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ABSTRACT

Research projects sponsored by the Coordinating Research Council, Air Pollution Research Advisory Committee, and dealing with vehicle emissions and their wide ranging effects on the environment are compiled in this status report. Spanning the range of problems associated with reducing emissions, they are divided into three main areas of research: (1) engineering projects that explore the interaction between the petroleum products and the automotive equipment in which they are used, (2) atmospheric projects that investigate pollutant behavior in the atmosphere, and (3) medical projects that study the effects of emissions on health. As a result of these projects, increased data are available which will be useful in the planning and development of effective emission control technology and provide assistance to government agencies in the promulgation of realistic air quality criteria and emission control requirements. Presented in the review are both a resume and a detailed account of 41 projects currently underway, enumerating project name and number, objectives, and current status. In addition, the Coordinating Research Council and its air pollution research program are described, together with membership lists, a progress chart of projects for 1971, and an anticipated schedule of progress during 1972. (BL)

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CRC
APRAC

STATUS REPORT

JANUARY 1972

AIR POLLUTION RESEARCH ADVISORY COMMITTEE
OF THE
COORDINATING RESEARCH COUNCIL, INC.

CRC
APRAC
STATUS REPORT

JANUARY 1972

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New York, N. Y. 10020

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Introduction

CRC-APRAC STATUS REPORT–JANUARY 1972

The Coordinating Research Council air pollution research program is in its fourth year of developing urgently needed data on vehicle emissions and their wide ranging effects on the environment. The program, jointly conducted by the automotive and petroleum industries and the Federal Government through its Environmental Protection Agency, has produced more than 40 major research reports to date, with 20 more scheduled for release this year.

The information contained in these reports is essential for both intelligent planning and development of effective emission control technology. As a result of the program, more is being learned about pollutant behavior in the atmosphere and the effects of specific pollutants on humans. Automotive and petroleum engineers are receiving valid data which they can rely on in their efforts to further reduce emissions through innovative engineering design and improved fuels. And lastly, Government receives information that may assist in the promulgation of realistic air quality criteria and emission control requirements.

The thirty-one research projects currently underway are being conducted under the guidance of the CRC at various universities, independent research organizations and industry and Government laboratories. These projects span the range of problems associated with reducing emissions and are divided into three main areas of research.

- Engineering projects that explore the interaction between the petroleum products and the automotive equipment in which they are used.
- Atmospheric projects that investigate pollutant behavior in the atmosphere.
- Medical projects that study the effects of emissions on health.

More than 300 experts from industry and Government are actively involved in these investigations as members of project groups responsible for the technical conduct of individual studies. Cross-breeding of professional disciplines within each project group is assured by organizing these groups to include experts from all fields of science, engineering and medicine.

Studies are planned in three year increments. The first three year phase, which is now completed, involved the expenditure of approximately $12 million over the period from 1968 through 1970. The second phase, now underway, involves the expenditure of an additional $10 million. Eighteen of the studies that were started as early as 1968 have been extended into the second phase so that new technical aspects uncovered during the initial years of research can be investigated further. The nine new projects initiated in this phase demonstrate the effectiveness of procedures established to review on-going projects and identify areas requiring further research.

As each study is completed, a formal report is prepared for distribution throughout industry and Government circles. CRC research findings also appear in numerous scientific journals and in May 1971 they were publicly reported at a CRC sponsored symposium on automotive air pollution research.

The success of this joint industry-Government program provides solid evidence that the CRC has established an effective mechanism for responding to the increasing need for data on atmospheric pollution. Accurate, objective information is the product of this research effort

and industry and Government benefit equally by its development. Even greater long-term benefits will be realized by the general public as individual companies apply the data to solving hardware or fuel problems, and as Government applies it to setting standards that are to affect the way each of us conducts his life.

Environmental improvements to meet public health and welfare needs should be accomplished without imposing unnecessary burdens on the economy. A sound scientific data base is required to fulfill this goal, and the CRC program is a proven means for providing such information. It is fully expected that this cooperative program will continue contributing to the evolvement of a balanced position that recognizes society's needs.

Resume of Engineering, Atmospheric, Medical Projects
and
In-House Programs

RESUME OF ENGINEERING PROJECTS

Fourteen engineering projects are underway within the APRAC program. Four of these projects are nearing completion.

Effects of Gasoline Additives (CAPE-2-68)

Three groups of 16 cars each were operated by Scott Research Laboratories on three test fuels; a base fuel and, using the same base fuel, a fuel modified with a detergent additive and a fuel modified with a dispersant additive. The testing was terminated when each vehicle had accumulated 12,000 miles.

Analysis of the data shows that vehicles operated on fuels containing the gasoline additives had lower carbon monoxide emissions than those operated on the nonadditive fuel. The higher CO emissions for vehicles operated on the nonadditive fuel were attributed to carburetor throttle body deposits. There appeared to be no differences in the deposit levels of the PCV valves between the vehicles using the three different fuels. There was a statistically significant effect of mileage interval on seven-mode hydrocarbons and steady-state hydrocarbons.

The final report will be available in February or March 1972.

Use of Leaded Fuels (CAPE-3-68)

Using available data from 18 participating organizations a study panel has prepared a report on "The Effects of Leaded and Unleaded Gasolines on Exhaust Emissions Caused by Combustion Chamber Deposits." Based on this review, it was concluded that cars operated on leaded gasolines have higher equilibrium hydrocarbon emissions than those operated on unleaded gasolines; however, no effect was noted for either carbon monoxide or oxides of nitrogen. The project was concluded with the issuance of a comprehensive report.

Fuel Volatility (CAPE-4-68)

The influence of fuel volatility on exhaust emission, evaporation losses, and vehicle driveability were studied. The U.S. Bureau of Mines conducted emission measurements and the Ethyl Corporation conducted driveability tests on twelve late model cars using a variety of test gasolines with varying volatility. The cars were tested for both cold and warmed-up driveability. Ambient temperatures were varied from 20° to 95°F. All testing was conducted on climate-controlled chassis dynamometers using test cycles simulating typical urban driving. Final reports covering the driveability and emission test results are in preparation, and publication is anticipated in early 1972.

Gasoline Composition and Polynuclear Aromatics in Exhaust (CAPE-6-68)

The purpose of this project is to determine the influence of fuel composition on the emission rates of polynuclear aromatics (PNA) and phenols in vehicle exhaust. Three standard production model automobiles and two automobiles with experimental advanced emission control systems have been used by Esso Research and Engineering Co. in this program. All measurements were made on the California seven-mode cycle with 2/1 hot/cold weighting.

Phenol emission was determined to be directly proportional to the aromatic content of the gasoline, and about 1,000 times the benzo(a)pyrene (BaP) emission. Engine modifications to reduce carbon monoxide and hydrocarbon emissions were also found to reduce PNA emissions. The 1968 engine modification car emitted about 70% less than the 1966 uncontrolled car; the 1970 engine modification car emitted about 80% less than the 1966 car. The PNA emissions from the two cars equipped with experimental low-emission systems (thermal and catalytic) were about 99% less than from the 1966 uncontrolled car. PNA emissions were found to be very sensitive to air/fuel ratio. For example, using carbon monoxide concentration over a narrow range as a measure of air/fuel ratio, a 45% change of BaP emission was associated with an 0.5% change of carbon monoxide emission.

An annual report covering the past year's research is in preparation. It is anticipated that the report will be published in mid-1972.

Exhaust Odor (CAPE-7-68)

Diesel exhaust odor has been characterized by Arthur D. Little, Inc. as consisting about equally of oily-kerosene and smoky-burnt odor fractions. The chemical classes associated with the oily-kerosene odor complex were previously determined to consist of alkyl benzenes, indans/tetraline, and indenes.

During this past year, the details of the methodology required for identification of the smoky-burnt odor fraction were completed. The most significant contributors to the smoky-burnt fraction have been identified as those species associated with the partial oxidation products of compounds found in the aromatic fraction of the diesel fuel.

The program is now emphasizing the development of a quantitative analytical methodology for characterizing diesel exhaust odor. A third year annual report was published in November 1971.

Combustion Processes within Engine Exhaust Systems (CAPE-8-68)

The University of Michigan has been successful in developing a thermal reactor simulation and parameter evaluation model. The goal has been to divorce their modeling approach from any specific reactor geometry and thus provide a general design basis which is widely applicable. Given the engine exhaust parameters, it is possible to predict the performance of a given reactor. It appears that the prime design variable is the extent of mixing.

The investigation has also obtained emission data from Du Pont reactors mounted on a Chevrolet 350 CID V-8 engine. An in depth study of the overall kinetics of oxidation of CO, hydrocarbon, and hydrogen in a well stirred reactor, mounted on the exhaust system of a single cylinder engine has been successful. Rate expressions for hydrogen, hydrocarbon, and carbon monoxide, for use in the simulation model, have been obtained by regression analysis of the reactor data. Completion of the project is planned for this year with the issuance of a final report in the fall of 1972.

Automotive Fueling Emissions (CAPE-9-68)

Scott Research Laboratories has completed the second year of study and an annual report will be published in early 1972. A model for estimating displaced hydrocarbon losses during fueling of passenger cars was developed as a function of average dispensed fuel temperature

and Reid Vapor Pressure. The five city, four season field survey in conjunction with controlled laboratory experiments indicated that displaced vapor losses accounted for over 94% of the total hydrocarbon losses during fueling operations. Spill losses accounted for the remaining 6% of the total.

Driving Patterns (CAPE-10-68)

Scott Research Laboratories has completed the vehicle operations survey on road routes representative of vehicle use pattern data developed by the System Development Corporation. The vehicle operations tests using instrumented cars as chase cars were conducted in Los Angeles, Houston, Cincinnati, Chicago, and New York City. All data acquisition and computer processing of the data have been completed. It is anticipated that the final reports will be published in early 1972.

Instrumentation for NO_x and Oxygenates in Exhaust Gas (CAPE-11-68)

Scientific Research Instruments Corporation has been able to simultaneously measure the nine most prevalent aldehydes and ketones present in auto exhaust. Work is now in progress to establish the sensitivity and accuracy under practical operating conditions. A report detailing the past year's work has been prepared and will be published in the first quarter of 1972.

Using a 1970 automobile on a chassis dynamometer, the Bureau of Mines has obtained quantitative exhaust oxygenate data from twenty two fuels (seven single-component and 15 multi-component). Thirty-four different oxygenates have been identified using techniques developed by the Bureau. An annual report will be published early in 1972.

Methods for Analysis of Particulates and Polynuclear Aromatics (CAPE-12-68)

Esso Research and Engineering Company has developed an improved method for determining benzo(a)pyrene (BaP), benzo(a)anthracene (BaA), and nine additional polynuclear aromatic hydrocarbons. The new method costs only one-third as much as that previously used, and accuracy is as good, in some cases better. In addition, methodology to determine the total PNA content of auto exhaust tar was developed. A third major accomplishment was the development of a quantitative method to determine individual phenols in the aqueous condensates produced along with exhaust tar.

Inspection, Maintenance, Surveillance and Economic Effectiveness Studies (CAPE-13-68)

TRW Systems and its subcontractor, Scott Research Laboratories, have completed an economic effectiveness model that estimates exhaust emission reductions, based upon measurements using the open, seven-mode cycle, for emission controlled vehicles for model years 1968 through 1970. Results have been published in three volumes—Volume I—Executive Summary, Volume II—Modeling of Inspection/Maintenance Systems and Volume III—Inspection and Maintenance Procedures.

An extended program was started in March 1971. Work on improving the capability of the economic effectiveness model to take into account recently developed test techniques has been completed. The maintenance state of in-use vehicles was diagnosed to determine more

accurately the frequency and extent of engine and control device malfunctions and their associated emission signatures (HC, CO and NO exhaust emissions measured in selected vehicle operating modes and cycles) for vehicles in several regional populations.

Statistically designed tests were conducted on basic power trains to determine the effects of engine malfunction and maladjustment upon exhaust emissions for precontrolled and California 1971 NO_x controlled vehicles.

Fleet tests are being conducted over a period of 18 months to establish the changes of engine adjustments with time and the associated change in mass emissions.

In addition, the contractor is conducting controlled experiments to characterize the effectiveness with which specified maintenance is performed by commercial service organizations.

Chemical and Physical Characterization of Automotive Exhaust Particulate Matter in the Atmosphere (CAPE-19-70)

Battelle Memorial Institute has begun testing two 1971 350 CID V-8 matched Ford engines installed in 1970 automobiles. Both cars have been operated on non-leaded gasoline on a chassis dynamometer and have accumulated approximately 4500 miles each. Total hydrocarbon, carbon monoxide, and total particulates in the exhausts are similar.

A major effort this year has been the design, construction, and testing of an exhaust dilution tunnel complete with sampling stations and essential on-line instrumentation. This system dilutes auto exhaust over the range of 600-2400 cfm which corresponds to an average dilution based on the 1972 Federal driving cycle of approximately 25:1 to 100:1.

An annual report is nearing completion and will be issued soon. Plans are to proceed soon with initial studies to determine the physical and chemical changes in auto exhaust particulate matter as it is further diluted and resides in the atmosphere for various lengths of time.

Nitric Oxide Formation in Diesel Engines (CAPE-20-71)

This is a new project for the purpose of determining the factors that control the formation of oxides of nitrogen in diesel engines. It is anticipated that a contractor will be selected and research will begin in the late spring of 1972. The present research plan includes an examination and correlation of combustion and engine parameters, development of a model of the diesel combustion process and verification of the model.

Truck Driving Pattern and Use Survey (CAPE-21-71)

The purpose of this new project is to develop background information on heavy duty truck use. Negotiations with a contractor for Phase 1 of a two phase program are proceeding and work should begin early in 1972. In the first phase, a contractor will compile available information on truck use patterns in urban areas. In the second phase, instrumented vehicles will be operated over representative routes to obtain detailed vehicle operating characteristics. This information is to be used as a data base for the development of truck driving cycles.

RESUME OF ATMOSPHERIC PROJECTS

Eleven projects are established in the area of research on atmospheric processes involving air pollutants.

Chamber Reactivity (CAPA-1-69)

Active research was begun in early 1971 to determine how design and operational variables effect the reactions occurring in environmental chambers. Lockheed Missiles and Space Company was selected as the contractor to conduct the research. The first phase of the study involves the design, fabrication, and testing of an irradiation chamber. Phase II will consist of experimental studies on the effects of surface variables, effect of radiation variables and the influence of reactant concentrations on surface effects.

Phase I is expected to be completed in early 1972.

Plant Damage (CAPA-2-68)

Stanford Research Institute has concentrated, during 1971, on gathering data on the effects of air pollution on forests, parks, cemeteries, campuses, and residential ornamentals. Economic estimates were assessed based on the value of products sold or annual maintenance costs. Based on this approach, the residential landscaping ornamentals represented the greatest potential loss. This information, however, is very preliminary and is based on extrapolations from losses in Southern California.

Emphasis in the continuing study will be placed on first hand observation of reported damage. An annual report is expected to be available early in 1972.

Diffusion Model of Urban Atmosphere (CAPA-3-68)

During this past year Stanford Research Institute has completed two major field studies of the dispersion of carbon monoxide in the urban atmosphere. The receptor oriented model developed in the first year's study was tested and refined using data gathered in San Jose. Further model validation was then accomplished by conducting a field study in St. Louis. In both studies, rigorous attention was paid to the street canyon effect on dispersion and, in turn, on the street effects on city wide CO dispersion.

A comprehensive report in the San Jose study has been published and a final report, including results from St. Louis, should be published early in 1972. Additionally, a user's manual will be published so that the model, which is considered completed for CO, can be used widely by interested professionals such as city planners.

Fate of Carbon Monoxide in the Atmosphere (CAPA-4-68)

Stanford Research Institute has continued the study of soil as a sink for atmospheric carbon monoxide. Natural soils from 17 different sites in California, Florida, and Hawaii were tested in the laboratory and ranged in their ability to take up CO from 2.16 to 16.99 mg $CO/hr/m^2$ exposed area. An average figure for the soils ability to take up CO would result in the removal of 569 million metric tons of CO per year in the continental United States.

Argonne National Laboratory is conducting two research projects concerned with natural sources of carbon monoxide. Studies of isotope ratios in CO have revealed that there are regular seasonal variations in natural CO sources. Speculation is that a principal source may be the oxidation of atmospheric methane.

A second study at Argonne has identified two sources of natural carbon monoxide; the biosynthesis of bilinoid pigments by fresh water algae and the degradation of chlorophyll in fresh water algae.

Light Hydrocarbons in the Atmosphere (CAPA-5-68)

The Air Pollution Research Center at the University of California has studied during the past year, the role of aromatics in the complex atmospheric photochemical reactions. Further work will continue into 1972 on the dependence of relative reactivities of aromatics upon time of reaction and concentration of reactants.

This research is to be concluded, and a final report is expected before mid-1972.

Haze Formation (CAPA-6-68)

Two studies on haze formation were active during 1971. One study was conducted by Science Spectrum on the light scattering from single aerosol particles. The instrument developed by Science Spectrum was able to demonstrate that particles from different origins have different optical properties. A final report has been published and the study has been completed.

A study was also carried out by Battelle Memorial Institute on aerosols obtained from the atmosphere in New York City and the Great Smoky Mountains, as well as from smog chambers and primary automobile exhaust. Results from detailed organic analysis indicate that the presence of certain materials associated with atmospheric particles may offer valuable clues about the origin of a particular atmospheric haze. This research is to continue; a report on the first year's study should be available early in 1972.

Measurements of Atmospheric Pollutants in Urban Areas (CAPA-7-70)

The reports containing data obtained by Scott Research Laboratory in New York City were published during this past year. The New York study involved taking data at three ground sites and taking air samples with a helicopter which was following a marked parcel of air. Among the findings from the Scott study was the observation that oxidant levels reached 3 pphm or higher on 12 out of 69 days at the Bronx site but only two out of 74 days at the Staten Island site.

Stanford Research Institute has completed a study to determine the feasibility of using the San Francisco Bay as an area to study photochemical reactions under simplified meterological conditions. Their measurements indicate that studies over the bay are warranted. A final report of this initial study is to be published early in 1972.

Determination of the Formation Mechanism and Composition of Photochemical Aerosols (CAPA-8-71)

A project has been established to better define the transition stage between a gaseous reactant and the resultant aerosol as well as the growth of the aerosol. Proposals for research

approaches have been received and evaluated. Although actual research has not yet begun it is likely that two studies will be started; one will concentrate on the chemical kinetics leading to a condensible phase and the other would emphasize the physics of aerosol growth. Research is expected to begin in spring of 1972.

