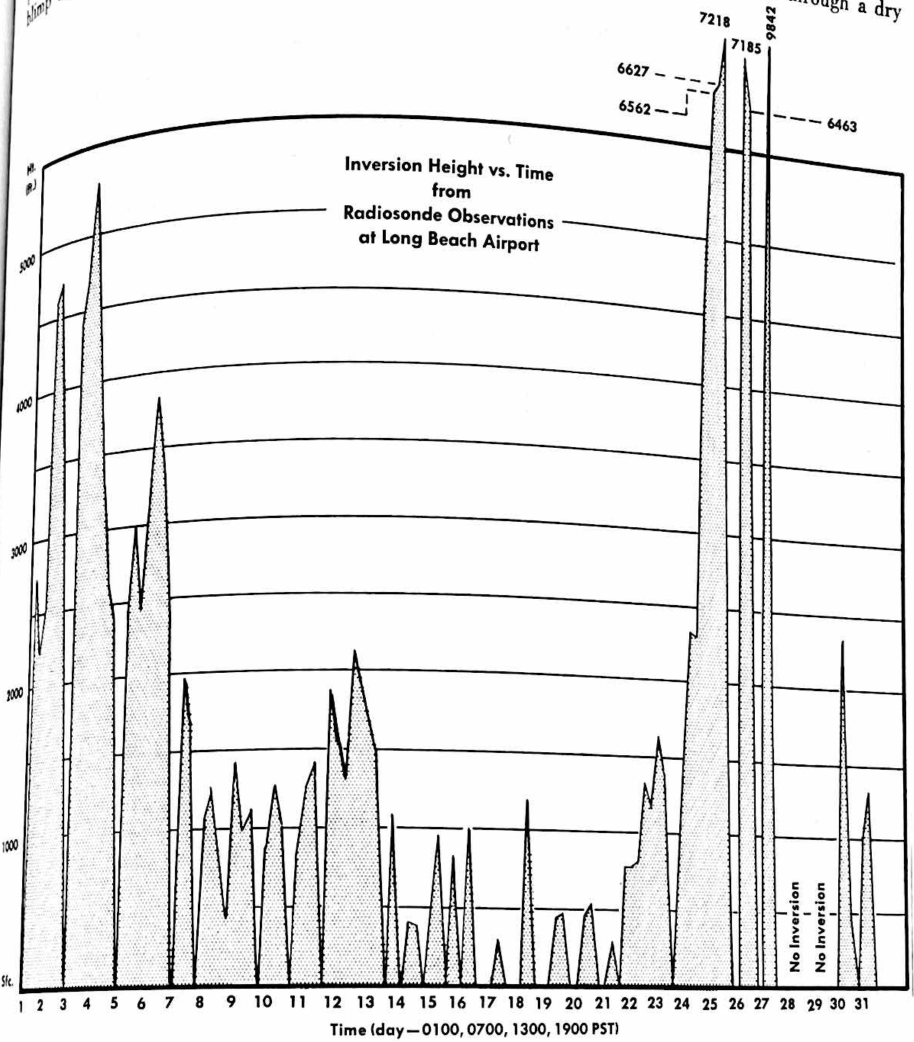


CHAPTER V – FIG. 18



the blimp was ballasted, it was usually not possible to attain altitudes very much above 3,000 feet without valving helium.

Oxidant determinations were made by sampling air over a period of six minutes while the blimp was circling. A special 24-volt motor attached to the blimp electrical system was used to drive an air pump which drew air through an A.S.T.M. sulfur absorber. This absorber contained a measured quantity of potassium iodide solution, which was placed in the scrubber just before sampling. Air was drawn through a dry



INVERSION HEIGHT VS. TIME—October 1954

CHAPTER V – FIG. 19

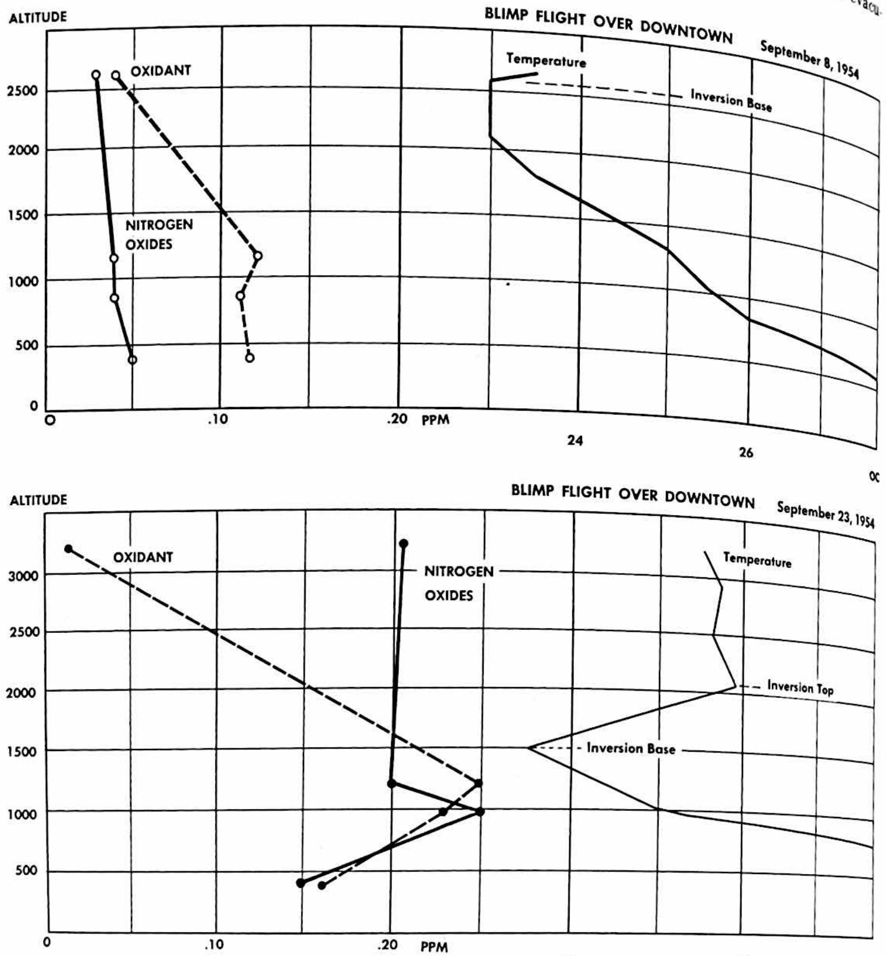
test meter at the rate of five liters per minute for about six minutes.

Immediately following sampling, the solution was removed from the scrubbers and placed in small bottles which were shielded from light. As soon as possible, the iodine concentration in the sample was measured colorimetrically, using the reagent from a second scrubber as a blank. Results were calculated in parts per hundred million of ozone.

Oxides of nitrogen samples were taken at the same time as the oxidant samples with an evacuated flask fitted with a serum stopper. In the flask was placed a measured amount of 0.05 normal sodium hydroxide solution. The flask was held out of the window of the blimp gondola while a hypodermic needle was plunged through the stopper. After one minute the needle was withdrawn. This experiment was repeated and the flasks were returned to the laboratory for analysis. The Griess-Ilosvay procedure was used for the determination of nitrogen dioxide essentially as described above.

Temperature and humidity determinations were also made with an aerometerograph at the same time as the chemical samples were being taken.

Plots are being made for each flight, showing variation in concentration of oxidant, oxides of nitrogen, and temperature with altitude. An example of the data obtained for two flights appears in Fig. 20.



CHAPTER V – FIG. 20

DATA REDUCTION

IBM Setup and Tabulations

Early in the setup of the Aerometric Survey it was realized that an enormous amount of data would be developed in the measurement program. Therefore, it was necessary to use modern methods of data handling in order to cope with manipulations required for the projected analyses and correlations of these data. A contract was made with Stanford Research Institute, Palo Alto, to handle not only the data reduction but also the processing of the information on IBM cards. Stanford Research Institute, in turn, subcontracted for the use of IBM equipment with the Department of Mathematics at Stanford University.

Plots and Graphs

Most of the data for the four-months survey were processed as follows:

1. Daily curves of oxidant concentration vs. time of day for each station for each day.
2. Twenty-four (24) hour integration of oxidant concentration for each day for each station.
3. Monthly curves for each station of oxidant concentration, showing hourly average vs. time of day, together with range of maximum values for each hour.
4. Daily curves of oxides of nitrogen (as NO_2) concentration vs. time of day for each station.
5. Monthly average curves for oxides of nitrogen (as NO_2) concentration.
6. Daily curves of hydrocarbon (as hexane) concentration vs. time of day for each station.
7. Monthly average curves for hydrocarbon (as hexane) concentration.
8. Daily curves of carbon monoxide concentration vs. time of day for each station.
9. Monthly average curves for carbon monoxide concentration.
10. Monthly bar graphs of mean seventy of injury to test plants vs. day of the month.
11. Monthly bar graphs of mean or maximum eye irritation vs. day of the month.
12. Daily curves of Coh units vs. time of day for each station.
13. Daily curves of ratio of carbon monoxide to hydrocarbon concentration vs. time of day.

In addition to these plots, Stanford Research Institute completed tables of all data which were printed directly from the IBM cards.

ANALYSES

Hypotheses

The following hypotheses were set up in October and forwarded to Stanford Research Institute for formulating the corresponding statistical hypotheses and pertinent tests:

1. Plant damage increases as 24-hour integrated oxidant increases.
2. Plant damage increases as 24-hour integrated oxidant increases where these integrations are performed above each of the levels 5, 10, 15, and 20 pphm oxidant.
3. Plant damage increases as 24-hour integrated oxidant increases for each of two groups of data; these groups being defined as (a) those with high value of the product of temperature and relative humidity, and (b) those with low value.

4. Plant damage increases as average value of NO_2 concentrations for the day increases.
5. Plant damage increases as average value of aldehyde concentrations for the day increases.
6. Plant damage increases as eye irritation increases.
7. Plant damage increases as average visibility (6:00 a.m. to 6:00 p.m.) decreases.
8. Twenty-four hour integrated oxidant at Stations 3 and 4 increases as total solar radiation increases (pyrheliometer data taken at U. S. Weather Bureau City Office).
9. Twenty-four hour integrated oxidant increases as inversion height at 7:00 a.m. decreases.
10. Same as (9) except inversion height at 1:00 p.m.
11. Eye irritation increases as oxidant value at time of irritation increases.
12. Eye irritation increases as oxidant value increases above a certain value (try 10, 20 ppm).
13. Eye irritation increases as average value of aldehyde concentration increases.
14. Eye irritation increases as average value of hydrocarbon concentration increases.
15. Eye irritation increases as average value of nitrogen oxide concentration increases.
16. Eye irritation increases as Coh value increases.
17. Eye irritation increases as visibility decreases.
18. Eye irritation increases as total organics concentration increases.
19. Eye irritation increases as total mass concentration of particulates increases.

Correlations

During November, Stanford Research Institute proposed the following method to determine the degree of correlation between the various pairs of variables:

1. Breakdown by Groups.

   Variable A will be sorted by value and then broken down into six (6) equal groups. Thus there will be six groups of equal size, each containing all the values of A in a certain range.

   The average value of A and the $\Sigma\Delta^2$ (Δ being the difference between A and the average value of A) will be computed for each group. The average value of the variable B and the $\Sigma\Delta^2$ will be likewise computed for each group.

2. Least Squares Fit.

   Variable A will be expressed as a function of B in the form:

   $$A = a + b\,B + c\,B_2$$

   The coefficients will be computed so as to give the least squares fit with the experimental data.

   The $\Sigma\Delta^2$ will be computed where Δ is the difference between the experimental A and the corresponding A on the least squares curve. Intermedial results such as ΣB, ΣB_2, ΣB_3 ΣAB, etc., will also be listed.

3. Analysis:

   The results of A and B will be analyzed for possible correlations. Where significant correlation is found, scatter diagrams will be drawn and the correlation will be expressed in its most meaningful form.

Pairs of Variables

Below is a list of the pairs of variables to be correlated:

Variable A	Variable B
Plant Damage	24-hr. Oxidant Integration
Plant Damage	" (above 5 pphm)
Plant Damage	" (above 10 pphm)
Plant Damage	" (above 15 pphm)
Plant Damage	" (above 20 pphm)
Plant Damage	NO_2 (daily average)
Plant Damage	HC (daily average)
Plant Damage	Aldehyde (daily average)
Plant Damage	Eye Irritation
Plant Damage	Visibility (6:00 a.m. to 6:00 p.m. average)

	Oxidant
Eye Irritation	Oxidant (above 10 pphm)
Eye Irritation	Oxidant (above 20 pphm)
Eye Irritation	Oxidant (daily average)
Eye Irritation	NO_2 (daily average)
Eye Irritation	HC (daily average)
Eye Irritation	COH value
Eye Irritation	Visibility
Eye Irritation	Total organics (24-hr. sample)
Eye Irritation	Total mass (24-hr. sample)

All of the above pairs are to be studied using:

1. Total data.
2. Data corresponding to a product of temperature and relative humidity greater than the median value.
3. Data corresponding to a product of temperature and relative humidity less than the median value.

Other pairs to be correlated are:

Variable A	Variable B
Visibility	Oxidant
Oxidant (24-hr. Intgr.)	Solar Radiation
Oxidant (24-hr. Intgr.)	Inversion Height 7:00 a.m.
Oxidant (24-hr. Intgr.)	Inversion Height 1:00 p.m.

During December Stanford Research Institute analyzed data for August and September to test the hypotheses outlined above. Some of the results can be summarized as follows:

1. Plant damage shows no significant correlation with concentrations of hydrocarbons and oxides of nitrogen; integrated oxidant; maximum oxidant; nor with concentrations of hydrocarbons, oxides of nitrogen, nor aldehydes at time of maximum oxidant; nor with average visibility (6:00 a.m.-6:00 p.m.); nor with visibility at time of maximum oxidant; but a possible correlation with average aldehyde concentration during daylight hours.
2. Mean eye irritation shows no correlation with concentration of average or instantaneous oxides of nitrogen; aldehydes; total organics from particulate sampler; nor with average or instantaneous visibility; but a possible correlation with instantaneous oxidant, and a stronger correlation with hourly particulate in Coh units and 24-hour integrated oxidants when integrated above 10, 15, and 20 pphm.
3. Plant damage shows no correlation with eye irritation.

Trajectories

For the interpretation of the chemical analyses and the measurements of eye irritation and plant damage, it is desirable to be able to tell where the air sampled at the various stations came from. For this purpose, we have undertaken to compute the trajectories of the air reaching the various Aerometric Survey stations for certain hours of interest. A total of 1,000 trajectories were planned, of which only about 3% could be computed for the explanation of the data at the various stations throughout the survey. However, the amount of work involved precluded the computation of a larger number of trajectories.

The basis for selection of the trajectories to be computed was principally the paths of the air for which the highest values of pollution were measured. The 1,000 trajectories were distributed throughout the four months of the Aerometric Survey roughly in proportion to the amount of pollution which was recorded.

The procedure of computing trajectories consists of plotting the wind observations for the approximately fifty wind stations in the area on hourly maps, drawing lines of constant speed on these maps and streamlines or lines representing the direction of flow over the area, and finally computing from these hourly maps the motion which an air parcel reaching a station would have traveled each hour previous to arrival at the station.

At the time of this writing, approximately half of the necessary maps have been plotted, and about one-fourth of them have been analyzed.

VI. GENERAL STATISTICAL DATA OF THE LOS ANGELES BASIN[1]

INTRODUCTION

THIS study of statistical data of the Los Angeles Basin in relation to the smog problem was made for the Air Pollution Foundation by Mr. Neil Goedhard while associated with the School of Public Administration of the University of Southern California. Mr. Neil Goedhard is now City Manager of Covina, California. A summary of this report follows.

AREA

Early in its work on statistical data of the Los Angeles Basin, the Foundation decided upon the meteorological approach as the most logical and scientific premise upon which to build a definition of the area of the Basin. The natural boundaries, such as the ocean and mountain ranges which hinder the unobstructed dispersal of elements in the air, were used to define the area; this area was then further broken down following statistical and/or political boundaries. Thus three basic regions were defined as shown in Fig. 1:

1a. Los Angeles Region
1b. Orange County Region
2. San Fernando Valley Region
3. San Gabriel Valley Region

The portions of Los Angeles and Orange Counties included in this definition of the Basin represent an area of 1,629.7 square miles or 33.4% of the total area (4,870.5 square miles) of Los Angeles and Orange Counties.

[1]in preparation as Report No. 6 of the Air Pollution Foundation.

POPULATION 1930 - 1960

The increase in population in the Los Angeles Basin is of primary importance in understanding the development of air pollution in southern California. This research has shown that the Basin's population is essentially that of Los Angeles and Orange Counties combined. Only 33.4% of the area of these two Counties is situated in the Basin, yet 97.6% of the people in these two Counties live in the Basin. The percentage increase of population in the Basin between 1930 and 1954 shows a startling picture:

Year	Population	Increase
1930	2,280,630	
1940	2,859,258	25%
1950	4,275,395	49% since 1940
1954	5,028,367	76% since 1940

Based on these figures, a 1960 population estimate was developed showing a low figure of 5,791,000 and a high figure of 6,191,000 for the parts of Los Angeles and Orange Counties situated in the Los Angeles Basin. This study is widely documented and includes detailed statistics such as per cent increase and numerical increase of the population in the Basin, in each county, and further in each statistical area or township.