Atmospheric Analytical Chemistry (CAPA-9-71)

The project on analytical atmospheric chemistry is being organized. The thrust of research that is planned would be to search for trace pollutants in the atmosphere that contribute to smog manifestations such as eye irritation and visibility reduction.

Reactivity of Diesel Exhaust (CAPA-10-71)

The project group is being organized that will be responsible for determining the reactivity of diesel exhaust. One goal of the study would be to compare the reactivity of diesel exhaust hydrocarbons to hydrocarbons from spark-ignited engines.

Contribution of Natural Hydrocarbon Emissions to the Overall Hydrocarbon Pollution Burden (CAPA-11-71)

The CAPA-6-68 project group which is conducting the study on haze formation will also carry out research planned on determining the role of natural hydrocarbons in the pollution burden. It is expected that a contractor will be selected early in 1972; research should start by mid-1972.

RESUME OF MEDICAL PROJECTS

Eleven projects dealing with the medical aspects of air pollution have been active during 1971.

Effects of Carbon Monoxide on Human Behavior (CAPM-3-68)

Studies during the third year of research at the medical College of Wisconsin were concentrated on the effects of CO upon the higher intellectual functions of man. Four different tests conducted in three different environmental situations were run to study the effect of CO exposure on time sense. Test environments ranged from tests in a group setting to tests on individuals isolated in an audiometric booth. Data analysis is nearly complete and the results are expected to show conclusively that time sense is resistant to carbon monoxide effect at low to intermediate levels of exposure.

The ability to perform arithmetic and general surveillance tasks were also studied to determine if CO exposure resulted in a decrement in performance. Carboxyhemoglobin levels approaching 15% of saturation produced no measurable decrease in performance.

Study of the effects of CO exposure combined with alcohol was begun. Medical students have been used in these tests which have thus far demonstrated no synergistic effect of carbon monoxide in combination with alcohol.

Effects of Chronic Exposure to Low Levels of Carbon Monoxide on the Cardiovascular System (CAPM-4-68)

Jefferson Medical College has completed three tests in which dogs were used to investigate the effect of carbon monoxide upon the cardiovascular system. One exposure test has also been completed using cynamolgus monkeys as the test animal. Results from the first experiment with dogs exposed to 100 ppm CO have been published. No statistical difference was found between the normal dogs and those with an experimentally induced myocardial infarct.

The second experiment with dogs was at 150 ppm CO for 26 weeks. The third experiment was conducted at 50 ppm CO followed by exercise. Again, the statistical analyses indicate no difference between the normal and diseased dogs.

An experiment also conducted using the cynamolgus monkey exposed for 26 weeks to 100 ppm CO. This test was completed in October 1971 and analysis of the data is in progress.

Toxicity of Polynuclear Aromatic Hydrocarbons in the Lung (CAPM-5-68)

The Eppley Institute for Research in Cancer of the University of Nebraska College of Medicine is conducting research on the toxicity of polynuclear aromatic hydrocarbons in the lung. In research carried out last year, benzo(a)pyrene followed by ferric oxide dust was injected into the lungs of hamsters. The benzo(a)pyrene (B(a)P) alone and the iron oxide either before or after the B(a)P was largely inactive.

Efforts continue to obtain a supply of characterized particles from automotive exhaust for use in the research at Eppley Institute. It is presently planned to have a supply of appropriate material by mid-1972.

Synergistic Effects in Certain Airborne Systems (CAPM-6-68)

Hazleton Laboratories has completed the research on possible synergism among air pollutants. Both rats and monkeys were exposed in inhalation chambers to major air pollutants over extended periods of time. Immediately available data analysis was obtained on various physiological parameters through the use of electronic data processing equipment. Data precision was greatly increased through the use of this equipment.

A number of significant conclusions have been revealed by these experiments. For example, animals exposed to the pollutants and their combinations could not be distinguished from controls with respect to growth, development, final body weight, general behavior and survival. Also, primates and rodents exposed to carbon monoxide showed the predicted elevation in carboxyhemoglobin, but no other toxic effects were evident.

Computer studies of the mass of data continued through most of 1971 and final reports are to be available early in 1972.

Determination of Carboxyhemoglobin in Various Segments of the Population (CAPM-8-68)

The medical College of Wisconsin is conducting a nationwide survey to determine carboxyhemoglobin levels in various population segments. During 1971 thirteen cities were surveyed and a total of 17,415 blood samples were collected. The survey will be continued during the first half of 1972. During 1972 plans call for a survey in Los Angeles and a revisit to New York City.

A second study is being conducted by the New York University School of Medicine to determine the erythrocyte oxygen uptake and delivery in individuals exposed occupationally to carbon monoxide. These studies are to be conducted on employees of the New York City Triborough Tunnel and Bridge Authority. The work is expected to be completed in 1972.

Effects of Low Levels of Carbon Monoxide upon Humans Performing Driving Tasks (CAPM-9-69)

The effects of low levels of carbon monoxide on humans performing complex driving tasks are being studied at both Harvard University and the Ohio State University.

Harvard is conducting laboratory and on-the-road testing. During 1971, Harvard tested 26 subjects in the laboratory using tests that can be related to the driving task. Tests under exposure to CO include measuring recovery from light shock and glare, measuring effects on peripheral vision, and measuring effects in depth perception.

Harvard's on-the-road tests are conducted using a visual interruption apparatus along with an automobile equipped to measure steering wheel reversals and devices to measure deviations from a marked lane. Analysis of data from Harvard's first year of research is currently in progress.

Ohio State is also conducting both laboratory and on-the-road testing on subjects exposed to carbon monoxide. Laboratory tests include pursuit tracking experiments, spatial relations tests, and bright and dark adaptation tests. The on-the-road testing at Ohio State is being

done under conditions of urban and open road daylight driving and open road night driving. Among the parameters being measured is the eye movement search and scan patterns. Preliminary data have been collected from several subjects and a report on the first year's work should be published early in 1972.

Effects of Low Levels of Nitrogen Oxides upon Humans (CAPM 10-71)

Research Triangle Institute will conduct a study on the effects of nitrogen oxide levels on selected health characteristics of persons in Chattanooga, Tennessee. Health indicators to be investigated include frequency of chronic respiratory disease symptoms, frequency of acute respiratory illness and ventilatory performance of school children.

The possibility of introducing chemiluminescent instruments for NO_2 measurements in the field is being investigated.

Effects of Low Levels of Oxidants upon Humans (CAPM-11-71)

A study to assess the effects of low levels of oxidants upon humans will be initiated early in 1972. Negotiations with a contractor to conduct a study in the Los Angeles Basin are in progress. Health indicators to be investigated include frequency of chronic respiratory disease symptoms, frequency of acute respiratory illness, ventilatory performance of school children and frequency and severity of asthma attacks.

Influence of Carbon Monoxide Levels upon Incidence of Motor Vehicle Accidents (CAPM-12-69)

A project to determine if a relationship exists between carbon monoxide exposure of drivers and accidents is expected to become active in 1972. An ad has been placed in the Commerce Business Daily and a number of research organizations have been selected as prospective contractors. The first task in the active study may be a thorough review of information currently available.

Effects of Carbon Monoxide Exposure upon Myocardial Infarction Fatality Rates (CAPM-13-69)

The Johns Hopkins School of Public Health is carrying out a study to determine the effects of carbon monoxide exposure upon myocardial infarction fatality rates. An initial pilot study has been completed. During this initial study, a total of 367 carboxyhemoglobin determinations were made on people who had died suddenly and were autopsied in the Baltimore area. Also, 68 blood samples were obtained on people who were admitted to a hospital with a myocardial infarction.

The main study has now been launched after some adjustments in the plans because of knowledge gained in the pilot study. A report of the first year's full research should be available late in 1972.

Eye Irritation and Lachrymation (CAPM-17-71)

A study of eye irritation and the lachrymation process is expected to begin in 1972. An initial phase of this study may involve exposing volunteers' eyes to smog at the same time detailed chemical analyses of the pollutants in the atmosphere are made.

RESUME OF IN-HOUSE PROGRAMS

Five programs have been established as in-house studies.

Composition of Diesel Exhaust (CAPI-1-64)

A fourth phase of the hydrocarbon, CO and NO measurements program is in the final planning stages. The program will start in early 1972, approximately 12 laboratories participating.

All available information on the effect of humidity on NO measurements has been gathered together and issued as a CRC status report.

Both bench and engine test procedures have been developed to assess the performance characteristics, operability, and durability of the full-flow, light extinction type smokemeter for various types of service. The procedures have been applied to several prototype meters.

The following reports have been released: "Correlation of Full-Flow Light Extinction Type Diesel Smokemeters by a Series of Neutral Density Filters" (CRC Report No. 442), "Cooperative Evaluation of Techniques for Measuring NO and CO in Diesel Exhaust" (CRC Report No. 443) and "Cooperative Evaluation of Techniques for Measuring Hydrocarbons in Diesel Exhaust" (CRC Report No. 440).

Exhaust Gas Sampling and Analysis Techniques (CAPI-2-58)

Written procedures are being prepared for chromatographic analysis of exhaust hydrocarbons and for measurement of exhaust NO_x by spectrophotometric techniques.

Written procedures for CVS sampling of exhaust and for chromatographic analysis of CVS samples will be prepared through contract effort.

Experimental evidence for comparison of exhaust NO_x alternative measurement methods is being solicited. Information is also being gathered on presently used methods for measurement of exhaust particulates.

Evaporation Losses (CAPI-3-65)

The program group remains inactive until results from the CAPE-5-68 and CAPE-10-68 contract activities are completed and published.

Vehicle Emissions (CAPI-5-65)

A program is being planned wherein one or more cars will be circulated among participating laboratories to measure vehicle exhaust emissions with the constant volume sampler (CVS). The CAPI-2-58 group has been requested to provide a recommended operating procedure that can be used during the testing at each laboratory.

Techniques for Irradiation Chamber Studies (CAPI-6-69)

The program group has been inactive during the past year. Based upon results from contract research being conducted under project CAPA-1-69, the desirability of additional test programs will be determined.

17/18

Released CRC-APRAC Reports

RELEASED APRAC REPORTS
AVAILABLE THROUGH NATIONAL TECHNICAL INFORMATION SERVICE*

APRAC Project No.	Title	NTIS Accession No.	Contractor
CAPE-2-68	Effects of Gasoline Additives on Carburetor and PCV System Performance as They Relate to Exhaust Emissions	PB 195 143	Scott Research Laboratories
CAPE-3-68	The Effects of Leaded and Unleaded Gasolines on Exhaust Emissions Caused by Combustion Chamber Deposits–Final Report	PB 201 946	In-House Program CRC Report No. 441
CAPE-5-68	Time Temperature Histories of Specified Fuel Systems (Vol. I)	PB 200 252	Scott Research Laboratories
CAPE-6-68	Gasoline Composition and Vehicle Exhaust Gas Polynuclear Aromatic Content	PB 200 266	Esso Research & Engineering
CAPE-7-68	Chemical Species in Engine Exhaust and Their Contributions to Exhaust Odor–First Year	PB 189 651	IIT Research Institute
CAPE-7-68	Chemical Species in Engine Exhaust and Their Contributions to Exhaust Odor–Second Year	PB 200 267	IIT Research Institute
CAPE-7-68	Chemical Identification of the Odor Components in Diesel Engine Exhaust–First Year	PB 194 061	Arthur D. Little
CAPE-7-68	Chemical Identification of the Odor Components in Diesel Engine Exahust–Second Year	PB 194 144	Arthur D. Little
CAPE 7-68	Chemical Identification of the Odor Components in Diesel Engine Exhaust–Third Year	PB 205 273	Arthur D. Little

*The primary source of these reports is National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia 22151; however, the reports are also available through the American Petroleum Institute, 1801 "K" Street, N.W., Washington, D.C. 20006.

RELEASED APRAC REPORTS
AVAILABLE THROUGH NATIONAL TECHNICAL INFORMATION SERVICE* (Continued)

APRAC Project No.	Title	NTIS Accession No.	Contractor
CAPE-8-68	Kinetics of Oxidation and Quenching of Combustibles in Exhaust Systems of Gasoline Engines	PB 198 079	University of Michigan
CAPE-9-68	Investigation of Passenger Car Refueling Losses	PB 195 435	Scott Research Laboratories
CAPE-10-68	A Survey of Average Driving Patterns in the Los Angeles Urban Area	PB 202 409	System Development Corporation
	A Survey of Average Driving Patterns in the Cincinnati Urban Area	PB 202 267	System Development Corporation
	A Survey of Average Driving Patterns in the Chicago Urban Area	PB 202 189	System Development Corporation
	A Survey of Average Driving Patterns in the Houston Urban Area	PB 202 188	System Development Corporation
	A Survey of Average Driving Patterns in the St. Paul/Minneapolis Urban Area	PB 202 190	System Development Corporation
	A Survey of Average Driving Patterns in the New York Urban Area	PB 202 191	System Development Corporation
	A Survey of Average Driving Patterns in Six Urban Areas of the United States Summary Report	PB 202 192	System Development Corporation
	A Survey of Average Driving Patterns in the Los Angeles Urban Area Based Upon Data Obtained in a Telephone Survey	PB 202 193	System Development Corporation
CAPE-11-68	Procedures for Determining Exhaust Carbonyls as 2, 4-Dinitrophenylhydrazones First Year and Second Year	PB 200 883	U.S. Bureau of Mines

*The primary source of these reports is National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia 22151; however, the reports are also available through the American Petroleum Institute, 1801 "K" Street, N.W., Washington, D.C. 20006

RELEASED APRAC REPORTS
AVAILABLE THROUGH NATIONAL TECHNICAL INFORMATION SERVICE* (Continued)

APRAC Project No.	Title	NTIS Accession No.	Contractor
CAPE-11-68	Carbonyls and Noncarbonyls in Exhausts from Simple Hydrocarbon Fuels—Third Year	PB 200 884	U.S. Bureau of Mines
CAPE-11-68	Improved Instrumentation for Determination of Exhaust Gas Oxygenate Content	PB 200 268	Scientific Research Instruments
CAPE-12-68	The Physical-Chemical Characteristics of Particulates Associated with Polynuclear Aromatic Hydrocarbons Present in Automobile Exhaust	PB 196 796	Battelle Memorial Institute
CAPE-12-68	Progress in Development of Rapid Methods of Analysis for Trace Quantities of Polynuclear Aromatic Hydrocarbons in Automobile Exhaust	PB 196 808	Esso Research and Engineering
CAPA-2-68	Economic Impact of Air Pollutants on Plants (Vol. I) (Vol. II)	 PB 200 235 PB 200 236	 Stanford Research Institute Stanford Research Institute
CAPA-3-68	A Practical Multipurpose Urban Diffusion Model for Carbon Monoxide	PB 196 003	Stanford Research Institute
CAPA-3-68	Field Study for Initial Evaluation of an Urban Diffusion Model for Carbon Monoxide	PB 203 469	Stanford Research Institute
CAPA-4-68	Mechanisms for Removal of Carbon Monoxide from the Atmosphere	PB 195 754	GCA Corporation
CAPA-4-68	The Biosphere as a Possible Sink for Carbon Monoxide Emitted to the Atmosphere	PB 195 433	Stanford Research Institute

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RELEASED APRAC REPORTS
AVAILABLE THROUGH NATIONAL TECHNICAL INFORMATION SERVICE* (Continued)

APRAC Project No.	Title	NTIS Accession No.	Contractor
CAPA-4-68	Soil as a Sink for Atmospheric Carbon Monoxide	PB 205 890	Stanford Research Institute
CAPA-6-68	Atmospheric Haze: A Review	PB 192 102	Bolt Beranek & Newman
CAPA-6-68	Optical Studies of Automotive and Natural Hazes Scattering from Single Particles	PB 202 361	Science Spectrum
CAPA-7-68	Atmospheric Reaction Studies in the Los Angeles Basin (Vol. I)	PB 194 058	Scott Research Laboratories
	(Vol. II)	PB 194 059	Scott Research Laboratories
	(Phase II)	PB 194 060	Scott Research Laboratories
CAPA-7-68	1969 Atmospheric Reaction Studies in the Los Angeles Basin (Vol. I)	PB 194 061	Scott Research Laboratories
	(Vol. II)	PB 194 062	Scott Research Laboratories
	(Vol. III)	PB 194 063	Scott Research Laboratories
	(Vol. IV)	PB 194 064	Scott Research Laboratories
CAPA-7-68	Analysis of Los Angeles Atmospheric Reaction Data from 1968 and 1969	PB 196 825	General Research Corporation
CAPA-7-68	1970 Atmospheric Reaction Studies in the New York City Area (Vol. I)	PB 104 580	Scott Research Laboratories
	(Vol. II)	PB 204 581	Scott Research Laboratories
	(Vol. III)	PB 204 582	Scott Research Laboratories
CAPM-3-68	Experimental Human Exposure to Carbon Monoxide	PB 195 432	Marquette School of Medicine

*The primary source of these reports is National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia 22151; however, the reports are also available through the American Petroleum Institute, 1801 "K" Street, N.W., Washington, D.C. 20006

RELEASED APRAC REPORTS
AVAILABLE THROUGH NATIONAL TECHNICAL INFORMATION SERVICE* (Continued)

APRAC Project No.	Title	NTIS Accession No.	Contractor
CAPM-4-68	The Effects of Chronic Exposure to Low Levels of Carbon Monoxide on the Cardiovascular System of Dogs. 1. Exposure to 100 ppm Carbon Monoxide	PB 203 566	Jefferson Medical College
CAPI-1-64	Cooperative Evaluation of Techniques for Measuring Hydrocarbons in Diesel Exhaust	PB 206 729	In-House Program CRC Report No. 431
CAPI-1-64	Cooperative Evaluation of Techniques for Measuring Hydrocarbons in Diesel Exhaust—Phase III	PB 206 730	In-House Program CRC Report No. 440
CAPI-1-64	Correlation of Full-Flow Light Extinction Type Diesel Smokemeters by a Series of Neutral Density Filters	PB 206 731	In-House Program CRC Report No. 442
CAPI-1-64	Cooperative Evaluation of Techniques for Measuring NO and CO in Diesel Exhaust	PB 206 732	In-House Program CRC Report No. 443
CAPI-1-64	Effect of Humidity of Air Intake on Nitric Oxide Formation in Diesel Exhaust	PB 206 733	In-House Program CRC Report No. 447

*The primary source of these reports is National Technical Information Service, U.S. Department of Commerce Springfield, Virginia 22151; however, the reports are also available through the American Petroleum Institute 1801 "K" Street, N.W., Washington, D.C. 20006.