MOTOR VEHICLE REGISTRATION GASOLINE & DIESEL FUEL CONSUMPTION

The concentration of motor vehicles in the Los Angeles Basin and the consumption of gasoline and diesel fuel have increased in proportion to the growth of population. Based upon the figure of 97.6% for all the people of Los Angeles and Orange Counties living in the Basin, prorated statistics for motor vehicles registered in the Basin are given in the table below:

CHAPTER VI – FIG. 1
Regions of the Los Angeles Basin
Black dots represent sampling stations used in Aerometric Survey

Motor Vehicle Registration in Los Angeles Basin

Year	All Vehicles	Automobiles	% of Total
1930	878,000	836,000	95.2
1954	2,361,000	2,115,000	89.7
1960*	2,980,000	2,657,000	85.8

*Estimated from 1950-1954 increase.

In developing figures for the consumption of automotive fuel, certain difficulties were encountered. Records of actual consumption are maintained by the California State Board of Equalization only on a state level. Therefore, a different approach had to be devised. In order to arrive at a figure for gasoline consumption in the Basin, three separate computations were made, based upon (a) the population of Los Angeles and Orange Counties proportional to that of California, (b) weighing the number of motor vehicle registrations in the counties proportional to that of California, and (c) total number of vehicle registrations in the two Counties proportional to that of California. In addition, certain figures for gallons of gasoline sold subject to retail sales tax were used for 1950 and 1954. Here then are the figures for estimated gasoline consumption in gallons in the Los Angeles Basin:

Year	Low	High	Daily Estimate
1936	665,991,000	686,703,000	1,825,000
1954	1,708,127,000	1,789,895,000	4,758,000
1960*	1,900,000,000	2,300,000,000	6,200,000

*Estimated from 1950-1954 increase.

The same problems were encountered in estimating gallons of diesel fuel consumed. Two computations were made: one, by population of the two Counties proportional to California, and two, by truck registrations in the two Counties proportional to California.

Year	By Population	By Truck Registration	Daily Estimate
1938	4,257,000	3,571,000	11,000
1954	73,965,000	57,802,000	202,000
1960*	115,000,000	89,000,000	315,000

*Estimated from 1950-1954 increase.

The above statistics show an upward surge in the use of diesel fuel far greater percentage-wise than the increase in gasoline consumption; but it is nevertheless quite apparent that in terms of total fuel used, the amount of diesel fuel consumed by motor vehicles is small compared to the tremendous consumption of gasoline in the Los Angeles Basin.

VEHICLE COUNTS IN THE CENTRAL BUSINESS DISTRICT, 1929 - 1950

In spite of the marked increase in population and motor vehicle registration in the Los Angeles Basin, the daily number of vehicles entering and leaving the Los Angeles Central Business District has been decreasing gradually since 1948. Likewise, the number of buses and streetcars entering and leaving the Los Angeles Central Business District between 8:00 a.m. and 11:00 a.m. and between 3:00 p.m. and 6:00 p.m. has been decreasing in the same period. This trend would conform to the economic decentralization of the Central Business District area as shown in a decrease of retail sales downtown and the increase of retail sales in outlying areas.

The downtown area, or Los Angeles Central Business District, is the area bounded by Sunset Boulevard on the north, Pico Boulevard on the south, Figueroa Street on the west, and Los Angeles Street on the east. This study analyzed seven 16-hour cordon counts made between 6:00 a.m. and 10:00 p.m. by the Automobile Club of Southern California, the County of Los Angeles Regional Planning Commission, and the City of Los Angeles Street Traffic Engineering Department, between 1929 and 1950 prior to the opening of the Hollywood and Harbor Freeways.

Year	Total Number Vehicles Entering or leaving Downtown Los Angeles	% Variation	Automobile Registration Los Angeles County	% Variation	Population Increase Los Angeles County % Variation
1941	625,513		1,176,174		
1947	800,274	+27.9	1,320,911	+12.3	+26.7
1950	770,933	— 3.7	1,719,900	+30.2	+14.3

Starting in 1948 the California State Highway Commission undertook annual traffic counts at two intersections in the Central Business District. The following conclusions can be made from these recent counts: the total flow of traffic has stabilized itself at a level comparable to that of 1948-1950, although decreasing at a slow rate. Estimates of traffic flowing along the freeways show an unparalleled increase in the total number of vehicles passing through the business district, thereby contributing to air pollution in this area. Due to the progress of freeway construction around the Central Business District, no 16-hour cordon counts were taken by the City of Los Angeles after 1950. However, a count has been scheduled for 1955.

INCINERATORS AND RUBBISH DISPOSAL

Very few accurate facts and records were available to determine (1) the number of residential and commercial incinerators, (2) the amount of open burning, and (3) the extent to which combustible rubbish is collected and disposed in the Los Angeles Basin.

(1) The following numbers of dwelling units are indicated for Los Angeles and Orange Counties.

1940	1,010,550	(1950 Census Count)
1950	1,521,849	(1950 Census Count)
1954	1,830,000	(estimated by Los Angeles Chamber of Commerce)
1960	2,292,000	(based on 1950-1954 increase)

Assuming one incinerator per dwelling unit, the above figures would establish a maximum number of backyard incinerators in the Basin. The Los Angeles County Air Pollution Control District estimates one incinerator for 1.3 dwelling units, or 1,500,000 backyard incinerators in 1953 for Los Angeles County.

(2) There are no burning dumps in the Los Angeles County portion of the Basin. In the Orange County portion, however, there are eleven burning dumps. No statistics are available on the tonnage of combustibles burned, but it has been observed that since the ban on open-dump burning has become effective in Los Angeles County, the Orange County dumps located near the Los Angeles County boundary have experienced a noticeable increase in daily volume of combustibles.

(3) Our study of combustible rubbish disposal in the Los Angeles Basin indicates that various types of collection service are provided for residential and commercial establishments in most of the 46 cities in Los Angeles County, the City of Los Angeles being one of the few exceptions. In Orange County, at least 8 of the 13 cities provide collection service. In the unincorporated areas of Los Angeles County combustible refuse is collected from all residential and most commercial establishments; no such service is provided in the unincorporated areas of Orange County, other than by private arrangement. Frequency and scope of collection are subject to the desire of the citizens. Concerning the quantity of refuse thus collected, three different reports[2] were studied, all of which arrive at a fairly close per capita figure of 1.10 lbs., 1.54 lbs., and 1.16 lbs. of combustible refuse collected per day from residential and commercial establishments. It should be remembered here that these figures do not represent all combustible refuse produced; if no backyard burning were to take place, the Rawn report[2] estimates that per capita production of combustible refuse would be 2 lbs. At present, it is estimated that the daily minimum of combustible refuse burned in the Los Angeles Basin amounts to 4,224,000 lbs. out of an estimated minimum of 10,057,000 lbs. produced. The difference of 6,000,000 lbs. of combustible refuse produced but not burned in commercial or domestic incinerators is collected; an unknown quantity of this amount is burned

[2]Arnold, C. E., "Report on Rubbish and Refuse Disposal for Los Angeles County," April, 1949.

Schneider, W. A., "Report on Proposed Plan for Collection and Disposal of Combustible Rubbish in the City of Los Angeles," April, 1948.

Rawn, A M, "Report upon the Collection and Disposal of Refuse in the County Sanitation Districts of Los Angeles County, California," October, 1950.

in municipal incinerators and in open burning dumps.

In general the rubbish disposal study showed a dire lack of reliable information and suggests additional study of the entire combustible refuse program in the Basin.

REFINERY EMISSIONS[3]

In order to obtain an independent audit of the daily hydrocarbon losses from refinery operations, the Foundation commissioned Southwest Research Institute to make the necessary investigations. As of March, 1954 total hydrocarbon emission to the atmosphere in Los Angeles County was found to be 251 tons per day; this compares with the figure of 224 tons per day reported by the Western Oil and Gas Association. Similarly, olefin losses of amylenes and heavier were audited to be 16.4 tons per day, which compares with the 12.2 tons per day reported by the Association (Table I).

CHAPTER VI — TABLE I

COMPARED HYDROCARBON VAPOR LOSSES RESULTING FROM THE PRODUCTION, REFINING, AND BULK MARKETING OF PETROLEUM PRODUCTS IN LOS ANGELES COUNTY AS OF MARCH, 1954

Source of Hydrocarbon Loss	Olefin Loss Amylenes and Heavier tons/day	Total Hydrocarbon Loss tons/day
Production	0	28
Refining	11.3	179.3
Marketing	5.1	43.8
Total	16.4	251

For the purpose of this investigation the industry was divided into three functions: production, refining, and marketing. Field trips were made wherever possible and supporting data from the literature were used to round out the information gathered.

Production Losses

A total of 359,409 barrels per day are produced from over forty oil fields in the Los Angeles Basin. Production losses occur during field storage, including breathing and filling losses, casinghead gas, and such other losses as occur during separation of bottom sediment and water.