RELEASED APRAC REPORTS
NOT AVAILABLE THROUGH NATIONAL TECHNICAL INFORMATION SERVICE*

APRAC Project No.	Title	Contractor
CAPE-3-68	The Effects of Leaded and Unleaded Gasoline on Exhaust Emissions Caused by Combustion Chamber Deposits–Summary Report	In-House Program CRC Report No. 441
CAPE-5-68	A Survey of Typical Driving Patterns of the Los Angeles Metropolitan Area Relative to Auto Air Pollution (Vol. I) (Vol. II)	Minnesota Mining and Manufacturing
CAPE-13-68**	The Economic Effectiveness of Mandatory Engine Maintenance for Reducing Vehicle Exhaust Emissions–Volume I–Executive Summary	TRW/Scott Research Laboratories
CAPE-13-68**	The Economic Effectiveness of Mandatory Engine Maintenance for Reducing Vehicle Exhaust Emissions–Volume II–Modeling of Inspection/ Maintenance Systems	TRW/Scott Research Laboratories
CAPE-13-68**	The Economic Effectiveness of Mandatory Engine Maintenance for Reducing Vehicle Exhaust Emissions–Volume III–Inspection/Maintenance Procedures Development	TRW/Scott Research Laboratories
CAPE-13-68**	Vehicle Emission Surveillance Study	TRW/Scott Research Laboratories
CAPE-13-68**	Evaluation of Instruments for Vehicle Exhaust Emission Inspection	TRW/Scott Research Laboratories

*Reports judged to be of limited interest to the general public have not been placed in NTIS; however, these reports are available through the American Petroleum Institute, 1801 "K" Street, N.W., Washington, D.C. 20006.

**CAPE-13-68 reports to be placed in NTIS in the near future.

RELEASED APRAC REPORTS
NOT AVAILABLE THROUGH NATIONAL TECHNICAL INFORMATION SERVICE* (Continued)

APRAC Project No.	Title	Contractor
CAPE-13-68**	The Economic Effectiveness of Mandatory Engine Maintenance for Reducing Vehicle Exhaust Emission—CRC Extended Phase I Study—Interim Report	TRW/Scott Research Laboratories
CAPM-2-68#	Effects of Chronic Exposure to Low Levels of Carbon Monoxide on Human Health, Behavior and Performance	National Academy of Sciences National Academy of Engineering
CAPM-5-68	Toxicity of Polynuclear Aromatic Hydrocarbons in the Lung	University of Nebraska
CAPM-7-68	Development of a Research Program for the Evaluation of the Effects of NO_x and/or Oxidants Upon Human Health in an Urban Environment	Tulane University School of Medicine
CAPM-8-68	Formulation of a Program for the Determination of the Range of Carboxyhemoglobin in the U.S.	Bertram D. Dinman

*Reports judged to be of limited interest to the general public have not been placed in NTIS: however, these reports are available through the American Petroleum Institute, 1801 "K" Street, N.W., Washington, D.C. 20006

**CAPE-13-68 reports to be placed in NTIS in the near future.

#This report may be obtained directly from the National Academy of Sciences, Printing and Publishing Office, 2101 Constitution Avenue, Washington, D.C. 20418.

The CRC and Its Air Pollution Research Program

THE CRC AND ITS AIR POLLUTION RESEARCH PROGRAM

The formal purposes of the Coordinating Research Council (CRC) are:

> To encourage and promote the arts and sciences by directing scientific cooperative research in developing the best possible combinations of fuels, lubricants, and the equipment in which they are used, and to afford means of cooperation with the Government on matters of national interest within this field.

To achieve this goal, four technical committees–Air Pollution Reasearch Advisory Committee, Aviation Fuel, Lubricant, and Equipment Research Committee; and Motor Vehicle Fuel, Lubricant and Equipment Research Committee–coordinate the volunteer activities of over 1000 automotive and petroleum engineers and medical experts from more than 200 industrial organizations, universities, independent research laboratories, and Government agencies. Working groups and panels carry out the directives of the four main technical committees in accordance with stated objectives of the work to be accomplished. A fifth committee–Coordination Committee–administers those projects which due to overlapping interest or security classification do not lie within the jurisdiction of a particular technical committee.

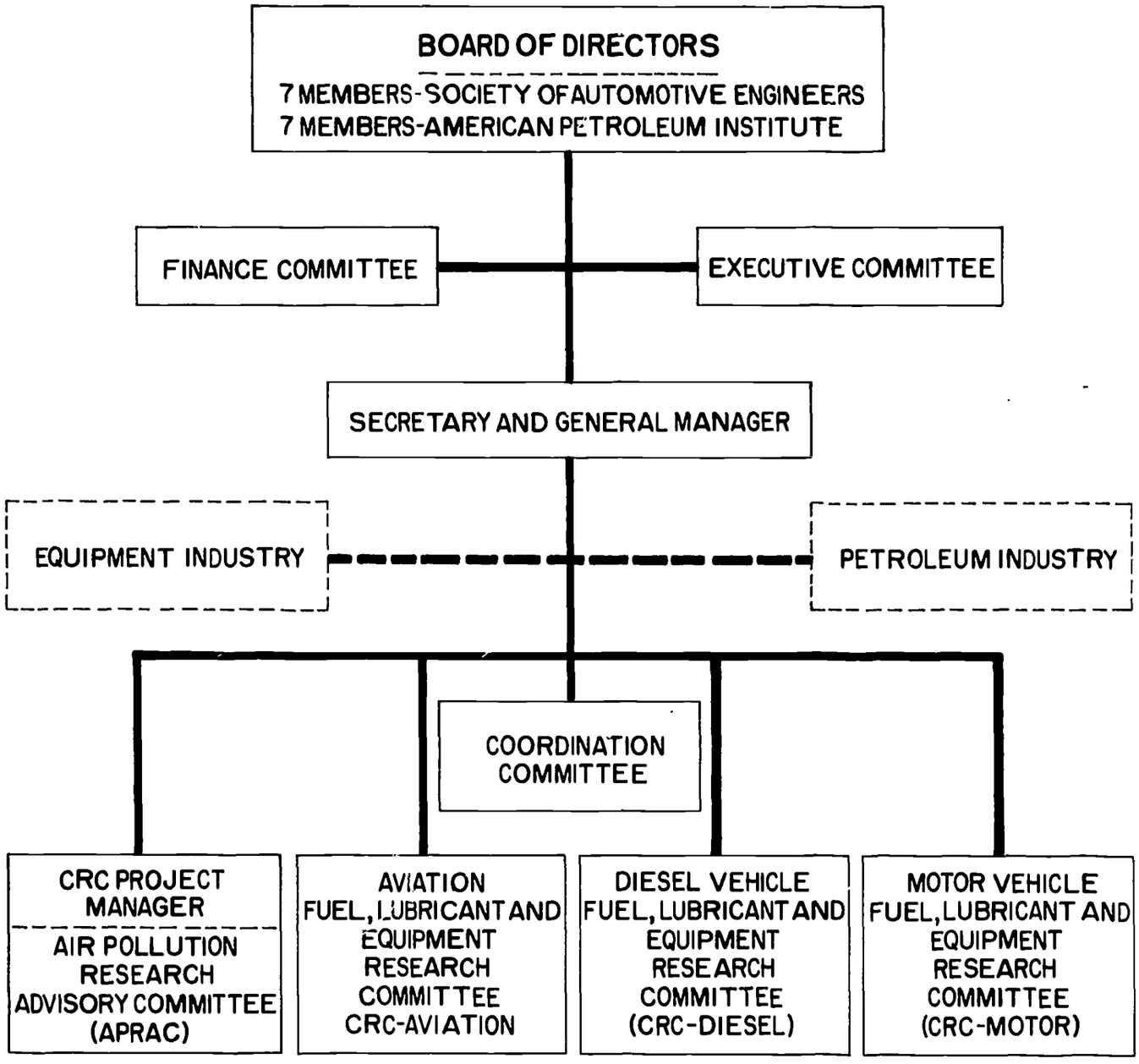
As indicated in the functional chart on the following page, the CRC technical committees are responsible to the Board of Directors whose members are nominated by the two CRC sustaining members: the Society of Automotive Engineers covering the automotive equipment industry and the American Petroleum Institute covering the petroleum industry. The Board retains direct supervision over the administrative, financial, and general functions of the CRC. It also acts as the coordinating agency between the equipment and petroleum industries to insure that projects both underway or proposed as CRC activities are within the scope of the CRC.

The CRC represents the outgrowth of almost 50 years of mutual endeavor between the automotive and petroleum industries to improve the adaptation of automotive vehicle equipment and the fuels and lubricants utilized in their operation. CRC has contributed for many years to significant advances in technology to reduce atmospheric pollution due to vehicle emissions, and the studies in this important area have been greatly expanded recently.

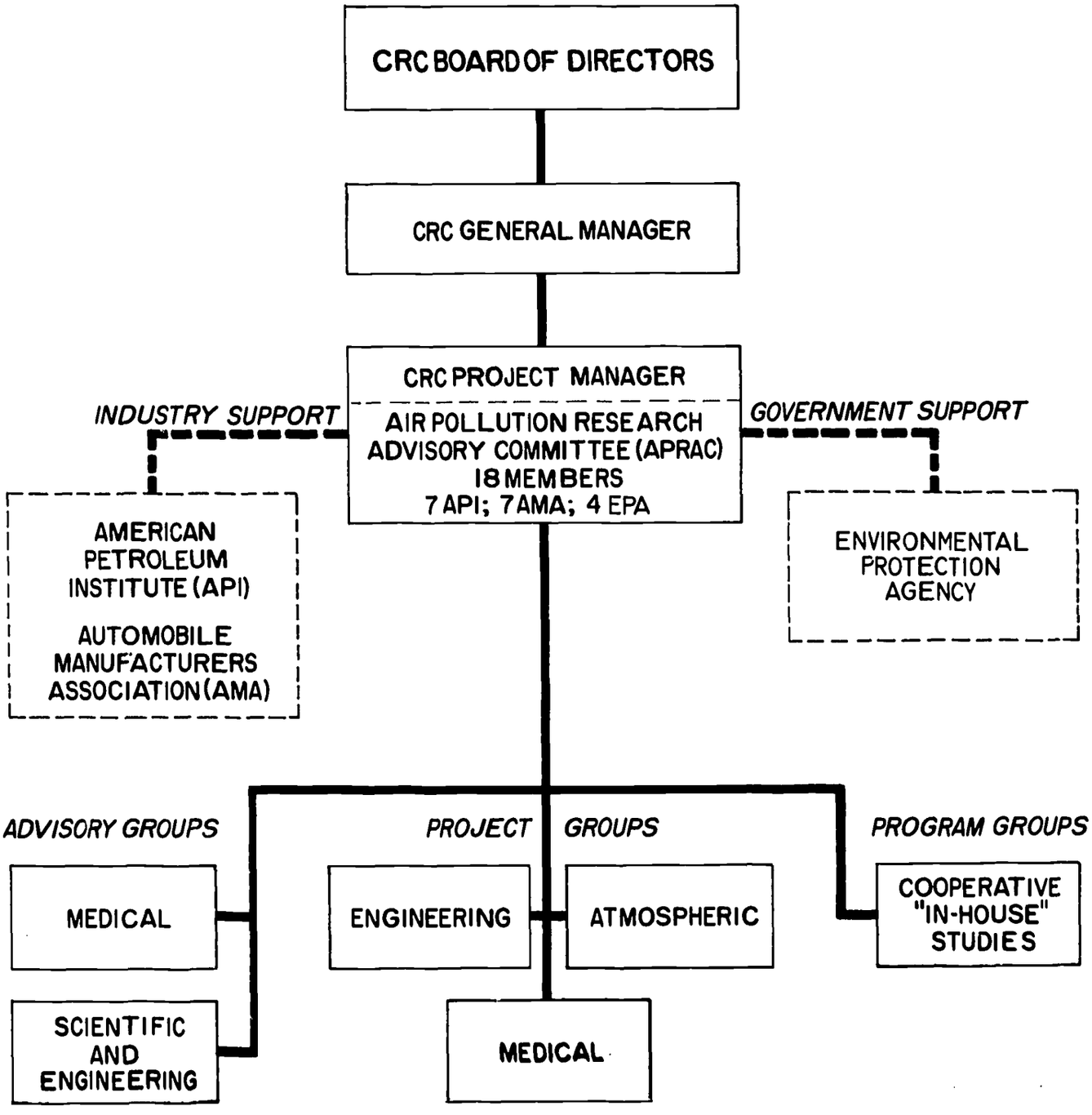
In the fall of 1967 the Air Pollution Research Advisory Committee was added to the CRC organizational structure in the form indicated on the functional chart on page 31. This committee, refered to as "APRAC," acts in an advisory capacity to the CRC Project Manager who directs the overall program. The committee has eighteen members, seven from the petroleum industry, seven from the automotive industry, and four from the Environmental Protection Agency.

The main purpose of the APRAC program is to develop basic information on the nature and effects of vehicle air pollution–not to develop automotive hardware or petroleum products. The data acquired from these investigations are expected to provide industry with the technical information needed to further reduce emissions through the development of improved equipment and petroleum products. The data are also expected to assist the Government in establishing air quality standards and emission control requirements. The Automobile Manufacturers Association and the American Petroleum Institute participate equally in the funding of projects. The Engine Manufacturers Association has also shared along with the American Petroleum Institute, in the support of selected projects. The

FUNCTIONAL ORGANIZATION CHART
COORDINATING RESEARCH COUNCIL, INC. (CRC)



FUNCTIONAL CHART FOR CRC AIR POLLUTION RESEARCH ACTIVITIES



Environmental Protection Agency is involved in the direction of all projects. On a selective basis, EPA shares in the financial support of a majority of the projects.

The dominant portion of the APRAC work is carried out on a contract basis, to insure the services of capable organizations within industry, the Government, universities and independent research organizations. Every contract is carried out under the direction of a particular project group. The predominant number of contracts is awarded through a competitive procurement process. In this process, an advertisement soliciting information on the capabilities of contractors is placed in the Commerce Business Daily, which is published by the U.S. Department of Commerce and read by a substantial majority of organizations interested in conducting contract research. Replies to these advertisements are then screened by the appropriate CRC project group and a request for proposal (RFP), including a detailed work statement, is sent to those organizations considered to be most capable of carrying out the research. The organizations that were not selected to receive the RFP are so advised; however, a statement is included in this "turn down" letter which provides them the opportunity to receive the RFP if they believe that they can compete successfully for the contract. If they reply, in writing, that they wish to compete for the contract, an RFP is sent to them.

All proposals received are carefully reviewed by the project group, and the organization that submitted the optimum proposal is recommended for the contract. After the contract is awarded, the project group monitors the work during the contractual period and upon completion of the work critically reviews a draft of the contractor's final report. If necessary, the draft is modified and the final version of the report is printed and made available to the sponsoring organizations and the public.

Individual Projects

EFFECTS OF GASOLINE PROPERTIES ON CARBURETOR AND PCV VALVE DETERIORATION
CRC Project No. CAPE-2-68

Objective

The objective of this project was to develop information on the effects of gasoline properties on carburetor and positive crankcase ventialting (PCV) valve performance as they relate to exhaust emissions.

Current Status

In the experimental program conducted by Scott Research Laboratories, each of forty-eight vehicles was driven in urban and suburban modes of operation. Three groups of 16 cars each were operated on the same base fuel, but two of the fuels were modified with additives, a detergent additive and a dispersant additive. Exhaust emissions, PCV flow, and idle RPM (for a total of 19 dependent variables) were measured when the vehicles started the test and at each subsequent 4,000-mile intervals through 12,000-miles. The original program was designed to accumulate 24,000 miles per car, but at the end of twelve months operation, it was decided that the testing be terminated when each car had accumulated 12,000 miles.

The effects of the fuel additives were found difficult to interpret because of the large number of statistically significant interactions involving fuel. Alternate methods of data analysis were pursued. An analysis of variance (AOV) was conducted on each of 16 measured dependent variables for the 0-mile, 4,000-mile, 8,000-mile and 12,000-mile intervals. Presentation of these data was formated to allow comparison and evaluation of significant differences among fuels, makes, mileage intervals, and their interactions on each dependent variables.

Each of 16 dependent variables was regressed on mileage in order to utilize fully the results obtained on those vehicles driven more than 12,000 miles. For each of these dependent variables the data for all makes were combined and the regressions computed separately for each fuel to isolate fuel differences. This analysis was supplemented by regressing ten of the dependent variables on mileage by both make and fuel.

Analysis of the data shows that vehicles operated on fuels containing the gasoline additives had lower carbon monoxide emissions than those operated on the nonadditive fuel. The lower carbon monoxide emissions were accompanied by increases in carbon dioxide. The higher CO emissions for vehicles operated on the nonadditive fuel were attributed to carburetor throttle body deposits. Inspection of the carburetors verified that use of the nonadditive control fuel resulted in such deposits. There appeared to be no differences in the deposit levels of the PCV valves between the vehicles using the three different fuels. There was a statistically significant effect of mileage interval on seven-mode hydrocarbons. There were also significant mileage effects on steady-state hydrocarbons as measured by the NDIR device.

The make effect was significant for all dependent variables except idle RPM and idle O_2 but no single make was consistently high or low across all dependent variables.

The final report preparation is nearing completion. The report should be available in February or March 1972.

EFFECTS OF GASOLINE PROPERTIES ON EXHAUST EMISSIONS CAUSED BY COMBUSTION-CHAMBER DEPOSITS
CRC Project No. CAPE-3-68

Objective

The objective of this project is to determine the effects of gasoline properties, including additives, on exhaust emissions caused by the effect of combustion-chamber deposits.

Current Status

The use of lead compounds when added to gasolines to enhance their antiknock properties has resulted in more efficient combustion in high compression engines, but their use has also caused lead deposits in the combustion chamber. In addition, there is some indication that under certain operating conditions these deposits may increase hydrocarbon emissions. To assess how lead antiknock compounds in gasolines influence combustion-chamber deposits and equilibrium emission levels, an intensive CRC state-of-the-art review has been made and data submitted by 18 different companies on pre-emission controlled cars and 1966 and 1967 models equipped with exhaust emission controls have been analyzed in depth by the CRC project group. Based on this review, it was concluded that cars operated on leaded gasolines have somewhat higher equilibrium hydrocarbon emissions than those operated on unleaded gasolines; however, no effect was noted for either carbon monoxide or oxides of nitrogen. A comprehensive report entitled "The Effects of Leaded and Unleaded Gasolines on Exhaust Emissions Caused by Combustion Chamber Deposits" was approved for release and has been distributed. The project was concluded with the issuance of the comprehensive report.