Refining Losses

In Los Angeles County there are ten major oil refineries representing 93.6% of the total of 748,770 barrels per day capacity, and eleven smaller refineries, representing the other 6.4%. Refinery losses consist of evaporation losses from gasoline and crude oil storage; from separators; from pump gland leakages; from vapor and liquid blowdown; losses from discharge gases in catalytic regeneration units; and miscellaneous losses resulting from leakages from valves and fittings, batch treating, sewer manholes, etc. In addition, there are losses due to fires and resulting non-normal operation, involving above average amounts of crude or gasoline in storage.

To obtain information on losses from storage, a detailed inventory was compiled describing the type of tank and the materials handled in all storage tanks at all refineries. The calculation methods used were those contained in a report by the American Petroleum Institute, published in November, 1952 and titled "Evaporation Loss of Petroleum from Storage Tanks."

Separator losses come mostly from uncovered separators, but there is some loss from covered ones through breathing and venting. Influent and effluent stream samples were specified and witnessed, and suitable analyses were performed.

Over 500 pumps, representing about 75% of the gasoline and lighter pump capacity of the refineries, were checked during this audit. The rate of pump leakage was determined either by actual timed measurements or visual observation.

Losses from vapor and liquid blowdown were checked by inspecting flares to see whether pilot burners were in operation. Also a check was made of units operating under vacuum and of blowdown facilities to handle emergency vapor discharges from relief valves.

The amount of hydrocarbons discharged from regeneration units of catalytic crackers was determined by mass spectrographic analyses of the flue gases.

Miscellaneous losses, such as leakage from valves and fittings, spills during blind changing, etc., were estimated by observation of actual losses during visits and discussions with operating personnel.

Marketing Losses

These include filling losses from tank cars, tank trucks, ships and barges, and filling and breathing losses from storage at bulk terminals and marine terminals. These losses were estimated according to correlations made by the American Petroleum Institute from reported vapor pressure, type and dimensions of tank, and volume throughput.

Olefin Losses

The percentage of olefins in the hydrocarbons going to the atmosphere was estimated by the Scientific Subcommittee of the Committee on Smoke and Fumes of the Western Oil and Gas Association on the basis of an average gasoline composition for 1953 for the Los Angeles area. The result is believed to be close to that obtainable from a compilation prepared from detailed hydrocarbon analyses of each individual source of olefin loss.

Status

Much effort has been made by the petroleum companies to reduce hydrocarbon vapor losses. The single largest item at present is the loss from gasoline stored in floating roof tanks, which are acceptable under Rule 56. The next largest item is the vapor loss from crude oil stored in cone roof tanks.

The refineries are installing mechanical seals on pumps, which will further reduce pump gland losses; separator losses are being reduced by further improvements in installations. Beyond this, the next significant improvement would result from the installation of expensive protection equipment, which would not be self-amortizing.

[3] In preparation as Report No. 5 of the Air Pollution Foundation.

VII. PHYSICAL MEASUREMENTS

INTRODUCTION

THE physical measurement program has three major objectives: (1) exploring of various techniques of detection, identification and concentration measurement of the various contaminants in smog based on the physical characteristics of these constituents; (2) obtaining physical descriptions of the reactions which take place in the atmosphere by suitable laboratory and field experiments correlated with appropriate theories; (3) determining the physical and chemical characteristics of the aerosols in smog.

As of the date of this report, only objective (1) has received attention, although literature surveys were conducted with the entire program in mind. Our review indicated the strong desirability of exploiting spectroscopic techniques to a much higher degree than had been attempted in the past on smog studies. These techniques cover not only those involving the ultraviolet into the far infrared absorption, i.e. 250 millimicrons to 15 microns, but also into the microwave region. In the microwave spectrum there are three possible methods of analysis.

(a) Absorption spectra

(b) Paramagnetic resonance spectra

(c) Nuclear magnetic resonance spectra

Mass spectrometry was also considered an important method to be explored further in this problem. Finally, modern electronics provides techniques for studying physical properties of aerosols. Physical methods of the above are considered appropriate not only because they potentially are capable of higher sensitivity and greater specificity, but by their nature they do not affect the chemistry of the constituent reactions, nor the constituents themselves, except possibly in the use of the mass spectrometer. Furthermore, they are more likely to lend themselves to direct measurements in smog.

OZONE

Background

According to the previous investigations of Dr. Haagen-Smit[1] for the Los Angeles County Air Pollution Control District, and Stanford Research Institute[1] for the Western Oil and Gas Association, ozone is one of the more important constituents of Los Angeles smog. It has been detected, identified, and its concentration measured by various techniques, namely:

(1) The release of iodine in a buffered potassium iodide solution. A continuous recording instrument based on this principle is discussed in Chapter V of this report;

(2) The oxidation of phenolphthalin ($C_{20}H_{16}O_4$) to phenolphthalein ($C_{20}H_{14}O_4$) and the measurement of color development using hydrogen peroxide H_2O_2 to develop a standard curve for the colorimeter;

(3) The cracking of bent or stretched rubber measuring either depth of crack or time of initial cracking to give ozone concentration;

(4) The absorption in the ultraviolet by spectroscopic means;

(5) The response of certain plants to ozone resulting in characteristic damage to upper leaf.

[1]see bibliography at end of chapter.

As a result of the use of these techniques, the status on the ozone identification and concentration in the summer of 1954 can be summarized as follows:

The potassium iodide and phenolphthalin methods gave different readings; when sampling the same atmosphere the latter method gave higher concentrations. Neither method is specific to ozone and both will respond to other "oxidants." Rubber cracking is not specific to ozone since free radicals give similar behavior and free radicals are possible constituents of smog. The spectroscopic evidence is based on eight readings in the atmosphere taken in July, 1952[2]. Of the eight, four agreed to about 10%, two agreed to about 30%, one agreed to 40%, and one to zero per cent when compared to the potassium iodide method where nighttime values were assumed to be 0 to 3 parts per hundred million. All of these values were for 16 pphm or less total oxidant. The difference between the average values by the two methods was 15%.

An additional bit of spectrographic evidence was obtained by Stanford Research Institute[3]. However, their method involved concentrating ozone on silica gel and desorbing into an optical cell with only 45% recovery.

The plants exposed to Los Angeles smog did not show characteristic ozone damage, although the oxidant values to which they were exposed, if they represented mainly ozone, should have caused it.

General Plan

With this background, the Foundation decided to obtain more definitive data on the presence and amount of ozone in the Los Angeles atmosphere. After reviewing the work of Regener, Stair, W. A. Baum, and O. R. Wulf[4], the Foundation decided to build an ozone spectrometer to be used directly on the atmosphere. This instrument is under contract with the Borman Engineering Company, North Hollywood, Calif.

The instrument will consist of a projector having a 6-inch aperture and using a type CH3 85-watt high pressure mercury lamp; the radiation will be pulsed at 90 cycles per second by a three-bladed shutter; it will have a prism radiometer with an exit collimator 5½ inches in diameter and 20 inches focal length. The prism is a Fresnel type assembly of four 60° fuzed quartz prism elements. The slit subtends 7½ millimicrons at 300 millimicrons. A synchronous motor will drive the wavelength and program cam. The radiation will be measured by means of a photo multiplier tube and is modified by transmission through two similar Corning glass filters.

Significant data for obtaining ozone concentration appear below:

Wavelength Millimicron	Relative Energy	Ozone Coeff.*
265	8.14	123
295	33.85	10
315	75.9	0.6

*Decadic absorption coefficient per cm. of ozone gas at STP (Standard Temperature and Pressure).

Initial experiments will be conducted at 675 ft. of optical path from projector to receiver. In order to establish energy at the source, auxiliary measurements will be made at about 60 ft. from the receiver and the projector aperture reduced by a diaphragm to simulate the long-range geometry. The attenuation of the diaphragm will be measured separately by means of an ultraviolet photoelectric photometer which evaluates energy at 365 millimicrons. Measurements of transmitted energy through smog will be repeated at 15-minute intervals, day and night.

Status

During this reporting period the manufacture and assembly of this instrument reached 75% completion. Also, the Foundation made a contract with the Ordnance Department of the U. S.

[2]see ref. (7) in bibliography.

[3]see ref. (11) in bibliography.

[4]see bibliography at end of chapter.

Army, Rock Island Arsenal, to provide them ozone data in exchange for the loan of equipment built for Ordnance by the Bureau of Standards (ref. 8).

Future Plans

It is planned to complete the instrument and give it an extensive field trial. It will then be put into service during the 1955 smog season and results will be compared with other measurements, particularly oxidant, as recorded by the potassium iodide and phenolphthalin methods.

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EXPLORATORY STUDIES

Solar Spectrometer Analysis of Smog

Background

Classically, astrophysicists have used spectrometry to detect and identify the gaseous constituents of the earth's atmosphere as well as solar and planetary atmospheres. Grating spectrometers, particularly, are capable of resolving the absorption lines of the various constituents, thereby identifying them. In recent years such compounds as methane and nitrous oxide have been found in the earth's atmosphere.

General Plan

The Foundation's approach to the use of this analytical technique consisted first of trying readily available prism spectrometers with the powerful light source, namely the sun, throughout the spectrum of available energy, 290 millimicrons in the ultraviolet to 15 microns in the infrared. It was necessary to do this in two parts because of equipment differences and availability. The first survey was conducted by Ralph Stair[5] on leave from the National Bureau of Standards. During the literature search and as a result of discussions with the Bureau, it was ascertained that they had available a Carl Zeiss double-prism or mirror monochromator mounted on a polar axis and capable of automatically following the sun for field measurements of solar radiant energy. Stair, who designed the equipment and had previously made spectral distribution studies of energy from the sun, was available to carry out a similar study in Pasadena. The equipment was set up on top (fourth floor) of the roof of the West Bridge Laboratory of Physics of the California Institute of Technology by October 1, 1954, and runs were made every day for about a month. Figs. 1 and 2 show the equipment in operation at Pasadena.

[5]see biblography at end of chapter.

The second survey was conducted by Professor D. M. Gates of the University of Denver. The equipment used for this purpose was a Perkin-Elmer model 12C spectrometer equipped with rocksalt and also with lithium fluoride optics. In addition, a heliostat was borrowed from the National Bureau of Standards to direct the sun's radiation on the slit of the spectrometer. A photograph of this equipment appears in Fig. 3. Observations of the solar spectrum were made in the infrared region, 2 to 15 microns, on all days during November, 1954 when the sun was not obscured by clouds. A number of measurements could be made each day, as only thirty minutes were required in order to scan from 2 to 15 microns.

Status

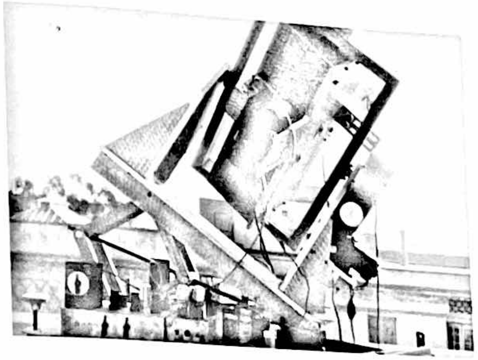
Reduction of the original data is in process and daily curves are being constructed for analyses at the National Bureau of Standards, at the University of Denver, and at the Foundation. The spectra will be compared with similar data obtained at Sacramento; Peak, New Mexico; Denver, Colorado, and possibly Washington, D. C. The following questions will be asked of the data from these experiments:

(1) Do any new absorption bands show up in the spectral region covered, namely 290 millimicrons to 15 microns, due to presence of gases or compounds in the lower atmosphere?

(2) Is there any evidence of the absorption of solar radiant energy which leads to photochemical reactions in the polluted atmosphere?

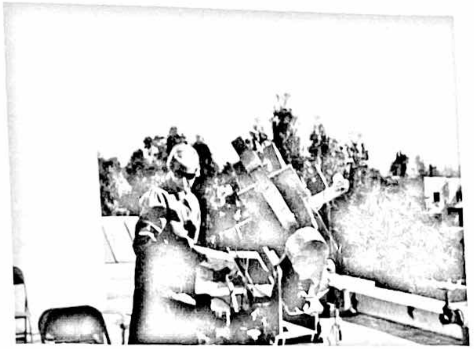
(3) What can be said about the attenuation in relation to aerosol scattering?

(4) What mechanisms, or the presence of what compounds or types of compounds, are necessary to explain the actual spectral data?



Chapter VII – Figs. 1 and 2

Solar radiometer at California Institute of Technology



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Carbon Isotopes in the Los Angeles Atmosphere[6]

Background

The earth's carbon cycle has attracted interest to many branches of science and a variety of techniques have been brought to bear on its study. These investigations involve photosynthesis and respiration by plants, the decay of organic matter, the preservation of carbon in the form of coal and oil, and the concentration of CO_2 in the atmosphere among other matters which are of well-recognized importance to our civilization. In recent years a new tool, the mass spectrometer, has been successfully adapted to the study of carbon in nature with significant and relevant results.

Understanding the significance of isotope measurements is due primarily to the early work of Urey and his colleagues[7], who showed that the thermodynamic properties of chemical compounds are dependent to a slight degree upon the isotopic composition of the atomic constituents. This leads to the expectation that processes involved in the carbon cycle fractionate the isotopes, so that carbon from different components of the cycle should be isotopically dissimilar.

About fifteen years ago Nier and his coworkers made the first precise measurements on the isotopic composition of carbon from a number of different natural sources. They found the C^{12}/C^{13} ratio in these materials varied by as much as 5%. For example, the C^{12}/C^{13} ratio of carbon in oil, coal, and terrestrial plants, although different, averaged approximately 92.5%, whereas the ratio in carbonates was about 89.2%. The C^{12}/C^{13} ratio in carbon from meteorites, certain graphites, and carbon dioxide of the atmosphere was of intermediate values[7].

Recently, interest in carbon isotope research has increased. Craig[7], using a modified Nier-type mass spectrometer with a precision $\pm 0.01\%$ of the C^{12}/C^{13} ratio, made a more complete survey on the variations of the isotopic composition of carbon in nature. He substantially verified and extended Nier's general finding, but in addition made an attempt to point out possible causes for C^{12}/C^{13} variations, including those found in a single chemical group. For example, he analyzed samples of wood from twenty-two modern trees grown in widely separated areas geographically and found a range in C^{12}/C^{13} ratio of 0.45% (over 20 times the experimental error). A similar range in ratio values was obtained from a series of tree rings in a single sequoia. Clearly, a better understanding of these variations with respect to the biology and ecology of tree growth and their possible correlation with variation in atmospheric CO_2 would be of utmost interest from a biological and climatological point of view. Craig's measurements of the C^{12}/C^{13} ratio of six samples of CO_2 in Chicago air showed a range of 0.25%. In this case the samples were collected within a week and could be markedly affected by the activity of surrounding steel mills and direction of wind.

Recent Work on Carbon Isotopes at California Institute of Technology

During the past year, the Division of Geological Sciences has pursued a limited study on the variation of the isotopic composition of carbon in nature. To date, principal investigations have been concerned with samples of wood. In collaboration with Professor Edmund Schulman of the University of Arizona, Tree Ring Laboratory, the C^{12}/C^{13} ratio has been determined for some 250 wood samples from two Douglas firs of the Mesa Verde region of Colorado and from a California sequoia. A mass spectrometer capable of a precision of better than .01% has been used in this work, and the results are summarized briefly below.

Upon dividing a single tree ring into 60 samples by means of a biological microtome, each sample representing about a week's growth, and analyzing the C^{12}/C^{13} ratio of each sample, a progressive and continuous change in the ratio with the growing season was found. The C^{12}/C^{13} ratio is highest in the first wood deposited in spring and tends to decrease progressively through the rest of the ring. The late wood has a C^{12}/C^{13} ratio about 0.1% less than the first grown wood. In addition, we have found that within a given year the carbon-isotope ratio changes slightly with the position around the circumference of the tree trunk. It is clear that several factors contribute to the variations in the isotopic composition of carbon in trees. Among these factors are probably the various aspects of ecological conditions under which the tree grew, including the isotopic composition of the carbon

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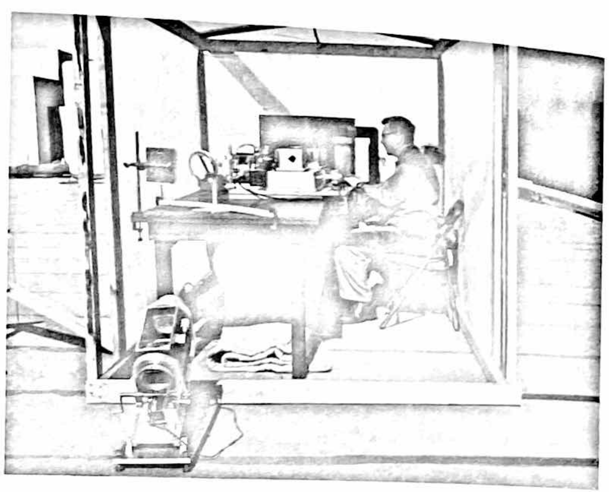
[6]by Samuel Epstein, Ph.D., Professor of Geochemistry, California Institute of Technology.

[7]see bibliography at end of chapter.



CHAPTER V – FIG. 3

D.M. Gates at the spectrometer

in the atmosphere. Investigations of these factors are feasible, and it is hoped that they will be pursued in the near future.