FUEL VOLATILITY
CRC Project No. CAPE-4-68

Objective

The objective of this project was to study the interactions of fuel volatility and automotive design as they relate to driveability and total emissions.

Current Status

Studies had shown that evaporative emissions from gasoline tanks and carburetors could be decreased by lowering volatility. However, such changes in the volatility of fuels could also cause driveability problems and possibly a significant increase in exhaust hydrocarbon emissions. Accordingly, the influence of fuel volatility on exhaust emissions, evaporation losses, and vehicle driveability were studied in two CRC contract activities under CRC Project CAPE-4-68.

Twelve late-model vehicles tuned to manufacturers specifications, and including four 1970 vehicles equipped with California-type evaporation controls, were tested for evaporative and exhaust emissions by the Bureau of Mines. These same 12 cars were tested for both cold and warmed-up driveability by the Ethyl Corporation. The investigation also involved eight specially prepared full boiling gasolines varying over a wide range in both front-end and mid-range volatility. Ambient temperatures were varied from 20°F to 95°F. All testing was conducted on climate-controlled chassis dynamometers using test cycles simulating typical urban driving.

Three of the test cars showed sufficient effects of volatility on driveability in the 45°F to 70°F temperature range to justify returning them to the manufacturers for minor mechanical modifications to improve driveability on a test fuel with low front-end volatility. The modifications did not change driveability sufficiently to warrant retesting to establish the effect of these mechanical modifications on vehicle emissions, as called for in the original program plan.

The Bureau of Mines final report covering the emission testing will be available in early 1972. Evaporation loss decreases with fuel volatility decreases were similar in terms of percentage changes to previous results obtained at the Bureau of Mines on an earlier study for the American Petroleum Institute. However, the evaporative controls on the 1970 models tested were very effective in reducing mass emissions on all fuels tested at high ambient temperatures. Exhaust emissions were also influenced by fuel volatility but to much less of an extent than evaporative emissions and generally in the opposite direction.

A final report on driveability test results is in preparation by Ethyl Corporation, and release is anticipated for early 1972. The driveability data were obtained by a new test procedure and no previous data are available for direct comparison. However, tests on similar vehicles and fuels run in a Coordinating Research Council field program in 1969 at Pasco, Washington, showed similar fuel and car effects. For example, the less volatile midrange gasolines generally gave poorer cold driveability.

Sensitivity to fuel volatility varied widely among the cars tested. While the fuel effects and

cold driveability problems were accentuated at 20°F, they were also substantial in several test cars at the higher test temperatures. Fuel effects were not apparent under warmed-up driving conditions. It is recognized that the test car sample was extremely small, and extrapolation of test results to the total car population is hazardous.

GASOLINE COMPOSITION AND VEHICLE EXHAUST GAS POLYNUCLEAR AROMATIC CONTENT
CRC Project No. CAPE-6-68

Objective

The primary objective of the project is to determine the relative contribution of total aromatics and fuel polynuclear aromatics to exhaust polynuclear aromatics, and to determine the fate of exhaust polynuclear aromatics in emission control systems.

Current Status

The impetus for the CAPE-6-68 study is derived from the notion that the aromatic content of gasoline may be increased to compensate for a reduction in the content of lead antiknock in order to maintain octane quality. The higher aromatic content as well as associated compositional changes may affect the emission of polynuclear aromatic hydrocarbons.

The previous year's research, conducted under contract by the Esso Research and Engineering Co., emphasized the effect of combustion chamber deposits developed with several fuels, as well as the immediate effect of fuel composition on the emission of polynuclear aromatic hydrocarbons and phenols. Three standard production model automobiles and two automobiles with experimental advanced emission control systems have been used in the program. All measurements were made on the California seven-mode cycle with 2/1 hot/cold weighting.

The following are the principal findings:

- For two vehicles (1966 uncontrolled and 1968 model with engine modification control), emission of benzo(a)pyrene (BaP) and benz(a)anthracene (BaA) were about 2-1/2 times higher with fuel of 46% aromatic content than with fuel of about 11% aromatic content. For a third vehicle (1970 with engine modification emission control) there was no significant difference in polynuclear (PNA) emission between the 46% aromatic and the 11% aromatic fuels.

- For the 1966 and 1968 vehicles, 16% of a high-boiling naphtha in the gasoline resulted in PNA emission about 1-1/2 times greater than with gasoline having no high-boiling naphtha. For the 1970 vehicle, there was no significant difference in PNA emission associated with the fuels with and without high boiling naphtha.

- Emission of PNA with gasoline having 2.9 ppm BaP as reformate still bottoms, was slightly higher than with gasoline having near-zero BaP. The increase was statistically significant for BaA but not significant for BaP.

- Phenol emission was directly proportional to the aromatic content of the gasoline, and about 1,000 times the BaP emission. Phenol emission from the 1970 vehicles was about 30% lower than from the 1966 and 1968 vehicles.

- The immediate effect of lead antiknock in gasoline on PNA emission was not significant.

- PNA emissions associated with combustion chamber deposits layed down with fuels of higher lead content, higher phosphorous content and higher reformate bottoms content were significantly greater than PNA emissions associated with deposits layed down with fuels lower in all these factors. At the present time it cannot be determined which of these deposit factors, or combinations, was most significantly related to the higher PNA emission.

- Engine modifications to reduce carbon monoxide and hydrocarbon emissions also reduce PNA emissions. The 1968 engine modification car emitted about 70% less than the 1966 uncontrolled car; the 1970 engine modification car emitted about 80% less than the 1966 car.

- PNA emissions from two cars with experimental low-emission systems (thermal and catalytic) were about 99% less than from the 1966 uncontrolled car.

- PNA emission was very sensitive to air/fuel ratio. For example, using carbon monoxide concentration over a narrow range as a measure of air/fuel ratio, a 45% change of BaP emission was associated with an 0.5% change of carbon monoxide emission.

The more rapid method of analyses for polynuclear aromatic hydrocarbons, developed in CAPE-12-68, has been used in CAPE-6-68 throughout the second year.

EXHAUST ODOR MEASUREMENT
CRC Project No. CAPE-7-68

Objective

The objective of this project is to develop technical information needed for the identification and measurement of engine exhaust odor.

Current Status

Diesel exhaust odor has been characterized by Arthur D. Little, Inc. as consisting about equally of oily-kerosene and smoky-burnt odors. The chemical classes associated with the oily-kerosene odor complex were previously determined to be associated with alkyl benzenes, indans/tetraline, and indenes.

During this past year, the details of the methodology required for identification of the smoky-burnt odor fraction were completed and applied to the analysis of this fraction. All of the odor-significant species in this fraction have been identified. While several paraffinic oxidation products were recognized as important odor contributors, the most important smoky-burnt odor species are those associated with the partial oxidation products of compounds found in the aromatic fraction of the diesel fuel.

Of the species identified, the greatest contribution to the smoky-burnt odor character appears to be from the higher molecular weight components and those with multi-functional substitution. Feel factors (irritation, pungency) are frequently associated with the lower molecular weight members of a particular chemical class. Analysis of this odor fraction was aided by the study of a large number of oxygenated reference compounds, many of which had appropriate odor character and intensity.

In summary, the odor and chemical identification results for the smoky-burnt odor complex show that:

- The smoky odor character is most consistently associated with hydroxy and methoxy indanones with some contributions from methyl and methoxy phenols.
- Burnt odors are associated with furans and alkyl benzaldehydes.
- The oxidized oily character is usually ascribed to alkenones, dienones, hydroxy cyclocarbonyls, and indanones.
- Irritation factors seem most frequently to be associated with the lower molecular weight phenols. Some benzaldehydes and methoxy benzenes may also contribute to this sensation.
- While some unsaturated aldehydes contribute to a portion of the exhaust odor complex, the most abundant exhaust aldehydes do not appear to contribute significantly.
- Neither sulfur nor nitrogen-containing species contribute to the smoky-burnt odor complex. Although such species were observed during portions of the analyses, none were associated with exhaust odors.

The present research program emphasizes the development of quantitative analytical methods for the aromatic (oily-kerosene) and oxygenated (smoky-burnt) odor fractions. Each of the steps in the analytical procedure is being examined from the points of view of reproducibility, potential for simplification, appropriateness for the final odor-chemistry correlation goal, and finally, convenience.

Adsorption methods appear promising for replacing the condensation method for sample collection. Quantitative analysis of the oily-kerosene aromatics odor fraction has been achieved with a low resolution mass spectrometry method. An analogous method for the smoky-burnt oxygenate fraction based on high resolution mass spectrometry is being evaluated.

An appropriate range of data with which to evaluate the effectiveness of the procedures is being obtained through the study of other diesel fuels and engine variables. The data obtained thus far show a good correlation between the amount of indans/tetralins present in the sample and the kerosene odor intensity. Similar correlations between the quantity of groups of chemical classes and odor intensity are being explored for the remaining exhaust odor character notes of interest.

KINETICS OF OXIDATION AND QUENCHING OF COMBUSTIBLES IN EXHAUST SYSTEMS OF GASOLINE ENGINES
CRC Project No. CAPE-8-68

Objective

The objective of this project is to develop an understanding of the oxidative phenomena of combustibles under temperatures, pressures, compositions, and flow conditions typical of the exhaust gas from gasoline engines.

Current Status

Three major lines of investigation have been pursued in this work by the contractor, the University of Michigan. These investigations include emission data from reactors mounted on a Chevrolet 350 CID V-8 engine, a computer simulation of reactor performance; and overall kinetics of oxidation of CO, hydrocarbon, and hydrogen in a well stirred reactor, mounted on the exhaust system of a single cylinder engine.

Both steady running conditions and warmup conditions have been investigated with the multicylinder engine-mounted reactors. Compositional measurements suggested a wide variation in the fraction of air injected as engine speed was changed. This was confirmed directly by hot wire anemometry of the air flow. Air flow was out of phase with the exhaust flow; at the time of maximum exhaust flow, the flow in the air tube was reversed. Emission measurements under steady running conditions showed that hydrocarbon, CO, and aldehyde emissions depended strongly on the air injection fraction, all reaching a minimum at a value of about 0.3 fraction air injection. Composition measurements of gases sampled at different points in the reactor showed that mixing of exhaust gases and injected air was not complete. Emissions from the reactor have been measured under a variety of engine conditions, and under warmup conditions. Hydrocarbon class analyses have been carried out; these suggest that the percent aromatics in the hydrocarbons emitted from the reactor do not vary much with air injection fraction. The percent paraffins passes through a minimum and the percent olefins passes through a maximum at an air injection fraction of about 0.2. Critical flow orifices have been installed in the air injection tubes in an effort to improve mixing of air with exhaust gas. Reactor emission measurements with this modification are currently being made.

The computer simulation model has been improved. A random coalescence model has been used to simulate the mixing. Comparison of computer calculations with reactor data permit a quantitative evaluation of mixing in the reactor. Hydrogen reacts at lower temperatures than carbon monoxide. Hence, by running the reactor very hot and measuring hydrogen conversion, one can measure mixing in the reactor. This has promise of practical application to the determination of mixing in reactors mounted in automobiles. Future work includes the comparison of the simulation model with the data obtained with improved mixing provided by the critical flow orifices in the air injection tubes. If required, as judged by the data, the simulation model will be refined.

Rate expressions for hydrogen, hydrocarbon, and carbon monoxide have been obtained by regression analysis of the single cylinder reactor data. The expressions apply to the specific case of oxidation of these substances in exhaust gas air mixtures. They are being used in the computer simulation model.

Completion of the University of Michigan effort is planned for this year with issuance of a final report in the fall of 1972.

AUTOMOTIVE FUELING EMISSIONS
CRC Project No. CAPE-9-68

Objective

The objective of this project is to survey the existing field situation to determine the magnitude and relative importance of fuel spillage and vapor evolution involved with vehicle fueling.

Current Status

The contractor, Scott Research Laboratories, has completed the second year of study and an annual report will be published in early 1972. A five city, four season field survey was conducted which involved over 6,000 observations of fueling operations. Spills were observed during one-third of the observed fueling operations. A regression model for the estimates of displaced hydrocarbon losses during fueling of passenger cars, based on 103 controlled laboratory experiments, is being developed as a function of average dispensed fuel temperature and Reid Vapor Pressure. Temperatures recorded for 732 fueling operations observed during the field survey, together with published Reid Vapor Pressure values, were used as inputs to the regression model. Displaced vapor losses accounted for over 94% of the total hydrocarbon losses during fueling operations. Spill losses accounted for the remaining 6% of the total.

It is anticipated that future work will determine the magnitude of losses associated with fueling trucks, and refinement of the existing mathematical model in terms of ambient temperature, underground fuel temperature, and other pertinent parameters.

TRAFFIC SURVEY FOR DEVELOPMENT OF AVERAGE DRIVING CYCLES
CRC Project No. CAPE-10-68

Objective

The objective of this project is to collect and evaluate information on urban traffic patterns and to recommend additional action for the development of an average driving cycle which could be used in future emission testing programs.

Current Status

Contract work in this project has been conducted in two phases. The objective of the first phase was to determine basic traffic patterns in six large metropolitan areas: Los Angeles, Houston, Cincinnati, Chicago, Minneapolis-St. Paul and New York. This phase was carried out by System Development Corporation. All traffic pattern survey information has been obtained and summary reports have been completed on each of the six cities. An over-all summary report of the results of the study has also been prepared and published. System Development Corporation also reanalyzed traffic survey data gathered by 3M in Los Angeles as part of the CAPE-5-68 activities. A report on this reanalysis has been published which provides a basic comparison of the results of these two surveys in Los Angeles.

The second phase of this project was conducted by Scott Research Laboratories. The objective of this phase was to obtain detailed vehicle modal operating parameter information (speed, acceleration, deceleration, engine vacuum, etc.) on test vehicles operating on the traffic patterns delineated by the SDC study. The basic measurements needed in the Scott study have been completed. Only five of the six cities originally surveyed by SDC were included in the phase two study. Minneapolis-St. Paul was deleted from the study because its basic traffic patterns appeared similar to those in other cities included in the study. All data acquisition and computer processing of the data have been completed. Reports on the project are in the process of being completed. It is anticipated that these reports will be published in early 1972.

IMPROVED INSTRUMENTATION FOR DETERMINATION OF EXHAUST GAS NITROGEN OXIDES AND OXYGENATE CONTENT
CRC Project No. CAPE-11-68

Objective

The objective of this project is to develop improved instrumentation for continuous measurement of exhaust gases for nitrogen oxides and oxygenate content on a concentration, mass and reactivity basis.

Current Status

To develop satisfactory continuous techniques for measuring exhaust oxygenates under both steady-state and cyclic operating conditions, two studies are being conducted under contract. The immediate objective of work sponsored at the Bureau of Mines is to obtain data on relative levels of carbonyl and noncarbonyl oxygenates in exhausts from current-model automobiles using simply hydrocarbon fuels. The ultimate objective is to estimate the contribution of noncarbonyl to total oxygenates in gasoline exhaust to determine whether routine analytical methods for noncarbonyl oxygenates are required. Using a 1970-model auto on a chassis dynamometer, quantitative exhaust oxygenate data have been obtained from 22 fuels (seven single-component and 15 multi-component). Applying analytical techniques developed by the contractor, 34 different oxygenates have been identified. These techniques include isolation of exhaust oxygenates as either oximes or dinitrophenylhydrazones with subsequent separation and identification by gas chromatography and mass spectrometry. Future work includes determination of oxygenates (all classes) in exhaust from (1) a current-model auto operated through typical traffic cycles using simple fuels and a full-boiling-range gasoline and (2) an advanced-design, low-emission auto using simple fuels. An annual report detailing progress will be published early in 1972.

In a second study being conducted by Scientific Research Instruments Corporation, the technology of chemical ionization has been combined with direct-reading mass spectrometry to construct a prototype instrument which simultaneously and continually measures the nine most prevalent aldehydes and ketones believed to be present in auto exhaust. Response time of the instrument has been shown to be adequate and work is now in progress to establish the sensitivity and accuracy under practical operating conditions with a current-model auto on a chassis dynamometer. Arrangements have been made with Esso Research and Engineering Company to provide facilities for testing the instrument early in 1972. The work will be monitored by Esso using the DNPH procedure. A progress report on the first year of work at SRIC has been issued; a report on the second year's work is in preparation and will be published in the first quarter of 1972.

TECHNIQUES AND INSTRUMENTATION FOR ANALYSIS OF EXHAUST GASES FOR PARTICULATE MATTER AND POLYNUCLEAR AROMATICS
CRC Project No. CAPE-12-68

Objective

The objective of this project is to develop techniques and instrumentation for the sampling and analysis of exhaust gases for particulate matter and polynuclear aromatic content. Reducing the analytical cost and elapsed analytical time is of prime importance.

Current Status

The major objective of the program has been accomplished. A final report from the contractor, Esso Research and Engineering Company, is in preparation and will be published in early 1972. The CAPE-6-68 project has used, and continues to use, the methods devised under this project to obtain analytical composition data essential to interpretation of PNA emission studies.

The major accomplishments of the program are as follows. An improved method to determine benzo(a)pyrene (BaP) and benz(a)anthracene (BaA) in auto exhaust tar, gasoline, and crankcase oil which results in a substantial reduction in analytical cost over previous methods of similar accuracy was successfully developed. The CAPE-6-68 project group cooperated in evaluation of the new method. The contractor conducting the CAPE-6-68 studies reported that the new method costs only one-third as much as the thin layer chromatographic method previously used and, the accuracy is at least as good, in some cases better. Also, nine additional polynuclear aromatic hydrocarbons are determined concurrently by the CAPE 12 method. These are pyrene, chrysene, triphenylene, methyl BaA, dimethyl BaA, benzo(e)pyrene(BeP), methyl BaP, methyl BeP, and benzo(g, h, i) perylene. The eleven compounds occur in auto exhaust tar in concentrations at the parts-per-million level; yet, all eleven are determined by the CAPE-12 method with an average total manpower cost of 20 man hours per auto exhaust tar analyzed (based upon analyzing the CAPE-6 samples for about one year). In the past year, three additional compounds [benzo(b)fluoranthene, benzo(j)fluoranthene, and benzo(k)fluoranthene] have been recognized as being determinable by the present method with only a small increase in analytical cost. The method can be extended to include still other similar compounds but such is not planned at this time. It is believed that is the first time that alkylpolynuclear aromatics have been determined accurately in auto exhaust tar; and, that this is a technically important feature of the new method.