One of the more interesting results obtained is a consistent increase of the C^{12} content in recent years. Since 1840, the carbon-isotope ratio (C^{12}/C^{13}) has increased in the trees so far investigated. This can be explained on the basis of a change in carbon ratio in carbon dioxide atmosphere resulting from the burning of the C^{12}–enriched coal and petroleum. The possible consequences of a changing concentration of the CO_2 in the atmosphere with reference to climate, rates of photosynthesis, and rates of equilibration with carbonate of the oceans may ultimately prove of considerable significance to civilization.

General Plan

From the above it is clear that a thorough investigation of the distribution of the isotopes of carbon in the atmosphere is desirable and of particular importance in connection with isotope studies pertaining to marine and terrestrial photosynthesis, to studies of carbonates, and with respect to changes in the atmosphere. Comparison of atmospheric samples gathered over the ocean, over mountainous areas, and from industrial localities similar to the Los Angeles Basin is desirable. The relationship between the C^{12}/C^{13} ratio in atmospheric carbon dioxide and in the air pollutant, the effect of industrial activity, elevation, geographic location, and fluctuations in weather and air currents on these ratios, and the isotopic composition of petroleum and plant materials would be important to geochemistry and should be relevant to the smog problem of the Los Angeles Basin.

The major aspects of the investigation are (1) collection of suitable samples, (2) preparation and isotope analyses of the samples.

(1) Collection of Samples: for collection of samples existing agencies already engaged in sampling the air for the pollution research program will be used. In addition, apparatus will have to be prepared for use in locations not dealt with by agencies already in existence.

(2) Preparation of Samples: this would be done entirely at California Institute of Technology by means of existing facilities and additional ones to be built.

Facilities

The operating equipment and materials necessary for this research are listed below:

(1) A mass spectrometer which is now functioning satisfactorily and can detect changes of 0.01 per cent in the C^{12}/C^{13} ratio. The analyses can be done by a technician in a routine manner. The use of this instrument is contingent upon the official approval of the AEC which provided the funds for its construction. Such approval is expected with considerable certainty.

(2) At least two high vacuum lines, one for the combustion of the carbon samples to carbon dioxide, the gas used in the mass spectrometer, and the other for separation of carbon dioxide from the air samples. The technique for these procedures is known and has in part been used in our previous work.

(3) Chemicals, glassware, liquid nitrogen, and dry ice constitute the principal expendable items used for this work.

(4) In addition, equipped chemical and instrumental laboratories are available at the Institute.

Status

A research grant was made to the California Institute of Technology, Department of Geological Sciences, by the Air Pollution Foundation on December 1, 1954. Training of a laboratory assistant and recruitment of a post-doctoral fellow were involved in getting started; permission for the use of the currently operating mass spectrometer was obtained from the Atomic Energy Commission.

Future Plans

It is planned to obtain samples of CO_2 as well as other carbon-bearing compounds and analyze them in the mass spectrometer. By the analysis of about one thousand samples definite information might be obtained on the feasibility of the

following applications for this technique:

(1) A method for determining the sources of the carbonaceous material in samples of the atmosphere.

(2) A method for tracing the flow of air masses over the Basin using CO_2 as the tracer gas.

(3) A method for arriving at an index of pollution by studying the change in isotopic composition of CO_2.

(4) A method for studying mixing rates of gaseous pollutants in the atmosphere by measuring the isotopic composition of CO_2 throughout the mixing volume and as a function of time.

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Nuclear Magnetic Resonance (n-m-r) Spectrometer

Background

Nuclear magnetic resonance spectroscopy is based on the fact that the various nuclei of the elements can be separately identified according to their differing nuclear gyromagnetic constants. Just as there is a certain mass and electric charge associated with each nucleus, so there is a spin, or angular momentum, associated with each nucleus. It has been found that all those nuclei whose spins do not have the value zero also possess a magnetic moment—that is, each behaves as though it were a tiny magnet with a well-defined, unique magnetic strength. The ratio of the magnetic moment value to the spin value, which is a constant for a given atomic nucleus, is called the gyromagnetic ratio for that particular nucleus. The fact that these ratios differ from isotope to isotope permits separation and identification according to the scheme of n-m-r spectroscopy.

It has been demonstrated that a special version of this new kind of spectroscopy, "High Resolution," represents a penetrating new method for determining molecular structure and identifying and measuring components in a mixture.

The method is completely nondestructive. Radio frequency energy of a particular frequency is applied to the sample, and the atomic nuclei in that sample respond with a signal of their own. It has been shown that the character of the responding signal can be profoundly affected by the chemical environment in which the atomic nuclei producing the signal find themselves. In this way valuable information concerning that chemical environment can be obtained without disturbing the molecular structure in any way.

General Plan

The first application of this technique was made on a freeze-out sample of the Los Angeles atmosphere as follows:

Date of sampling: November 24, 1954.

Location: downtown Los Angeles, Hall of Records, fourth floor.

Amount of air sampled: 28,000 liters.

Approximate volume of condensate in capillary tube: 0.030 ml.

Duplicate sets of ten Shepherd traps, immersed in liquid oxygen, were connected in parallel to a common manifold air intake and a manifold outlet. The outlet connections on the manifold were made with Tycon tubing to 5/12 socket joints which could be connected first to the traps. The outlet manifold was connected first to a dry test meter and then to a rotary vacuum pump. A bleeding device between the pump and the meter served to regulate the rate of flow.

At the end of the sampling period, all traps were evacuated to 50 mm. while still at liquid oxygen temperature and returned to the laboratory.

The capillary sample cell, submitted by Varian Associates, was sealed to the bottom of a Shepherd trap. This trap was then immersed in liquid oxygen. The outlet was connected to a regular trap also immersed in liquid oxygen. The purpose of this second trap was to collect vapors which might not be condensed in the trap with the capillary.

Each of the twenty traps was then connected over an ascarite bridge to the inlet connection of the capillary trap. While flushing nitrogen gas through the complete assembly, the trap was warmed up to 80°C to insure complete evaporation.

Five liters of nitrogen were used on each trap over a period of ten minutes. After the contents of all twenty traps were transferred, the trap at the outlet connection was removed from the liquid oxygen and its content was also transferred to the capillary trap in the same manner.

The capillary trap was then evacuated to 50 mm., while still immersed in the liquid oxygen, and the stopcocks closed off. The trap was removed from the liquid oxygen and slowly brought back to room temperature. At this stage, no liquid was down in the capillary tube; however, a few droplets were hanging on the inside wall of the Shepherd trap. To condense the vapors into the capillary, the trap was warmed while the capillary itself was cooled with a dry ice bath. This procedure was repeated several times until no more liquid condensed out.

While still immersed in the dry ice, the capillary was then sealed off about one centimeter below the trap and removed. This sample was then mailed to Varian Associates, Palo Alto, California.

Status

Varian Associates analyses of the above sample were as follows:

Fig. 4 is the record of the spectrum as obtained from the high resolution n-m-r spectrometer.

The present interpretation of the various regions in the spectrum follows (Fig. 5).

Region (1)—Protons on aromatic rings.
Region (2)—Protons in olefinic parts of hydrocarbon—actually attached to doubly bonded carbon atom.
Region (3)—Protons on first carbon atom in side chains attached to aromatic rings.
Region (4)—Cyclo paraffins.
Region (5)—CH_2 groups in saturated hydrocarbons.
Region (6)—CH_3 groups in saturated hydrocarbons.

Fig. 6, made up from known compounds, verifies some of these assignments. All of these groups appear to be present in gasolines, although in different blends, except the cyclo paraffin peak, which may be present in a small enough quantity to be masked by the large CH_2 and CH_3 background from the saturated hydrocarbons.

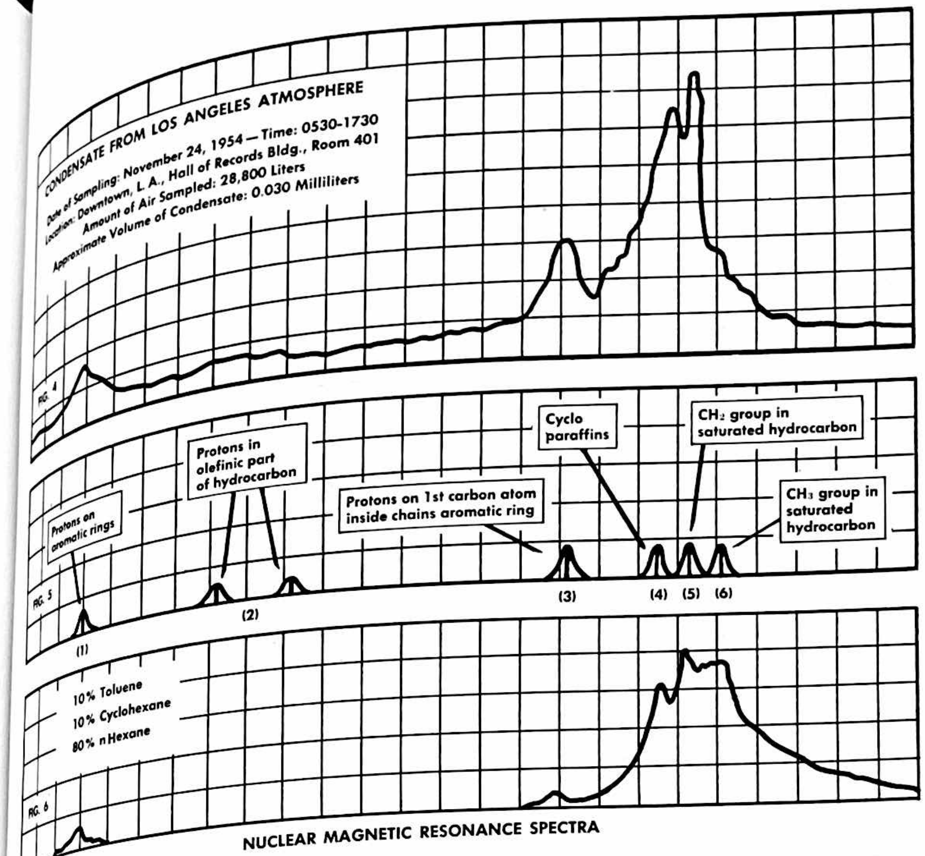
The condensate appears to contain the major chemically identifiable groups in proportions which probably approximate the average of most of the major gasoline blends sold in the area. It might be an interesting experiment to make up such a blend with liquid gasolines and compare spectra again.

It certainly seems that the percentage of unsaturated hydrocarbons in the condensate represents a very small fraction of the total hydrocarbon in the atmosphere, assuming that the unsaturates get through the ascarite drying agent.

We believe that the n-m-r determination represents a strong piece of evidence verifying the suspected existence of unmodified, unburned gasoline in the Los Angeles atmosphere.

Future Plans

It is planned to collect samples during the next smog season (1955) under different conditions, i.e. night time sample vs. day (irradiated)



NUCLEAR MAGNETIC RESONANCE SPECTRA

sample; eye irritation vs. no eye irritation, etc., and subject them to n-m-r analyses in order to identify the hydrocarbon components responsible for manifestations of smog, if any. It may be interesting to see if this technique is useful in analyzing hydrocarbons from auto exhaust. Ideally, of course, it would be preferable to analyze the gaseous smog directly by this method in order to get indications of the various hydrogen-bearing intermediate reaction and oxidation products.

Paramagnetic Resonance Spectrometer

Background[8]

A few gaseous substances, the most familiar of which are O_2, NO, NO_2, Cl_2O, and F_2O, have unpaired electrons in the ground state and hence have large magnetic moments as compared with

[8] Gordy, W., Smith, W. V., Trambarulo, W. F., *Microwave Spectroscopy*, John Wiley & Sons, Inc., N.Y. (1954).

those of most molecules which have a $^1\Sigma$ ground state. These paramagnetic gases have large Zeeman effects; also, when there is a nucleus with $I \neq 0$, they have large magnetic hyperfine structures.

One of the simplest ways to study paramagnetic gases in the microwave region is to observe transitions between Zeeman components of a given rotational state. This type of observation is analogous to paramagnetic resonance and nuclear magnetic resonance commonly observed in solids. A field of only a few kilogauss is required to bring the resonance frequency of a free-electron spin into the microwave region. One can conveniently leave the microwave oscillator frequency fixed and "sweep" the absorption line to the desired frequency of observation by varying the magnetic field. Hyperfine structure and other effects can be studied as perturbations of the "Zeeman lines." The strong fields, which must be employed, break down weak magnetic couplings so that the simple theory of the Paschen-Back effect is often adequate for interpretation of the perturbations. Nevertheless, the resulting spectrum is frequently complex because of the large number of interactions usually present.

So far, the study of paramagnetic resonance spectra of gases has been concentrated at Yale, with the experimental side developed by Beringer and Castle[9], and the theoretical aspects treated by Margenau and Henry. Three of the more common paramagnetic gases, O_2, NO, and NO_2, have been investigated. Although there are only a few more substances of this type to be studied, the possible application of the experimental method and the theory to gaseous free radicals or ions makes the subject potentially of wide interest.

Status

An attempt will be made to detect and subsequently identify free radicals formed in an irradiated mixture of hydrocarbon and air. Stanford Research Institute at Palo Alto will provide the chemistry of the experiment and Varian Associates will analyze the gas mixture for the presence of free radicals.

A paramagnetic resonance spectrograph along the lines of the general principle described[9] has been assembled at Varian. Preliminary runs using strongly paramagnetic gas NO_2 will be run to test out the apparatus and procedure. When successful, the free radical experiments will be run.

Future Plans

It is planned to give some attention to the feasibility of developing an instrument for measuring NO_2 and NO concentrations in air mixtures using a paramagnetic resonance spectrometer.

Long Path Infrared Absorption Cell

This study applied a Perkin-Elmer infrared spectrometer with a 10-meter multiple reflection cell, capable of being pressurized to 10 atmospheres, to direct studies on the atmosphere to determine unusual components for the concentrations of known components. This procedure may offer advantages in the identification and determination of gaseous components as compared with trapping procedures.

The first phase of this project required the selection and modification of a suitable air compressor which could introduce a minimum contamination into the sample. The unit selected was a three-stage Cornelius compressor which was modified to operation at 1/10 its designed speed and was lubricated with silicone oil instead of hydrocarbon oil. When a silicone is used for lubrication, it is preferable that either or both surfaces be of nonferrous material. Accordingly, brass liners were introduced in the cylinders, and the cylinders rebored and repolished to take these liners. This compressor is now operating satisfactorily.

The second phase of this project will be the development of a means for removal of excess carbon dioxide and water from atmospheric samples with the least amount of change in the original composition of the sample. This phase of the project is now in progress.

[9]Beringer and Castle, *Phys., Rev., 78*, 581 (1950).

COLLABORATIVE STUDIES

Microwave Absorption Spectroscopy[10]

Background

The normal atmosphere is transparent to radio waves from the longest waves of about 15,000 meters down to waves approximately 3 cm. in length (corresponding to a frequency of 10,000 megacycles). Nitrogen, hydrogen, and carbon dioxide do not absorb any radio frequency waves. However, if one goes to shorter wave lengths (higher frequencies) the atmosphere becomes highly absorbing, water vapor absorbing at 1.37 cm. (22,235 mc.) and oxygen absorbing at 6 mm. (50,000 mc.). Radar equipment works successfully for long-range purposes at 3.2 cm. (9400 mc.), while components exist for work at 8 mm. (38,000 mc.). At this latter wave length, transmission is accomplished between the water vapor and oxygen absorption bands. In addition, more than 100 gases such as formaldehyde, the alcohols, sulfur dioxide, and others absorb microwaves, particularly in the wave length region below 1.0 cm. Microwave propagation, as contrasted to propagation of visible light, is not greatly affected by particles in the atmosphere such as smoke or haze.

During World War II, radar equipment developed at 1.25 cm. was found to be useless owing to the short range of the waves in an atmosphere with high water vapor content. In an atmosphere of pure water vapor, the signal strength would drop to half its initial value in one mile of travel, and the absorption in moist gases is proportional to the partial pressure of the water. Thus, signal strength at 1.25 cm. falls to one-half the initial value after 100 miles of travel when one per cent of the atmosphere is water vapor by volume.

General Plan

In the microwave spectroscope, the gas under study is confined in a section of wave guide or in a resonant cavity at reduced pressure, and microwave power is passed through the gas sample to determine its propagation characteristics. Tools used are klystrons, crystal detectors, cavities, etc. The gases of interest in a smog study would be studied in the microwave spectroscope. Resolution in the spectroscope is better than in the optical region by a factor of 10,000. Ozone, the aldehydes, and oxides of nitrogen may be of particular interest in the present study. Whether it would be desirable to irradiate a sample of gas with ultraviolet light is open to question, but the method of handling a sample would permit such techniques to be employed, if field studies indicate that the incidence of sunlight on gases in the inversion layer has a measurable effect on microwave propagation through the layer. In this portion of the study samples would be collected from the atmosphere when smog occurs and the microwave spectroscope would be used in analysis.