A second accomplishment is the development of a method to determine the total PNA content of auto exhaust tar. This method also is being used by the CAPE-6-68 contractor. To determine total PNA, an aliquot of the same PNA concentrate used in the GC/UV procedure is analyzed by low voltage mass spectrometry utilizing triphenylbenzene as an internal standard. The PNA types reported include from tri- to hepta-cyclic aromatics. Individual compounds have been found to account for only a small portion of the total PNA. For example in a typical sample BaP and BaA are only 0.4 and 1.0%, respectively, of the total PNA (including four and more rings). The BaP and BaA concentrations in the whole auto exhaust tar are in the parts-per-million level.

In the third major accomplishment, a solvent extraction-gas chromatographic method was developed for the quantitative determination of individual phenols in the aqueous

condensates produced along with exhaust tar in CAPE-6 engine tests, the phenol concentration in two condensates was found to be 65 and 100 ppm, the individual cresols ranged from seven to 15 ppm, and the xylenols were less than one ppm.

INSPECTION, MAINTENANCE, SURVEILLANCE AND ECONOMIC EFFECTIVENESS STUDIES
CRC Project No. CAPE-13-68

Objective

The objectives of this project are to:

(a) Develop short-time interval exhaust emission test cycles for use in state inspection procedures and franchised inspection facilities.
(b) Develop inspection and maintenance procedures which will evaluate the visually observed and measured parameters having a primary effect on exhaust emissions.
(c) Evaluate the effectiveness of short test cycles (Item a) and inspection and maintenance procedures (Item b) in controlling emissions from vehicles in service.
(d) Optimize statistical and testing techniques for an effective customer's vehicle surveillance program.
(e) Model practical inspection, maintenance, surveillance schemes for motor vehicle pollution control and make an economic-effectiveness comparison of the alternate combinations.

Current Status

TRW Systems and its subcontractor Scott Research Laboratories have completed the original Phase One Program. The economic-effectiveness model developed during this program estimates exhaust emission reductions based upon measurements using the open, seven-mode cycle and describes emission controlled vehicles for model years 1968 through 1970 only. Phase one program results have been published in three volumes–Volume I–Executive Summary, Volume II–modeling of Inspection/Maintenance Systems and Volume III–Inspection and Maintenance Procedures.

The Extended Phase One Program was started in March 1971. Tasks were undertaken to:

- Diagnose the maintenance state of in-use vehicles to determine more accurately the frequency and extent of engine and control device malfunctions and their associated emission signatures (HC, CO and NO exhaust emissions measured in selected vehicle operating modes and cycles) for vehicles in several regional populations. This task was completed in 1971.

- Conduct statistically designed tests on basic power trains to determine the effects of engine malfunction and maladjustment upon exhaust emissions for precontrolled and California 1971 NO_x controlled vehicles. This task will be completed in January 1972.

- Perform fleet tests over a period of 18 months to establish the changes of engine adjustments with time and the associated change in mass emissions as measured with the 1972 Federal test procedure. Nine months of this testing program were completed in 1971.

- Perform controlled experiments to characterize the effectiveness with which specified maintenance is performed by commercial service organizations. Approximately one third of these tests were completed in 1971.

- Revise the computer model using the closed, seven-mode cycle mass emissions data obtained during Phase One and report the results for interim use. This task was completed in 1971 and a draft of an interim report issued.

- Use the mass emissions data based upon the 1972/75 Federal test procedure which is available at the end of the first year of the Extended Phase One Program to reevaluate the economic-effectiveness of mandatory inspection/maintenance procedures. This task has been started.

An operating computer model is available with which to evaluate the economic-effectiveness of mandatory inspection/maintenance. Specific data are required to describe such things as the vehicle population density and the relative importance of reducing individual exhaust emission species when using the model to evaluate inspection/maintenance as a means for controlling air pollution within selected regions. A wide range of emission inspection and engine parameter inspection procedures can be studied and optimized. The following preliminary conclusions are based upon using the computer model with closed, seven-mode mass emissions data:

- The most cost effective inspection/maintenance interval is approximately yearly regardless of the procedures applied.

- Inspection procedures performed in a state lane using emission measurements under load are generally more cost effective than those performed in franchised garages using conventional diagnostic instruments, but produce smaller emission reductions.

- The economic-effectiveness of vehicle inspection/maintenance is highly dependent on the demographic and air quality objectives (relative importance of reducing various emission species) of a given region.

- The predicted percentage reduction of exhaust emissions for various programs of mandatory inspection/maintenance are smaller when mass emission measurements are used than when based upon concentration measurements.

- The absolute magnitude of emission reductions in tons per year is slightly greater when based upon mass emission measurements rather than upon concentration measurements.

- Larger HC and NO emission reductions (absolute) and smaller CO emissions reduction (absolute) are estimated for similar inspection/maintenance procedures when mass emission data are used in place of concentration data.

CHEMICAL AND PHYSICAL CHARACTERIZATION OF AUTOMOTIVE EXHAUST PARTICULATE MATTER IN THE ATMOSPHERE
CRC Project No. CAPE-19-70

Objective

The objective of this project is to determine the physical and chemical characteristics of particulate matter from internal combustion engines as a function of sampling procedure, engine operating conditions including emission control systems, fuel composition, and residence time in the atmosphere. Emphasis is to be placed on the study of particulate matter during its lifetime in the atmosphere.

Current Status

Work, at the Battelle Memorial Institute, during the second contract year (which was initiated by CAPE-12-68) has been reoriented to accomplish the broadened objective as defined with the formation of CAPE-19-70.

Two 1971 350 CID V-8 matched Ford engines (exhaust emission control by engine modification) have been installed in 1970 Fords. These engines were supplied after assembly from production parts which had been selected for close dimensional similarity. Both cars have been operated on non-leaded gasoline on a chassis dynamometer and accumulated approximately 4,500 miles each. Total hydrocarbon, carbon monoxide, and total particulates in the exhausts are similar. Particle size distribution, particle morphology, and chemical analyses currently are being studied. Once similarities are suitably documented, one car will begin operation on leaded gasoline.

A major effort this year has been the design, construction, and testing of an exhaust dilution tunnel complete with sampling stations and essential on-line instrumentation. This system dilutes auto exhaust over the range of 600-2,400 cfm which corresponds to an average dilution based on the 1972 Federal driving cycle of approximately 25:1 to 100:1. Mixing was found to be uniform and velocity profiles flat at the major sampling station. Diluted exhaust is sampled on cascade impactors to obtain particle size classification above 0.25 micrometer; and, to provide samples for physical and chemical analyses. Total particulate matter is measured by filtration. Light scatter measurements are made on the freshly generated and diluted aerosols. Initial study by electron microscopy of particles emitted from a 1971 engine operated on non-leaded (less than 0.03 gm Pb/gal) gasoline indicated that these particles are agglomerates. The particles resembled soot and had relatively transparent cores compared to those previously examined from operation with leaded gasoline in another auto.

Analytical techniques have been studied which may aid to determine the chemical changes which take place in auto exhaust particulate matter in the atmosphere. Several methods for measuring benzo(a)pyrene (BaP) and other polynuclear aromatic hydrocarbons associated with small quantities of exhause particulate were investigated. A minimum of one nanogram BaP was measurable with a spectrofluorometer. High pressure liquid chromatography using oxypropionitrile on Porocil C in a microcolumn gave good separation of polynuclear aromatic hydrocarbons. The combination permitted measurement of 0.02 micrograms BaP. The determination of benzo(a)pyrene associated with single discrete agglomerates was not attained, and does not appear attainable without fractionation of the organic component of the particulate matter.

The second Annual Report on this work by Battelle Memorial Institute currently is nearing completion and will be issued soon. Plans are to proceed soon with initial studies to determine the physical and chemical changes in auto exhaust particulate matter as it is further diluted and resides in the atmosphere for various lengths of time.

NITRIC OXIDE FORMATION IN DIESEL ENGINES
CRC Project No. CAPE-20-71

Objective

The objective of this project is to determine the factors that control the formation of oxides of nitrogen in diesel engines.

Current Status

The organizational meeting of this project group was held in the fall of 1971. At this first meeting, the guidelines for the program were developed and a statement of work was prepared. Requests for proposals are to be made in early 1972 and it is anticipated that a contractor will be selected and research will begin in the late spring of 1972.

The present research plan includes an examination and correlation of combustion and engine parameters, development of a model of the diesel combustion process and verification of the model.

TRUCK DRIVING PATTERN AND USE SURVEY
CRC Project No. CAPE-21-71

Objective

The objective of this project is to develop background information on heavy duty truck traffic patterns and use in major urban areas to allow formulation of a recommendation for an average truck driving cycle to be used in future emission testing programs.

Current Status

A two phase program has been developed. In the first phase, a contractor will compile available information on truck use patterns in urban areas. Information will include, but not be limited to, total yearly mileage, daily number of trips, distance of trips and truck load factor per trip. Vehicles will be characterized by gross vehicle weight, use type and engine type. Representative routes for the various truck categories, in both New York City and the Los Angeles Basin, will be determined.

In the second phase, which may involve a second contractor, instrumented vehicles will be operated over representative routes to obtain detailed vehicle operating characteristics, such as acceleration and deceleration rates.

Negotiations with a contractor for the Phase I effort are proceeding and work should begin early in 1972.

FACTORS AFFECTING REACTIONS IN ENVIRONMENTAL CHAMBERS
CRC Project No. CAPA-1-69

Objective

The objective of this project is to study how various design and operational variables affect the reactions which occur in environmental chambers.

Current Status

The research program has been divided into two phases. Phase I covers the design, fabrication, and testing of an irradiation chamber capable of accommodating controlled and independent variations in surface area, surface materials, surface treatment, irradiation intensity, and spectral distribution. Phase II covers the execution of three experimental studies to delineate: a) the effects of surface variables on photochemical reactions, b) the effects of radiation variables on photochemical reactions, and c) the influence of such factors as humidity, hydrocarbon concentration, NO_x concentration, and SO_2 concentration on the surface effects observed in (a) above.

Actual execution of Phase I was initiated in February 1971, at Lockheed Missiles and Space Company. The design and fabrication of the irradiation chamber, associated temperature control equipment, and reactant charging apparatus has been completed. In addition the analytical methods are operational for propylene, NO_2, NO, and acetaldehyde, formaldehyde, oxidant, water, and carbon monoxide. Subsequent work added SO_2 methodology to the analytical capability, leaving peroxyacetylnitrate as the only compound of interest without an operational method. A resolution of the peroxyacetylnitrate analysis problem is anticipated in the near future.

The smog chamber is designed to be illuminated by an existing collimated-beam, xenon-arc solar simulator. The existing reflector mirror is being replaced by a sixty inch rhodium coated reflector mirror, overcoated with aluminum to increase reflectance particularly in the 300 to 400 nm wave length range. Completion of Phase I is anticipated in March or April of 1972.

PLANT DAMAGE BY AIR POLLUTANTS
CRC Project No. CAPA-2-68

Objective

The objectives of this project are to:

(a) Determine the nature and extent of damage produced to plants by air pollutants.

(b) Identify the principal sources of pollution which may cause significant plant damage and the economic value of such damage.

(c) Indicate the degree to which specific automotive emissions are responsible for plant damage.

Current Status

Research on this project during the past year has been directed toward obtaining information regarding air pollution effects on forests, parks, cemeteries, school and college campuses, and residential ornamentals. Detailed information on acreage and the location of such landscaped areas is not available from published surveys, so it was necessary to accumulate such data.

Secondly, the estimated exposure of each area to air pollution was determined. An effort was made to assess the probable degree of damage on the basis of type and level of pollution, and sensitivity of the plant, shrub, or tree to damage. Since it is difficult to assess the value of forests, parks, etc., an estimate was based on the annual value of products sold, or annual maintenance costs.

From this information, it was estimated that residential landscaping ornamentals represented by far the greatest potential loss. Initial estimates of potential losses are very preliminary and are based on extrapolations from losses in Southern California. An important objective in the continuing study will be to refine the estimating procedure and to confirm it by spot checks of representative areas throughout the country.

Also, during the past year the contractor, Stanford Research Institute, has made efforts to confirm calculated losses to commercial crops in several specific locations. Local estimates of economic losses have agreed moderately well with calculated losses. The calculated losses referred to here are based on a tabulation of market value for each agricultural crop, and air pollution exposure for each of 551 counties in the United States, representing the prime exposure areas. The loss estimation procedure has been computerized. Results will be updated as new information from the recent census and new crop information become available. A continuing emphasis will be placed on confirming the calculated loss procedure through first-hand observation by the contractor, and through appropriate agricultural sources.

An annual report summarizing results of the past year will be published in early 1972.

DIFFUSION MODEL OF URBAN ATMOSPHERE
CRC Project No. CAPA-3-68

Objective

The objective of this project is to develop a mathematical model which will predict the spread of automotive air pollutants throughout a city which contains both urban and suburban areas, and which can be extended to predict how the contamination from such a city will spread throughout neighboring geographical regions.

Current Status

This project is directed toward the development of a methodology for predicting the concentrations of air pollutants at any selected location throughout an urban area as a function of local meteorology and the distribution of pollution sources. It is limited to pollutants which result from automotive emissions, either directly or as the result of subsequent chemical or photochemical reactions. At any particular location, in addition to predicting long-term average exposure, it is also expected to predict the percentage of the time at which hourly averaged concentrations above any specified level can be expected to occur. The methodology is being developed as a tool for city planning organizations so that they may be able to predict the pollution patterns which might be expected to develop in any urban region as a result of predicted growth.

Although the ultimate aim of this program is to handle all types of automotive generated pollutants, a first step was to develop procedures for predicting the dispersion of a chemically inert pollutant such as carbon monoxide. A contract for developing such a model was granted to Stanford Research Institute in April 1969. They were charged with developing and validating the model from existing information, with identifying the information needed to complete the validation of the model, and with designing a field program which would provide the missing information.

The working model was completed during 1970. This receptor-oriented model incorporates diffusion submodels based upon both gaussian-shaped and uniform vertical concentration profiles. Model inputs are traffic volumes on major streets and highways in the urban area, atmospheric stability, mixing depth, and wind speed and direction. Traffic volumes can be obtained from either past measurements or forecast values. Methods have been developed for estimating atmospheric stability and mixing depth from conventional (i.e., airport) hourly meteorological measurements and twice daily radiosonde data. The model can provide statistical summaries as well as hour-by-hour predictions. It has been applied to five different cities (St. Louis, Washington, Chicago, Cincinnati, and Denver) in several different ways to demonstrate its usefulness. Among others, the following different types of calculations were performed:

- Maps of concentration isopleths for the five cities, based on calculated concentrations at 725 points (25 X 25 grid).
- Week-long sequences of calculated hourly concentrations at single points in each of the five cities.
- Maps of concentration isopleths for St. Louis based on forecasts of 1980 traffic, and two hypothesized levels of exhaust emission control.

- Concentration frequency distributions for various averaging times and times of day, for a location in St. Louis, based on a five-year (1960-64) meteorological record and historical as well as forecast traffic data.

- The median and 90-percentile values of hourly concentration at nine St. Louis locations, based on the same data as above.

For validation purposes, the field concentrations calculated by the model have been compared with those measured at Continuous Air Monitoring Program (CAMP) stations in the five cities studied. These comparisons demonstrated that while the relative pattern of CO levels could be predicted for continuous periods as long as one week, the observed concentrations were usually higher than those predicted, particularly during peak periods. To some extent, these discrepancies can be attributed to inadequate input data for the model and to inaccuracies in the CAMP data. They appear principally due however to the weakness of the model in treating diffusion from nearby sources since the CAMP stations are located at ground level alongside busy downtown streets.

During the second year of the project a field program was undertaken in San Jose, California to obtain additional data for improvement of the model. San Jose was selected for this study because (1) it is a typical, small-size city with rather uniform building heights, (2) it is one of the few cities equipped with a computerized traffic network which can provide accurate input information, and (3) it is close to the SRI laboratories which facilitated the initial shakedown of the equipment and procedures. The principal activity in this program was the careful instrumentation of a street intersection and the adjacent side streets in the downtown section of San Jose to obtain data on how the carbon monoxide being emitted by the street traffic was circulating within the street "canyons." Other studies involved the use of a helicopter to measure carbon monoxide concentrations at building top level throughout the city and to improve the procedures for predicting the meteorological parameters in the urban area from radiosondes taken at the nearby airport.

The San Jose program was quite successful in extending the model to predict the CO concentrations which might be expected at various levels between the buildings which border busy downtown streets. These observations showed that, depending upon the wind direction and velocity at roof top level, carbon monoxide concentrations measured near the sidewalk on opposite sides of the street could differ by a factor of three or more. The data obtained from the helicopter flights contributed to the improvement of the model as a whole.

Field studies were continued during the third year of the project to determine whether the model as developed in San Jose could be validated with data in another city. St. Louis was selected for this phase of the project since it provided the opportunity to obtain data from a downtown section in which the buildings were higher than San Jose. These studies were completed in the late fall of 1971 and the data are now being analyzed. A final report on the CO modelling study should be issued in the spring of 1972.

FATE OF CARBON MONOXIDE IN THE ATMOSPHERE
CRC Project No. CAPA-4-68

Objective

The objective of this project is to identify significant mechanisms by which carbon monoxide is removed from the atmosphere.

Current Status

While carbon monoxide is generally regarded as an unreactive material under ambient conditions, the worldwide level of CO in the atmosphere is actually much lower than would be predicted based on annual emission rates. In addition the production of CO by natural processes far exceeds that produced from combustion. The main focus of three CRC contract efforts in this subject has been to learn more about the removal mechanism accounting for the CO lifetime in the atmosphere. Research at Stanford Research Institute has indicated that the soil may be a major natural sink for atmospheric carbon monoxide. Greenhouse potting soil was found to deplete the CO in an experimental atmosphere from over 120 ppm to undetectable concentrations within a three-hour period. Sterilization of the soil by autoclaving or with antibiotics or sodium chloride completely eliminated this activity. Natural soils from a total of 17 different sites in California, Hawaii, and Florida, when tested at 25°F under laboratory conditions, ranged in uptake activity from 2.16 to 16.99 mg CO/hr/m^2 exposed surface area, with an average rate of 8.44 mg CO/hr/m^2. Activity varied in proportion to organic matter content and pH. If this average is used as a basis for estimating the activity of natural soils, the soil of the continental United States would theoretically be capable of removing 569 million metric tons of CO per year from the atmosphere.