The value of microwaves in a field study of smog arises in part from the fact that by their use a large area may be surveyed for gases, particularly those not visible to the eye in the presence of smoke or other particles. In the preliminary study of the instrumentation it is proposed that a long-distance transmission path be set up in Los Angeles in sunlight and the usual weather conditions. A transmitter working at two wave lengths, say 1.25 cm. and 8 mm., could, for example, be set up on the roof area at City Hall and a narrow beam or pencil of radiation transmitted to receivers located at UCLA, where automatic records of the received signal strength at both operating frequencies would be obtained. Only one absorption line occurs for water, that at 22,235 mc., while 30 lines have been observed for methyl alcohol and 8 lines for formaldehyde, scattered over the band. Multiple line absorption is common, and single lines are exceptions. The differential absorption at the two wave lengths is the criterion to be used in studying

[10]by W. D. Hershberger, Department of Engineering, University of California at Los Angeles.

smog. Water vapor mainly determines absorption at 1.25 cm., the wave length to be used as a monitor, and the other gases are mainly responsible for absorption at 6 mm. or 8 mm. A beam width of 3° is reasonable and beam formation will be accomplished by a parabolic reflector or horn, such as is used in radar. One aspect of the proposed study is the development of the instrumentation needed for study of smog *along a single path*, as for example, between City Hall and UCLA. The problem requiring an experimental solution is the one that arises because the water vapor content of the atmosphere is variable and because the magnitude of absorption by contaminants peculiar to the Los Angeles area is not known.

If the results under the above are sufficiently precise and revealing, it would be possible in a future program to employ a receiver with a slowly rotating microwave antenna at City Hall; a complete rotation could be made once every twenty minutes or so. Transmitters now could be placed at outlying points so that City Hall would be visible from the outlying stations. Such stations could be located at UCLA, International Airport, Palos Verdes, Long Beach, Burbank, Pasadena, San Gabriel, etc., and information would become available as to absorption along each of the named paths. Automatic records of atmospheric absorption would be kept for each path and, from records obtained after a clearing rain or wind, one could evaluate smog sources as regards to their location and importance. Heavy industrial areas and oil refineries have been blamed as well as exhaust gases from automobiles. The purpose of the study would be to localize the sources of smog, if local sources are responsible. If local sources are not responsible, this fact needs to be known. The merit of this method is that it would permit the rapid collection of data simultaneously over an extended area during the critical time when smog is in the process of formation. Once smog is present in large quantities over the whole area, general observations probably would not be particularly revealing.

One could refine the method to determine direction of arrival of the microwave beam and thus the height of the inversion layer responsible for trapping the gases known as smog. This is accomplished by "nodding" as well as rotating the parabolic reflectors or horns which are used to focus microwave beams. Also, in the Los Angeles area, transmissions may be effected through the inversion layer itself by placement of a transmitter on Mount Wilson to make direction-of-arrival studies.

Status

The University of California at Los Angeles has initiated support of this research under the general supervision of Dean L. M. K. Boelter and the technical direction of the writer. Equipment is being purchased and assembled for the gas absorption spectrometer.

Future Plans

The Foundation will work closely with this investigation and maintain itself in a position to take advantage of the results obtained.

VIII. DISPOSAL OF REFUSE

CONFERENCE ON INCINERATION, REFUSE DISPOSAL, AND AIR POLLUTION

ON December 2 and 3, 1954, a Conference on Incineration, Rubbish Disposal, and Air Pollution[1] was held for the purpose of orienting all interested parties as to available information on incinerator emissions, types of equipment currently available and their merits, methods of "cut and fill," composting, and any other disposal means, complete with cost data. Participants of the Conference included sanitation engineers, government administrators in the field of sewage and sanitation on the municipal, state and federal levels, academic personnel, and various other specialists in the field of air pollution control.

These engineers, scientists, and administrators agreed upon specific recommendations and conclusions, which were adopted as representing the soundest advice that could be offered to Los Angeles communities:

RECOMMENDATIONS AND CONCLUSIONS

1. The combustion of rubbish in household and backyard incinerators has the twofold detrimental effect of distillation of a large proportion of the material, and the production and discharge to the air of particulate materials capable of forming extensive and persistent aerosols which aggravate air pollution. Household and back-yard-type incinerators and open rubbish fires should be recognized as unsatisfactory solutions of the community refuse disposal problem in the Los Angeles metropolitan area.

2. Combustion of rubbish in the municipal or industrial incinerator, which leads to the discharge into the atmosphere of an unsatisfactory stack effluent, is indefensible.

3. Since the sanitary landfill method of refuse disposal has been shown to be economical and acceptable from the standpoint of public health, and since it creates no air pollution problems, this method should be given immediate consideration for the disposal of rubbish in the Los Angeles metropolitan area.

4. In the economic appraisal of the proposed solutions to the community refuse disposal problems, assuming there is some profit to be gained, the criterion of appraisal should be the least net cost of the total operation, particularly where some means of conservation is involved such as land reclamation by sanitary landfill, garbage feeding to hogs, composting, or transportation and treatment of garbage with sewage in a water-carriage system.

5. Engineering studies should be instituted immediately to determine not just the most economical but the most satisfactory pattern of storage, collection, transportation, and disposal of solid refuse, with particular reference to air pollution.

6. By the application of these measures, the total interests of the citizens in this area will be served and a great step will be taken with respect to the air pollution aspects of community waste disposal problems.

[1]The Proceedings of this Conference are published as Report No. 3 of the Air Pollution Foundation.

APPENDIX

REPORTS ISSUED IN 1954

Report No. 1, Neiburger, M. and Edinger, J. G., "Meteorology of the Los Angeles Basin," April, 1954

"*Proceedings* of the Conference on Vehicle Combustion Products and Other Emissions," August, 1954 (Note: This report was distributed to conferees only.)

Report No. 2, Faith, W. L., "Combustion and Smog," September, 1954

President's Report, Hitchcock, L. B., Address given before Annual Meeting of Air Pollution Foundation, Hotel Ambassador, November 16, 1954

Report No. 3, "Proceedings of the Conference on Incineration, Rubbish Disposal, and Air Pollution," December, 1954

REPORTS SCHEDULED FOR PUBLICATION IN 1955

Report No. 5, Hydrocarbon Losses from the Petroleum Industry in Los Angeles County

Report No. 6, Statistical Data of the Los Angeles Basin

Report No. 7, Air Tracer Surveys

Report No. 8, Visibility Study

Report No. 9, Aerometric Survey, 1954

TECHNICAL CONFERENCES HELD IN 1954

SUBJECT	LOCATION	DATE
Reactions of Hydrocarbons and Other Organic Compounds in the Los Angeles Atmosphere	California Club	February 26 and March 5
Rubber Cracking, Ozone Formation and Detection	Foundation Office	May 13-14
Meteorology of the Los Angeles Basin	Foundation Office	May 17
	University of California, Los Angeles	May 18
Vehicle Combustion Products and Other Emissions	The Huntington-Sheraton Hotel	August 19-20-21
Incineration, Rubbish Disposal, and Air Pollution	The Huntington-Sheraton Hotel	December 2-3

PRINCIPAL LECTURES BY FOUNDATION STAFF 1954

DATE	STAFF MEMBER	LOCATION	SUBJECT
4/13	Hitchcock	Los Angeles County Council of Real Estate Boards	"The Foundation's Program Against Smog"
5/12	Hitchcock	APF Luncheon at Ambassador Hotel	"President's Report—First Progress Report Review"
6/15	Rogers	Property Owners Division of Pasadena Realty Board	"The New Air Pollution Foundation—Who, Why, and How"
6/23	Hitchcock	Los Angeles Breakfast Club, Radio KPOL	"Free As Air?"
6/27	Hitchcock	KNBH—NBC (TV)	"Get the Facts" (L. A. EXAMINER) with Mr. Fred Ortman as panel guest
7/2	Faith	San Bernardino County Air Pollution Study Committee	
7/14	Hitchcock	Rotary Club, Pasadena	"Scientific Approach to Direct Action"
7/30	Hitchcock	KFI Radio Station	"Town Hall of the Air" W. B. Miller, Moderator; with A. M. Zarem and Gordon Larson
8/17	Hitchcock	American Institute of Chemical Engineers	"Scientific Approach to Direct Action"
8/25	Leiper[2]	Rotary Club, Culver City	
9/23	Hitchcock	Western Governmental Research Association, 14th Annual Conference, Claremont Hotel, Berkeley	"The Scientific Approach to Control of Urban Air Pollution"[1]
10/13	Faith	American Society of Civil Engineers, Southern California Section	"Atmospheric Waste Pollution"
10/14	Faith	American Society of Civil Engineers, Riverside-San Bernardino Branch	"Atmospheric Waste Pollution"
11/1	Hitchcock	University of California, Riverside, Synapsis Club	"Air Pollution Research Challenges the Scientist"
11/4	Leiper	Sigma Delta Chi Forum, Roger Young Auditorium	
11/16	Hitchcock	APF Annual Meeting, Hotel Ambassador	"President's Report"[1]
12/7	Renzetti	Scientific Research Society of America, China Lake Chapter	"Some Technical Aspects of Air Pollution"
12/30	Hitchcock	American Association for the Advancement of Science, Symposium on Air Pollution, Berkeley, California	"Definition of Air Pollution Today in American Cities"
12/30	Faith	American Association for the Advancement of Science, Symposium on Air Pollution, Berkeley, California	"Vehicle Combustion Products and Possible Remedies"[1]

[1]Reprints available.
[2]Public Information Officer, Air Pollution Foundation

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