Among the 200-plus different soil microorganisms isolated from three of the natural soils, 16 fungi were found which were able to remove CO from experimental atmospheres in pure culture. These fungi were: four strains of Penicillium digitatum; Penicillium restrictum; four Aspergillus species; Mucor hiemalis; and two strains each of Haplosporangium parvum and Mortierella vesiculata. None of the bacteria isolated were found to have activity. Hence the capability of natural soils for CO uptake appears to reside in the activity of certain soil fungi.

Research is in progress to determine more precisely the capacity of the soils of the North American continent to serve as a sink for atmospheric carbon monoxide. A field study has been designed and started during 1971. Soils will be tested in their natural state at numerous sites selected to represent the major vegetation classes of the North American continent. Also, laboratory studies on the influence of environmental variables (e.g. soil: pH; organic content; temperature; moisture content; surface) is continuing. Data obtained from this study will be used to arrive at an estimate of the capacity of the soils of North America to serve as a sink for CO and appropriate extrapolation will be made to arrive at a global estimate.

Argonne National Laboratory is conducting a study of carbon monoxide in the atmosphere with special emphasis on the kinds and extent of natural sources. Extensive sampling of the atmosphere and isotopic analysis of both carbon and oxygen in the contained CO indicate the existence of atmospheric CO with different isotopic compositions of which two are different from that found in emissions from combustion. The isotopic composition of

atmospheric CO of noncombustion emission origin, shows regular seasonal variations with the annual occurrence of two distinct varieties. The principal type occurs predominantly in the summer in the northern hemisphere and appears to originate from a source in the atmosphere rather than from surface emissions. The most logical source of this CO is the oxidation of atmospheric methane. For the northern hemisphere the rate of production is estimated at 3 to 6×10^8 tons/month during June to September and 2 to 4×10^9 tons annually. The second variety of atmospheric CO occurs in the autumn and appears to originate from surface emissions which are probably the result of the degradations of chlorophyll in plants and trees.

This seasonal burst of CO is estimated to be as high as 1×10^9 tons emitted over a one-and-one half month period. In addition, studies with green and blue-green algae provide evidence for two other sources of carbon monoxide in nature; the biosynthesis of bilinoid pigments by fresh-water algae and the degradation of chlorophyll in fresh-water algae. Studies have been made of the amounts and isotopic composition of CO in ocean water, fresh water systems, rainwater, and some trees and plants in the growing season. Preliminary results indicate that none of these produce CO in amounts comparable to the sources discovered.

LIGHT HYDROCARBONS IN THE ATMOSPHERE
CRC Project No. CAPA-5-68

Objective

The objectives of this project are to:

(a) Analyze ambient air samples for hydrocarbons in a broad spectrum of locations to determine the relative amounts of these hydrocarbons as compared with the distribution reported from known sources, including automotive exhaust.

(b) Improve the chromatographic column-freezeout technique to extend the range of hydrocarbons to the higher carbon number so as to include aromatics and terpenes.

(c) Irradiate samples of ambient air and determine the disappearance rates of the hydrocarbons.

Current Status

The study of ambient air hydrocarbons conducted under contract by the Air Pollution Research Center at the University of California, Riverside, had been limited to paraffins and olefins of six carbons and less. This work was useful in evaluating the contribution of paraffins and olefins under real ambient air conditions. It was concluded that paraffins, even though they are of medium to low reactivity, must make a significant contribution to total reactivity.

At one time aromatic hydrocarbons were thought to be nearly inactive in the atmospheric reaction because of the inertness of benzene and toluene. More recently it was found that the di- and trialkyl benzenes have quite significant reactivity and, furthermore, they undergo ring rupture to form (among other products) peroxyacyl nitrate. Still more surprising was the contrasting finding that benzylic hydrocarbons react by side chain oxidation to form peroxybenzoyl nitrate, a very potent eye irritant. These findings generated renewed interest in the role of aromatics in the smog reaction and prompted a redirection of this project toward a study of aromatics.

In the past year, significant advances have been made in technique and initial experiments relating to the study of aromatics have begun. A new gas chromatograph was fitted with a column suitable for the separation of about a dozen aromatics.

This system also permits detection of some natural products (alpha and beta pinene) and four oxygenated compounds (acetaldehyde, propionaldehyde, acetone and methyl ethyl ketone). Samples of ambient air have been analyzed before and after four hours ultraviolet irradiation. The contribution of aromatics to "total hydrocarbons reacted" was appreciable as compared to the olefins and paraffins. Moreover the relative reactivities of the various hydrocarbons were as expected based on prior laboratory studies of individual aromatics.

The activity of the aromatics and especially the side chain oxidation of the benzylic hydrocarbons raises the question of the active species responsible for the attack. If the active specie is different for different hydrocarbons (e.g., O atoms for ring rupture versus NO_3 for side chain oxidation), relative reactivities may well be dependent on time of reaction and on concentration of reactants. Toluene, propene and isopentane were

photolyzed statically with nitric oxide in a 50 liter Pyrex bottle in a first test of this idea. No effect of reaction time on relative rates was detected. Further tests of this hypothesis are planned for the near future.

HAZE FORMATION: ORIGINS AND IMPORTANCE TO AIR POLLUTION
CRC Project No. CAPA-6-68

Objective

The objective of this project is to identify, analyze and measure atmospheric haze in order to distinguish between photochemical haze derived from automotive sources and haze resulting from non-automotive sources.

Current Status

Two experimental programs were underway during 1971. These were directed toward the analysis of aerosols of natural and man-made origins. Science Spectrum, Inc., investigated the light scattering of single aerosol particles from automotive and natural hazes. The results indicated that particles of different origins have different optical properties. However, more work is necessary to develop a practical analytical method. The study has been completed and a final report has been published.

The second experimental program was conducted by Battelle Memorial Institute. Battelle analyzed aerosols obtained in New York City, Great Smoky Mountains, in laboratory smog chamber facilities, and from primary automobile exhaust.

The results indicated that certain organic chemicals were present in aerosols associated with auto exhaust which were not present in aerosols from rural atmospheres. On the other hand, at least one organic compound was present in aerosols from rural atmospheres which was not present in urban air aerosol samples. These results indicate that the presence of certain organic compounds in aerosol samples may indicate the origin of a haze. An annual report describing the research is in preparation and should be published in early 1972.

MEASUREMENTS OF ATMOSPHERIC POLLUTANTS IN URBAN AREAS
CRC Project No. CAPA-7-70

Objective

The objective of this project is to provide measurements needed to determine the validity of laboratory studies of the effect of nitrogen oxides on atmospheric reactions to provide measurements of the chemical changes occurring to pollutants under atmospheric conditions.

Current Status

An experimental study was carried out by Scott Research Laboratories during the summer of 1970 in the New York-New Jersey area. This aerometric study was similar to the aerometric studies conducted by Scott in the Los Angeles Basin the previous two summers. Measurements were made during 40 days at three ground level sites; airborne measurements were made on 20 of those days. A helicopter following launched tetroons was used to sample the atmosphere.

At one of the ground level sites the carbon monoxide concentrations for a one hour average, exceeded 10 ppm on seven out of 48 days; and, at a second site, it exceeded 10 ppm on seven out of 63 days.

The maximum one hour average for total oxidants reached three pphm or higher on 12 out of 69 days at the sampling site located in the Bronx, but only two out of 74 days at the site located on Staten Island. The Bronx site also measured nitrogen dioxide levels in excess of 10 pphm on 24 out of 66 days.

The final report on the New York-New Jersey study has been released and is available. Further analysis of the data, along with possible atmospheric modeling efforts, may be conducted during 1972.

Stanford Research Institute has conducted a study of the smog patterns over the San Francisco Bay. This preliminary study has been completed and it has been concluded from climatological and field oxidant sampling that studies of photochemical reactions over the bay are warranted. Photochemical reaction studies can be conducted without the complication due to a continuous input of pollutants to the air mass undergoing change.

DETERMINATION OF THE FORMATION MECHANISM AND COMPOSITION OF PHOTOCHEMICAL AEROSOLS
CRC Project No. CAPA-8-71

Objective

The objective of this project is to determine the formation mechanism and composition of photochemical aerosols in a smog chamber.

Current Status

The importance of photochemically-produced atmospheric aerosols has been recognized in recent years as a significant factor in the reduced visibility associated with photochemical smog. The actual transition stage between a gaseous reactant molecule and the product aerosol, as well as the growth of small aerosols to light-scattering entities, are not well defined.

In its discussion with potential contractors, the project group emphasized the desirability of innovative approaches to the problem as operational studies to date have been plagued with experimental uncertainties, such as wall effects and stirring.

The project group has selected two proposals, both of which meet the project's objective, but approach the problem from different points of view. One is concentrated on the chemical kinetics of simple hydrocarbon-NO_x systems with the detection and characterization of initial condensible products as a prime goal. This study is designed so as to reduce or eliminate wall effects in the experimental system. The other study will emphasize the physics of aerosol growth and decay. Environmental chambers of varying surface-to-volume ratio will be used along with detection equipment which embody the latest advances in particle counting, particle size distribution, etc. Research effort will commence early in 1972.

ATMOSPHERIC ANALYTICAL CHEMISTRY
CRC Project No. CAPA-9-71

Objective

The objective of this project is to search for additional components in polluted atmospheres that contribute to eye irritation and visibility reduction in concentrations in the parts per billion range.

Current Status

It is intended to search for trace components in polluted atmospheres that may contribute to eye irritation and visibility reduction. Oxygenated hydrocarbons, such as peroxides, and chlorinated hydrocarbons, such as acyl chlorides, are examples of materials suspected of contributing excessively to physiological and phytotoxilogical responses.

The project group is being organized. Early steps leading to a selection of a contractor should begin in spring of 1972.

REACTIVITY OF DIESEL EXHAUST
CRC Project No. CAPA-10-71

Objective

The objective of this project is to determine the reactivity of diesel exhaust hydrocarbons in large reaction chambers.

Current Status

To assist in properly establishing the degree of control necessary for diesel engines, information on the reactivity and quantity of hydrocarbons exhausted should be developed. In particular, a comparison of exhaust reactivity should be made between hydrocarbons exhausted from diesels and hydrocarbons exhausted by spark-ignited engines. Also, the diesel exhaust hydrocarbons are to be divided into light and heavy fractions and the reactivity of each fraction is to be measured.

The project group is being organized. It is expected that the initial actions required to select a contractor will be complete early in 1972.

CONTRIBUTION OF NATURAL HYDROCARBON EMISSIONS TO THE OVERALL HYDROCARBON POLLUTION BURDEN
CRC Project No. CAPA-11-71

Objective

The objective of this project is to assess the contribution of natural hydrocarbon emissions to the overall hydrocarbon pollution burden in the atmosphere.

Current Status

Little effort has been expended to assess the concentration and photochemical reactivity of natural hydrocarbon emissions such as the terpenes and isoprene in environments close to urban areas. In this project emphasis will be directed toward aerosol formation involving these materials, with subsequent transport to urban areas. The relatively high reaction rates of natural emissions with ozone and the formation of particulate matter over forested areas indicate that these emissions cannot be ignored, especially with increasing control of automotive hydrocarbon emissions.

This study is being conducted by the CAPA-6-68 project group along with the study on haze formation. A contractor will be selected early in 1972 and the research should begin by mid-1972.

EFFECTS OF CARBON MONOXIDE ON HUMAN BEHAVIOR
CRC Project No. CAPM-3-68

Objective

The objective of this project is to increase knowledge on the effects of exposures to air pollutants, in particular, carbon monoxide, with special emphasis on impairment of behavior not heralded by symptoms.

Current Status

The third year of investigation at the Medical College of Wisconsin into the effects of CO upon man was primarily directed to investigating more intensively the effects upon the higher intellectual functions of man. To accomplish this, experiments in the controlled environment-chamber were conducted.

The investigation of carbon monoxide upon time sense included four tests performed in three different environmental situations. The four tests were: the Beard-Wertheim test, the 10-second time estimation test, the 30-second time estimation test, and the Marquette time test (parameters of this test are described in detail in the Archives of Environmental Health, August 1970). These four tests were performed in the group setting within the chamber, with the individual isolated in the chamber and with the individual isolated in an audiometric booth situated within the exposure chamber. To preclude error, the data have been analyzed by two independent biostatistical groups. The analyses are nearly completed and will comprise a report which demonstrates that time sense is resistant to carbon monoxide effect. One can intoxicate a healthy adult to a point where the individual has headache, demonstrable increase in reaction time, and impaired manual coordination without impairing time sense.

In addition to investigating the effect of CO upon time sense, the ability to perform arithmetic and general surveillance tasks was also intensively investigated using the standardized Flanagan tests. Exposures to carbon monoxide, below carboxyhemoglobin saturation levels of 15% produced no measurable decrement in performance.

Two additional test devices were devised and included in the third year of work. The first was the General Motors Phystester™ ignition interlock system. This is an electronic push-button device which tests visual acuity, short-term memory, eye-hand coordination and secondary task performance. The details of this segment of the test program will be included in the annual report to be published early in 1972. The second device developed was the Marquette eye-hand coordination test which is a pursuit-tracking task sensitive to blood alcohol concentrations in excess of 50 mg. Carbon monoxide exposures which did not result in carboxyhemoglobin saturations in excess of 15% did not result in decrement in performance of this test device.

The first of the studies investigating the combined effects of carbon monoxide plus drugs was commenced using alcohol plus carbon monoxide. To adequately investigate this area it was necessary to incorporate nine test devices into the testing protocol, these were: (1) Phystester™ ignition interlock system, (2) Marquette eye-hand coordination test, (3) AAA hand-steadiness test, (4) AAA driving simulator, (5) Flanagan coordination test, (6) Flanagan arithmetic test, (7) hand-reaction time test, (8) alcohol induced positional nystagmus, and (9) Crawford collar and pin test. To obtain adequate baseline data on these devices,

since there were no pre-existing performance norms for two of the devices, a total of 37 adult volunteers were trained and tested to establish the effects of alcohol. This group included the medical student groups upon whom the effects of carbon monoxide were being determined. The detailed analysis of this series of experiments has not been completed, but it appears that there is no synergistic effect of carbon monoxide upon alcohol intoxication, resulting in only additive effects.

EFFECTS OF CHRONIC EXPOSURE TO LOW LEVELS OF CARBON MONOXIDE ON THE CARDIOVASCULAR SYSTEM
CRC Project No. CAPM-4-68

Objective

The objective of this project is to obtain quantitative correlations between chronic exposure levels with carbon monoxide and physiological parameters of the heart and blood.

Current Status

The Jefferson Medical College of Philadelphia was selected to conduct a study of the effects of chronic exposure to low levels of carbon monoxide on the cardiovascular system. The program called for initial studies at CO levels of 100 ppm to be performed on two groups of dogs: normal and those with induced coronary disease. The first experiment concluded at the end of January 1970, after 14 weeks continuous exposure. The four treatment groups included:

12 dogs infarcted with Latex spheres exposed to 100 ppm of CO
6 dogs infarcted with Latex spheres exposed to ambient air
12 non-infarcted dogs exposed to 100 ppm of CO
6 non-infarcted dogs exposed to ambient air

The results of this initial experiment, which have been published in a formal report, were that no untoward obvious signs were noted which could be interpreted as carbon monoxide induced. Throughout the exposure to carbon monoxide the animals were in clinically good health. Although there were in a few selected animals exposed to 100 ppm carbon monoxide circumscribed areas suggestive of newer infarction, this did not represent a statistical difference. Also, there were no characteristic alterations of the ECG or serum enzymes, which could be attributed to carbon monoxide exposure. Hematologic parameters did not appear to change significantly during exposure to 100 ppm carbon monoxide. Carboxyhemoglobin averaged fourteen percent at 100 ppm carbon monoxide exposure.

Similar studies were then conducted with control and infarcted animals exposed to 150 ppm CO and to ambient air with the exposure period extended to 26 weeks. A third group of dogs was then prepared in the same way and exposed to 50 ppm of CO for about 26 weeks. During the final 22 weeks of this exposure both exposed and control animals were exercised at regular intervals.

The statistical analyses from these studies are complete and indicate no significant difference between the CO exposed and non-exposed groups. These two experiments will be detailed in a formal report to be published early in 1972.

At the conclusion of the dog studies it was decided to extend the work to another species. The cynamolgus monkey was chosen as an example of a primate. Except for smaller dose levels of microspheres because of the smaller size of the monkey's heart, the technique used was identical with that used in the dogs. An exposure level of 100 ppm CO was decided upon with an exposure period of about 26 weeks. This experiment ended in late October and analysis of the data is in progress.

TOXICITY OF POLYNUCLEAR AROMATIC HYDROCARBONS IN THE LUNG
CRC Project No. CAPM-5-68

Objective

The objective of this project is to study the role of some physiochemical characteristics of particulates in relation to the effect on respiratory carcinogenesis.

Current Status

Studies have been concerned with the effects of various dusts on the mechanism of carcinogenesis by polycyclic hydrocarbons, particularly benzo(a)pyrene. Prior studies had demonstrated that, whereas benzo(a)pyrene was not an effective carcinogen when administered endotracheally alone, it became a potent inducer of bronchiogenic carcinoma when combined with ferric oxide dust.

In last year's studies benzo(a)pyrene has been administered alone and then followed by repeated endotracheal instillations of ferric oxide dust. In another study ferric oxide dust instillations preceded the instillations of benzo(a)pyrene. The benzo(a)pyrene alone, as in prior studies, was largely inactive, inducing only a few benign tumors (papillomas) of the trachea and larynx; the ferric oxide either before or after the carcinogen had no appreciable effect and was, as before, without effect alone. In progress are a series of studies involving other dusts including aluminum oxide, magnesium oxide, and carbon black. The study with carbon black is starting to yield results, although it is much less effective as a carrier dust than the ferric oxide. The other studies are scheduled for completion next year. The studies with benzo(a)pyrene alone and with various combinations of iron are being prepared for publication.

Also, electron microscopic study, which is now underway, of the tumors induced in hamster lungs is permitting much more accurate diagnosis and clearer distinction between tumors induced by the various carcinogens.

SYNERGISTIC EFFECTS IN CERTAIN AIRBORNE SYSTEMS
CRC Project No. CAPM-6-68

Objective

The objective of this project is to investigate the possible joint physiological action of five common air pollutants in animals by simulating exposures to both high concentrations for a short time and at realistic levels encountered in urban air for long periods of time.

Current Status

The research, being carried out by Hazleton Laboratories, was designed to elucidate toxic effects in rats and monkeys resulting from the inhalation of major pollutants of urban air. The experimental work was started in late 1967 when a series of acute exposures to atmospheric pollutants at high levels were carried out, permitting observations of toxic effects and the development of highly sensitive and reproducible test procedures. From this information, pollutant concentrations were selected for chronic exposures, to continue for one year for rodents and two years for primates. The investigation of chronic effects got underway during the first half of 1969, and the last primate exposure chamber was terminated in September 1970. During this phase of the operation, animals were exposed on a virtually continuous basis, since they were removed from the inhalation chambers for the minimum time required for testing and other necessary procedures.

The three gaseous and two particulate pollutants, and the levels selected for chronic exposures–singly and in binary combinations–were the following: sulfur dioxide–0.5 and 10 parts per million (ppm); nitorgen dioxide–0.5 and 7.5 ppm; carbon monoxide–20 and 67.5 ppm; calcium sulfate (representing the ubiquitous particulate sulfate in urban air)–10.0 milligrams/cubic meter (mg/M^3); and lead chlorobromide (the predominant form of particulate lead emitted in automotive exhaust)–0.6 mg/M^3. The levels designated are at and above those attained in severely polluted air. The higher concentration of nitrogen dioxide and the concentration of lead chlorobromide were established far above "realistic" levels in ambient air, in order to induce toxic effects which would permit observations on possible interactions of contaminants. It was recognized that such interactions could be either additive, synergistic or inhibitory.

Batteries of highly sophisticated toxicologic test procedures were carried out on the experimental animals prior to and throughout the exposure period. Use of on-line, real-time electronic data processing equipment increased the precision of evaluation, permitting the detection of subtle toxic effects which otherwise might have been masked by individual test variations. As an indication of the complexity and magnitude of the research effort, there were over 3.3 million observations recorded on the 180 monkeys, and over 900,000 items on the 960 rats, exposed in twenty chambers with differing atmospheric constituents. Computer programs were developed to analyze the data. Under the guidance of consulting biostatisticians, mathematical evaluations were carried out by various techniques to insure validity of results. While preliminary findings were available in early 1971, additional computer studies of the mass of data continued through most of 1971. Final reports will be available early in 1972.

Among the important findings revealed by the research project are the following:

- Animals exposed to the pollutants and their combinations could not be distinguished from controls with respect to growth, development, final body weight, general behavior and survival.

- Physiologic, biochemical and pathologic observations in animals exposed to high and low levels of sulfur dioxide, and to calcium sulfate particulate, revealed no significant abnormalities as compared to controls.

- Primates and rodents exposed in chambers containing carbon monoxide showed the predicted elevation of carboxyhemoglobin, but no other toxic effects were evident.

- Animals inhaling lead chlorobromide particles at a concentration significantly above "realistic" levels in ambient air had elevated blood lead, increased urinary excretion of coproporphyrins, and a decrease in the enzyme delta-aminolevulinic acid, as expected. They also showed pulmonary irritant effects. Pathologic examination of kidney tissues revealed abnormalities attributed to lead.

- Monkeys exposed in chambers containing nitrogen dioxide at 7.5 ppm exhibited subtle impairment of respiratory function, as measured by the distribution of ventilation throughout the lungs. Pathologic changes were observed in the lung tissues.

- No evidence of synergism was found in animals exposed to various combinations of pollutants.

- There was suggestive evidence of antagonism between nitrogen dioxide and sulfur dioxide, in that the deleterious effects of NO_2 at the higher level in monkeys were reduced in the presence of SO_2 at 10 ppm.

DETERMINATION OF CARBOXYHEMOGLOBIN IN VARIOUS SEGMENTS OF THE POPULATION
CRC Project No. CAPM-8-68

Objective

The objective of this project is to obtain baseline information on the carboxyhemoglobin levels of various population segments.

Current Status

During the first year of the carboxyhemoglobin mass screening study (October 1970 to October 1971) a total of 15 separate sampling programs were conducted in cooperation with blood collection centers in 13 different cities throughout the nation. A total of 17,415 blood samples, 1,025 breath samples and 350 ambient air samples were collected.

Samples collected in the field were packaged in special mailing containers and shipped via air mail to the Medical College of Wisconsin.

Data from non-smokers is being calculated for mean carboxyhemoglobin values for all cities and locations sampled to date. Breath analysis data is being used to establish a blood-breath relationship for CO under field sampling conditions.

The sphere of sampling has been expanded to the New England states with the cooperation of the Red Cross Blood Center in Burlington, Vermont. New York City will be re-visited with sampling emphasis directed to special occupational groups, hospitals, and other locations in the New York metropolitan area. A similar study is planned for Los Angeles, and perhaps one other major metropolitan sampling area.

The blood collection phase of this program should be completed by June 1, 1972. Upon completion of the data analysis, a final report will be published.

A second study is being conducted, on a small scale, by the New York University School of Medicine. This work has the following goals:

- The quantitative evaluation of erythracyte oxygen uptake and delivery; both in individuals occupationally exposed to automobile exhaust and in vitro.
- The precise measurement of the possible polycythemic stimulus of continued occupational exposure to carbon monoxide (CO).

The studies will be performed on members of Bridge and Tunnel Officer's Local No. 1396 who are employees of the Triborough Bridge and Tunnel Authority (TBTA) in New York City. These men are occupationally exposed to high levels of automobile exhaust throughout the working day. This health evaluation will consist of complete pulmonary function testing, sampling of CO levels, analysis of lead levels, administration of a health questionnaire, physical examination, and routine clinical laboratory testing. Most of the studies will be performed in a mobile trailer at the various bridges and tunnels.

The New York University work is expected to be completed in late spring of 1972.

A third study has been carried out under CAPM-8-68 that involved validating the use of panelists by means of the alveolar air carbon monoxide determination during the operation of an automobile while being exposed to carbon monoxide. This work, which was conducted under contract by Columbia University School of Public Health and Administrative Medicine, has been completed using New York City Taxicab drivers and panelists. A final report should be available in spring of 1972. A prime conclusion is that non-smoking panelists can be compared to non-smoking taxicab drivers.

EFFECTS OF LOW LEVELS OF CARBON MONOXIDE UPON HUMANS PERFORMING DRIVING TASKS
CRC Project No. CAPM-9-69

Objective

The objective of this project is to determine the effects of low levels of carbon monoxide upon humans performing complex tasks, with particular emphasis on actual driving.

Current Status

Harvard University and Ohio State University are studying the effects of low concentrations of carbon monoxide upon human performance while driving an automobile. Both Universities are conducting laboratory and "on the road" research.

At Harvard University during the past year over 26 subjects completed a series of laboratory tests, and of these, 8 subjects completed the schedule of over-the-road driving tests after the driving tests were standardized. The laboratory program consists of tests which can be related to the driving tasks. Equipment being used consists of (a) a Visual Discriminometer and a Biometrics Glare Testing Device for measuring recovery from light shock and glare (b) a specially designed complex task which measures human responses to concurrently presented central and peripheral visual recognition tasks (c) a test of peripheral vision which measures the ability to perceive targets in various segments of the visual field, and (d) a Verhoeff apparatus which measures depth perception.

For the road experiments the driver is equipped with a Bolt, Beranek and Newman Visual Interruption Apparatus and the automobile is equipped with sensing and recording equipment. Data on driver informational input demands in terms of numbers of 0.5 second "looks" required and time intervals between "looks" is recorded on a 4-channel recorder. Objective measures of driver "error" are provided in terms of touching or crossing lane markers. These data are provided by two externally mounted photo-transducers which sense light reflected from the lane markers. This information is fed into the recorder along with the number and time of brake pedal applications. The number and magnitude of all steering wheel movements are measured while driving is being conducted over a closed test course. .

An analysis of the first year's laboratory test data and the over-the-road portion of the experiment utilizing the visual interruption apparatus are currently in progress.

Ohio State University has initiated both their laboratory test program and their road test program. The laboratory test program is designed to measure human performances on psychometer and psychophysical tasks. These tasks have two primary purposes. These included:

- Determination of road tests which can be expected to be sensitive to COHb levels. Lab tests should enable the elimination of road tests which are unlikely to reflect difference in COHb levels, thus, increasing testing efficiency.

- Laboratory tests will be substituted for road tests which cannot be done on the highway. Lab tests will be used, for example, to determine the effect of COHb on situations requiring maximum driver alertness which might be encountered but which, for safety reasons, cannot be run on the road.

The laboratory pursuit tracking task is created by a cam follower driven by a variable speed motor. The motor response is controlled by the experimenter through a variable voltage control.

Selective attention and choice response time tasks are also being used in laboratory testing. Visual stimuli, photographed on 16 mm movie film, are projected on either side of the oscilloscope screen. The subject responds to selected stimuli by pressing the appropriate response buttons, located on the spokes of his steering wheel.

Additional tests evaluated for use in the laboratory included: (1) spacial relations test, (2) finger tapping test; (3) rail walking test, (4) brightness discrimination test and (5) bright and dark adaption test. Preliminary results indicate that some of the tests are not sensitive monitors of CO decrement. Insensitive tests will either be modified or discontinued.

Both urban and open road daylight driving and open road night driving research is being conducted. Open road tests are conducted under both "loaded" and "unloaded" alertness conditions imposed on the driver. Analysis of the data involve the determination of eye movement search and scan patterns for the variety of driving conditions. Alertness loading is accomplished by visual occlusion.

In an urban driving test the driver is requested to drive the vehicle in his normal manner. His route takes him on urban streets and roads of different types and traffic densities. Analyses of the data involve the determination of eye movement search and scan patterns in this complex environment.

In the open road daylight experiment several types of data are collected including:

- Open road eye movements: light traffic normally prevails on this section of highway.
- Open road driving with lane placement obtained from center line: this test emphasizes the presence of car following.
- Elected car following: no load constant lead car velocity profile.
- Elected car following: no load, high variance lead car velocity profile.
- Elected car following: load (via visual occlusion) constant lead car velocity profile.
- Elected car following: load (via visual occlusion) high variance lead car velocity profile.
- Open road driving with voluntary visual occlusions.

These experiments enable eye movements to be studied in conditions that are more controlled and less complex than those obtained in the other data collection segments. These tests also allow the effects of alertness loading via visual occlusion to be determined over a wide range of different types of loading.

Preliminary data from several subjects have been collected on the above tests. Detailed analysis of these data are in progress. An annual report covering the first year's effort will be published early in 1972.

EFFECTS OF LOW LEVELS OF NITROGEN OXIDES UPON HUMANS
CRC Project No. CAPM-10-71

Objective

The objective of the project is to obtain information required to assess the effects of low-levels of NO_x upon humans.

Current Status

Research Triangle Institute was chosen, through a competitive procurement, to conduct a study on the effects of nitrogen oxides on selected health characteristics of persons in Chattanooga, Tennessee. The study will be conducted in four residential areas of Chattanooga with three schools in each area being involved. Chattanooga was chosen as the location for the study because of its point source of nitrogen oxide emissions from a TNT plant which create varying exposure levels in different areas. In addition, pollutant levels other than nitrogen oxides are relatively low. The study will provide the following:

- Data for estimates of the prevalence of chronic respiratory disease symptoms in parents living in areas selected to provide gradients in NO_2 pollution exposure.
- Data concerning the incidence of lower respiratory illness in school children living in each different area.
- Data concerning the presence of asthma in any of the family members.
- Data to compare the incidence of acute respiratory illness among selected families in each area.
- Data from pulmonary function tests administered to 1,800 to 2,000 children in each area.
- Data concerning the incidence of acute symptoms immediately preceding four particular pollution episode dates to be selected during the contact period.
- Scalp hair samples from normal hair cuts from all members of families selected.
- Placental sets collected at parturition from residents in each community.
- Data from panel studies of selected asthmatics.

A CRC ad hoc committee composed of industry and Government representatives is exploring the possibility of incorporating chemiluminescent NO_x monitoring equipment in the Chattanooga area. A recommendation will be made to the CAPM-10-71 project group early in 1972.

EFFECTS OF LOW LEVELS OF OXIDANTS UPON HUMANS
CRC Project No. CAPM-11-71

Objective

The objective of the project is to obtain information required to assess the effects of low levels of oxidants upon humans.

Current Status

A study to assess the effects of low levels of oxidants upon humans is planned to be initiated early in 1972. Negotiations with a contractor, to conduct a study in the Los Angeles Basin, are in progress. The communities selected in the Los Angeles Basin will be chosen to reflect an exposure gradient for oxidants. Air Monitoring data for oxidants, oxides of nitrogen, sulfur dioxide and suspended particulates are being obtained by the Environmental Protection Agency under a separate contract. Health indicators to be investigated include frequency of chronic respiratory disease symptoms, frequency of acute respiratory illness, ventilatory performance of school children and frequency and severity of asthma attacks in a panel of patients. Data similar to that collected in the CAPM-10-71 study will be obtained. The study will provide the following:

- Data for estimates of the prevalence of chronic respiratory disease symptoms in parents living in areas selected to provide gradients in oxidant pollution exposure.
- Data concerning the incidence of lower respiratory illness in school children living in each different area.
- Data concerning the presence of asthma in any of the family members.
- Data to compare the incidence of acute respiratory illness among selected families in each area.
- Data from pulmonary function tests administered to 1,800 to 2,000 children in each area.
- Data concerning the incidence of acute symptoms immediately preceding four particular pollution episode dates to be selected during the contact period.
- Scalp hair samples from normal hair cuts from all members of families selected.
- Placental sets collected at parturition from residents in each community.
- Data from panel studies of selected asthmatics.

INFLUENCE OF CARBON MONOXIDE LEVELS UPON INCIDENCE OF MOTOR VEHICLE ACCIDENTS
CRC Project No. CAPM-12-69

Objective

The objective of this project is to determine if a relationship exists between the carbon monoxide exposure of motor vehicle operators and the incidence of motor vehicle accidents.

Current Status

This project was organized as a result of a recommendation by the National Academy of Sciences review of carbon monoxide effects carried out under the former CAPM-2-68 project. It is planned to measure carboxyhemoglobin levels, as well as other pertinent health factors, of drivers involved in motor vehicle accidents. Ideally the measured levels would be compared to comparable people not involved in accidents.

An ad has appeared in the Commerce Business Daily and a list of prospective contractors has been compiled. Although the project has been delayed somewhat in order to evaluate information being developed in other APRAC studies on the effects of carbon monoxide, it is expected that a contractor will be selected and the study started in 1972.

EFFECTS OF CARBON MONOXIDE-EXPOSURES UPON MYOCARDIAL INFARCTION FATALITY RATES
CRC Project No. CAPM-13-69

Objective

The objective of this project is to conduct an epidemiological study to determine the effects of carbon monoxide exposures upon myocardial infarction fatality rates.

Current Status

This study is being conducted by the Johns Hopkins School of Public Health. An initial pilot study that lasted for seven months has been completed. By the end of August 1971, a total of 367 carboxyhemoglobin determinations had been done on blood samples from individuals who had died suddenly and were autopsied by the medical examiner's office. The causes of death have been divided into three groups: (1) sudden arteriosclerotic heart disease; (2) sudden deaths from other non-traumatic causes; and (3) sudden traumatic deaths.

For most of the sudden ASHD deaths, fairly detailed smoking histories are available, including whether the deceased was smoking at the time of death. For practically all of the sudden deaths from non-traumatic causes (ASHD and all other causes) data describing place of death and activity at onset are also available, and it is planned to obtain smoking histories on some of these deaths from other causes in the future as well.

Blood samples from patients admitted to a hospital with a myocardial infarction or suspected myocardial infarction have been collected from three hospitals. To date, 68 bloods have been analyzed.

The surveillance of ASHD deaths and myocardial infarctions as part of a study of factors associated with the onset of myocardial infarction and sudden death in Baltimore has been expanded to include all ASHD deaths from about one-half of Baltimore County which surrounds the original city area sample.

The total population in this area is probably around 1,000,000. All ASHD deaths, ages 25 to 64, are being identified and the next of kin or other relatives interviewed.

The area wide survey of patients admitted to a hospital with a myocardial infarction has been expanded to eleven hospitals. Similar types of data are being collected as for sudden deaths. Data for total ASHD deaths and myocardial infarction admissions are now available for the entire study area. Ambient CO measurements and other air pollution data have been obtained from the State Health Department's air pollution monitoring stations within the area.

A more detailed local environmental investigation has begun for every sudden non-traumatic death with a blood carboxyhemoglobin level greater than four. The contractor will try to determine whether any local environmental exposure other than cigarette smoking could account for the "elevated carboxyhemoglobin levels." In order to further possibly adjust for the effects of cigarette smoking, blood samples of normal individuals with detailed smoking histories have been obtained in several community studies and some estimates of the expected levels of carboxyhemoglobin levels among normal individuals should be possible in relation to smoking habits.

EYE IRRITATION AND LACHRYMATION
CRC Project No. CAPM-17-71

Objective

The objective of this project is to measure eye irritation threshold response times using the Los Angeles atmosphere as the exposure medium during the smog season and to define the mechanism of the lachrymation process with special emphasis on insult by gaseous and particulate air pollutants.

Current Status

It is envisioned that during the first year of this study, a field study would be carried out that included exposing volunteers' eyes to a polluted atmosphere at the same time that detailed chemical measurements were made of the pollutants present. Additionally, a medical investigation of the lachrymation process will be started after a thorough review of the current state of knowledge concerning eye irritation and lachrymation is completed.

The project group is being organized and detailed project planning is expected to begin in early 1972.

COMPOSITION OF DIESEL EXHAUST
CRC Project No. CAPI-1-64

Objective

The objectives of this project are to:

(a) Exchange information on all aspects of emissions from diesel engines.

(b) Develop research techniques for sampling, measuring, and evaluating exhaust emissions and smoke from diesel engines.

(c) Conduct or sponsor appropriate programs and surveys to measure and evaluate the amount, composition, and character of diesel exhaust emissions and smoke.

Current Status

A fourth phase of the hydrocarbon, CO and NO measurements program is in the final planning stages. In this phase, a multi-cylinder diesel generating set will be circulated among participating laboratories, and each laboratory will measure hydrocarbons, CO, and NO. NO_2 and CO_2 data will be obtained also. The basic objective of Phase IV is to determine agreement and repeatability of available instruments and techniques for measuring diesel exhaust emissions when the observations are taken in a manner that assures their maximum statistical independence. The program will start in early 1972 and approximately 12 laboratories have agreed to participate.

All available information on the effect of humidity on NO measurements has been gathered together and issued as a CRC status report.

In accordance with the continuing need to evaluate available smoke meters for measuring smoke in the exhaust of diesel engines, both bench and engine test procedures have been developed to assess the performance characteristics, operability, and durability of the full-flow, light extinction type smokemeter for various types of service. The procedures have been applied to several prototype meters. A summary report of the procedures and data on several prototype meters is being prepared. Several new smoke measurement programs are in the planning stages. One program is to summarize all measurement experience with the PHS Smokemeter into a CRC report. In addition, a program for evaluating several new full-flow, light extinction type smokemeters is planned.

The following reports have been released: "Correlation of Full-Flow Light Extinction Type Diesel Smokemeters by a Series of Neutral Density Filters" (CRC Report No. 442), "Cooperative Evaluation of Techniques for Measuring NO and CO in Diesel Exhaust" (CRC Report No. 443) and "Cooperative Evaluation of Techniques for Measuring Hydrocarbons in Diesel Exhaust" (CRC Report No. 440).

EXHAUST GAS SAMPLING AND ANALYSIS TECHNIQUES
CRC Project No. CAPI-2-58

Objective

The objectives of this project are to:

- Provide information on sampling and analysis techniques and problems. This includes:

  (a) Preparation and updating of (written) procedures in current use for sampling and analysis of exhaust gas.

  (b) Serving as a forum for the exchange of information on sampling and analysis techniques being developed.

- Initiate the development of "golden" standards for calibrating instruments and methods used in exhaust analysis.

- Establish experimentally the degree of equivalence among alternative methods for measurement of exhaust emissions.

Current Status

Objectives of the Group were reviewed and redefined by an ad hoc committee. The new objectives are believed to reflect more appropriately current and anticipated research needs in the area of automotive exhaust sampling and analysis.

Written procedures were prepared for chromatographic analysis of exhaust hydrocarbons and for measurement of exhaust NO_x by spectrophotometric techniques. Procedures are to be reviewed by the Group members and released as reports.

Written procedures for CVS sampling of exhaust and for analysis of CVS samples will be prepared through contract effort.

The Methods for Exhaust NO_x Measurement Panel was established and is now soliciting experimental evidence on comparison of alternative methods for exhaust NO_x measurement. Following review of available evidence, the panel will consider initiation of contract effort to generate additional evidence.

Information is also being gathered on presently used methods for measurement of exhaust particulates.

EVAPORATION LOSSES
CRC Project No. CAPI-3-65

Objective

The objective of this project is to develop techniques for measuring evaporation losses from fuel tanks and carburetors, recognizing the interdependence of fuel variables, equipment variables and operating conditions, and to conduct a survey on a variety of fuels and vehicles to measure the amount and composition of the emitted vapors.

Current Status

The program group remains inactive until results from the CAPE-5-68 and CAPE-10-68 contract activities are completed and published. Following a thorough review of the data obtained from these studies on driving habits and car fuel system time-temperature histories and depending on the needs that exist, the group may formulate the details of a cooperative test program to obtain pertinent information on evaporation losses from vehicles on the road.

VEHICLE EMISSIONS
CRC Project No. CAPI-5-65

Objective

The objective of this project is to conduct a program which will be a cooperative determination of exhaust gas composition, this program to:

(a) Encompass vehicles operating at certain specified conditions.

(b) Cover vehicles in standard condition.

(c) Include a study of the effect of fuel composition.

Current Status

A program will be conducted wherein one or more cars will be circulated among participating laboratories to measure vehicle exhaust emissions with the constant volume sampler (CVS). Since each laboratory will test only one vehicle, this test will be of primary value in evaluating the reproducibility of the test procedure including the CVS system.

A standardized operating procedure is necessary before this program can be initiated. The CAPI-2-58 group has been requested to provide a recommended operating procedure that can be used during the testing at each laboratory. It is anticipated that this program will begin in early 1972.

TECHNIQUES FOR IRRADIATION CHAMBER STUDIES
CRC Project No. CAPI-6-69

Objective

The objectives of this project are to:

(a) Compare and correlate techniques used and data obtained in irradiation chambers.

(b) Develop common methods of expressing various measures of hydrocarbon reactivity.

(c) Develop a CRC hydrocarbon reactivity scale or scales.

(d) Cooperate in atmospheric chemistry studies.

Current Status

The program group has been inactive during the past year. Based upon results from contract research being conducted under project CAPA-1-69, which was recommended by the program group, the desirability of additional test programs will be determined.

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APPENDIX A
Membership

CRC Air Pollution Research Advisory Committee

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Mr. C. M. Heinen, Vice Chairman	Chrysler Corporation
Dr. A. P. Altshuller	Environmental Protection Agency
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Mr. J. C. Ellis	Shell Oil Company
Mr. E. F. Fort	International Harvester Company
Mr. D. G. Levine	Esso Research & Engineering Company
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Dr. C. E. Moser	Texaco Incorporated
Mr. E. H. Scott	Standard Oil Company, Ohio
Mr. Eric Stork	Environmental Protection Agency
Mr. P. D. Strickler	Gulf Research and Development Company
Dr. C. S. Tuesday	General Motors Corporation
Mr. R. B. Welly	Jeep Corporation
Mr. W. D. Innes, Sponsoring Director	Ford Motor Company

* * * * * * * * * * * * * * *

Mr. A. E. Zengel, Project Manager
Mr. T. C. Belian, Assistant Project Manager

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Dr. Serge Gratch	Ford Motor Company
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Mr. C. E. Moser	Texaco Incorporated
Mr. Raymond Smith	Environmental Protection Agency
Dr. C. S. Tuesday	General Motors Corporation

Medical Advisory Group

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Dr. F. G. Hueter	Environmental Protection Agency
M. R. Plancey, M.D.	Atlantic Richfield Company
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Mr. E. F. Fort	International Harvester Company
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1973 APRAC Symposium Group

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Dr. D. S. Barth	Environmental Protection Agency
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Mr. D. G. Levine	Esso Research & Engineering Company
Dr. C. E. Moser	Texaco Incorporated
Dr. B. Weinstock	Ford Motor Company

CRC-APRAC CAPE-2-68

Effects Of Gasoline Properties On
Carburetor And PCV Valve Deterioration

Mr. G. D. Ebersole, Ldr.	Phillips Petroleum Company
Mr. C. J. Domke	Environmental Protection Agency
Mr. R. L. Everett	General Motors Corporation
Mr. L. E. Furlong	Esso Research & Engineering Company
Mr. K. L. Kipp	Chevron Research Company
Mr. H. T. Niles	Ford Motor Company

CRC-APRAC CAPE-4-68

Fuel Volatility

Mr. R. K. Stone, Ldr.	Chevron Research Company
Mr. H. E. Alquist	Phillips Petroleum Company
Mr. R. R. Awe	Shell Oil Company
Mr. E. W. Beckman	Chrysler Corporation
Mr. H. A. Bigley	Gulf Research and Development Company
Mr. J. B. Duckworth	American Oil Company
Mr. R. L. Everett	General Motors Corporation
Mr. J. C. Gagliardi	Ford Motor Company
Mr. G. D. Kittredge	Environmental Protection Agency
Mr. D. T. Wade	Esso Research & Engineering Company

Emissions Panel

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Mr. J. C. Gagliardi	Ford Motor Company
Mr. G. D. Kittredge	Environmental Protection Agency
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Driveability Panel

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Mr. E. W. Beckman	Chrysler Corporation
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Mr. J. B. Duckworth	American Oil Company
Mr. G. D. Kittredge	Environmental Protection Agency

CRC-APRAC CAPE-6-68

Gasoline Composition And Vehicle Exhaust
Gas Polynuclear Aromatic Content

Mr. C. R. Begeman, Ldr.	General Motors Corporation
Mr. H. F. Elkin	Sun Oil Company
Mr. P. L. Gerard	Mobil Research & Development Corporation
Mr. D. S. Gray	American Oil Company
Mr. J. S. Ninomiya	Ford Motor Company
Dr. A. J. Pahnke	E. I. Du Pont de Nemours & Company, Inc.
Mr. J. H. Somers	Environmental Protection Agency

CRC-APRAC CAPE-7-68

Exhaust Odor Measurement

Dr. R. S. Spindt, Ldr.	Gulf Research and Development Company
Dr. G. J. Barnes	General Motors Corporation
Mr. R. C. Bascom	Cummins Engine Company, Inc.
Mr. H. F. Butze	National Aeronautic and Space Administration
Mr. F. J. Hills	Mobil Research & Development Corporation
Dr. E. W. Landen	Caterpillar Tractor Company
Mr. J. E. Sigsby	Environmental Protection Agency

CRC-APRAC CAPE-8-68

Kinetics Of Oxidation And Quenching Of
Combustibles In Exhaust Systems Of Gasoline Engines

Dr. P. R. Ryason, Ldr.	Chevron Research Company
Dr. E. N. Cantwell	E. I. Du Pont de Nemours & Company, Inc.
Dr. R. J. Corbeels	Texaco Incorporated
Dr. J. B. Edwards	Chrysler Corporation
Dr. R. C. Schwing	General Motors Corporation
Dr. T. E. Sharp	Ford Motor Company
Dr. J. H. Somers	Environmental Protection Agency

CRC-APRAC CAPE-9-68

Automotive Fueling Emissions

Mr. E. R. Bergun, Ldr.	Shell Oil Company
Mr. W. F. Deeter	Atlantic Richfield Company
Mr. L. E. Furlong	Esso Research & Engineering Company
Mr. M. F. Homfeld	General Motors Corporation
Mr. D. C. MacDonald	Chrysler Corporation
Mr. C. W. Schwartz	Ford Motor Company
Dr. J. H. Somers	Environmental Protection Agency
Mr. R. Zeitlow	International Harvester Company

CRC-APRAC CAPE-10-68

Traffic Survey For Development Of Average Driving Cycles

Mr. C. J. Elder, Ldr.	General Motors Corporation
Mr. D. L. Hittler	American Motors Corporation
Dr. T. A. Huls	Environmental Protection Agency
Mr. F. E. Johnson	Chrysler Corporation
Mr. H. E. Leikkanen	Texaco Incorporated
Mr. C. W. Schwartz	Ford Motor Company
Mr. Mark Sherbinsky	International Harvester Company
Mr. W. A. Steele	Ethyl Corporation

CRC-APRAC CAPE-11-68

Improved Instrumentation For Determination Of
Exhaust Gas NO_x And Oxygenate Content

Mr. C. E. Legate, Ldr.	Shell Oil Company
Mr. L. F. Gilbert	Ethyl Corporation
Dr. E. S. Jacobs	E. I. Du Pont de Nemours & Company, Inc.
Mr. G. J. Nebel	General Motors Corporation
Mr. J. E. Sigsby	Environmental Protection Agency
Dr. E. E. Weaver	Ford Motor Company

CRC-APRAC CAPE-12-68

Techniques And Instrumentation For Analysis Of Exhaust
Gases For Particulate Matter And Polynuclear Aromatics

Mr. F. P. Hochgesang, Ldr.	Mobil Research & Development Corporation
Mr. C. R. Begeman	General Motors Corporation
Dr. Kamran Habibi	E. I. Du Pont de Nemours & Company, Inc.
Dr. L. W. Mixon	American Oil Company
Dr. Eugene Sawicki	Environmental Protection Agency

CRC-APRAC CAPE-13-68

Inspection, Maintenance, Surveillance
And Economic Effectiveness Studies

Mr. W. S. Fagley, Ldr.	Chrysler Corporation
Mr. R. R. Awe	Shell Oil Company
Dr. L. S. Bernstein	Esso Research & Engineering Company
Mr. C. J. Elder	General Motors Corporation
Mr. G. C. Hass	California Air Resources Board
Mr. Lee Hamkins	American Motors Corporation
Dr. T. A. Huls	Environmental Protection Agency
Mr. H. D. Orloff	Ethyl Corporation
Mr. J. F. Wagner	Gulf Research and Development Company

CRC-APRAC CAPE-19-70

Chemical And Physical Characterization Of Automotive
Exhaust Particulate Matter In The Atmosphere

Mr. F. P. Hochgesang, Ldr.	Mobil Research & Development Corporation
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Mr. C. R. Begeman	General Motors Corporation
Dr. Kamran Habibi	E. I. Du Pont de Nemours & Company, Inc.
Dr. L. W. Mixon	American Oil Company
Dr. G. S. Musser	Esso Research & Engineering Company
Dr. W. R. Pierson	Ford Motor Company
Dr. Jack Wagman	Environmental Protection Agency

CRC-APRAC CAPE-20-71

Nitric Oxide Formation In Diesel Engines

Dr. J. M. Perez, Ldr.	Caterpillar Tractor Company
Mr. F. J. Hills	Mobil Research & Development Corporation
Mr. J. H. Hoelzer	International Harvester Company
Mr. G. D. Kittredge	Environmental Protection Agency
Mr. D. F. Merrion	General Motors Corporation
Mr. A. V. Wilson	Cummins Engine Company, Inc.

CRC-APRAC CAPE-21-71

Truck Driving Pattern And Use Survey

Mr. Mark Sherbinsky, Ldr.	International Harvester Company
Mr. E. A. Baesanyi	Ford Motor Company
Mr. J. W. Bozek	Environmental Protection Agency
Mr. C. T. Hoffman	General Motors Corporation
Mr. T. O. Wagner	American Oil Company

CRC-APRAC CAPA-1-69

Factors Affecting Reactions In Environmental Chambers

Mr. D. B. Wimmer, Ldr.	Phillips Petroleum Company
Mr. Frank Bonamassa	California Air Resources Board
Mr. J. M. Heuss	General Motors Corporation
Mr. Stanley Kopczynski	Environmental Protection Agency
Dr. Hiromi Niki	Ford Motor Company
Dr. E. E. Wigg	Esso Research & Engineering Company

CRC-APRAC CAPA-2-68

Plant Damage By Air Pollutants

Dr. D. M. Teague, Ldr.	Chrysler Corporation
Dr. D. G. Gillette	Environmental Protection Agency
Dr. W. W. Heck	Environmental Protection Agency
Dr. H. W. Otto	State of Delaware
Mr. R. R. Poynor	International Harvester Company
Dr. R. H. Schieferstein	Shell Development Company

CRC-APRAC CAPA-3-68

Diffusion Model Of Urban Atmosphere

Dr. J. F. Black, Ldr.	Esso Research & Engineering Company
Dr. A. P. Altshuller	Environmental Protection Agency
Mr. J. M. Colucci	General Motors Corporation
Mr. R. P. Doelling	Cities Service Oil Company
Mr. W. B. Johnson	Environmental Protection Agency
Mr. F. J. Mason	Ford Motor Company
Dr. J. J. Mitchell	Texaco Incorporated
Dr. Irving Solomon	U.S. Army Munitions Command

CRC-APRAC CAPA-4-68

Fate Of Carbon Monoxide In The Atmosphere

Dr. B. Weinstock, Ldr.	Ford Motor Company
Dr. J. J. Bufalini	Environmental Protection Agency
Dr. W. A. Glasson	General Motors Corporation
Mr. R. L. Raymond	Sun Oil Company

CRC-APRAC CAPA-5-68

Light Hydrocarbons In The Atmosphere

Mr. J. M. Heuss, Ldr.	General Motors Corporation
Mr. H. E. Alquist	Phillips Petroleum Company
Dr. A. P. Altshuller	Environmental Protection Agency
Mr. J. C. Neerman	Ford Motor Company

CRC-APRAC CAPA-6-68

Haze Formation Origins And Importance To Air Pollution

Dr. R. L. Bradow	Texaco Incorporated
Dr. W. W. Brehob	Ford Motor Company
Dr. P. J. Groblicki	General Motors Corporation
Dr. P. L. Hanst	Environmental Protection Agency
Dr. Joseph Vardi	Esso Research & Engineering Company

CRC-APRAC CAPA-7-70

Measurements Of Atmospheric Pollutants In Urban Areas

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Dr. J. F. Black	Esso Research & Engineering Company
Mr. Frank Bonamassa	California Air Resources Board
Mr. R. P. Doelling	Cities Service Oil Company
Mr. F. F. Farley	Shell Development Company
Mr. J. M. Heuss	General Motors Corporation
Mr. D. A. Skinner	Union Oil Company of California
Dr. B. Weinstock	Ford Motor Company

CRC-APRAC CAPA-8-71

Determination Of Formation Mechanism And
Composition Of Photochemical Aerosols

Dr. R. J. Campion, Ldr.	Esso Research & Engineering Company
Dr. Marijon Bufalini	Environmental Protection Agency
Dr. P. J. Groblicki	General Motors Corporation
Dr. J. M. Larkin	Texaco Incorporated
Mr. J. S. Ninomiya	Ford Motor Company

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Effects Of Carbon Monoxide On Human Behavior

Richard Call, M.D., Ldr.	Union Oil Company of California
Edwin DeJongh, M.D.	General Motors Corporation
Dr. J. H. Knelson	Environmental Protection Agency

CRC APRAC CAPM-4-68

Effects Of Chronic Exposure To Low Levels Of Carbon
Monoxide On The Cardiovascular System

J. J. Thorpe, M.D., Ldr.	Standard Oil Company (New Jersey)
Dr. Trent Lewis	NIOSH
Dr. R. McIntosh	Chrysler Corporation

CRC APRAC CAPM-5-68

Toxicity Of Polynuclear Aromatic Hydrocarbons In The Lung

D. L. Coffin, D. V. M., Ldr.	Environmental Protection Agency
J. W. Kaminski, M.D.	Ford Motor Company
H. W. Spies, M.D.	American Oil Company

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Synergistic Effects In Certain Airborne Systems

N. K. Weaver, M.D., Ldr.	Humble Oil and Refining Company
K. I. Campbell, D.V.M.	Environmental Protection Agency
J. A. Taylor, M.D.	General Motors Corporation

CRC APRAC CAPM-7-68

Effects Of Low Levels Of Oxidant And NO_x On Morbidity And Mortality

J. F. Finklea, M.D., Ldr.	Environmental Protection Agency
Mr. D. A. Greschaw	Ford Motor Company
F. W. Wilson, M.D.	Texaco Incorporated

CRC-APRAC CAPM-8-68

Determination Of Carboxyhemoglobin In Various Segments Of The Population

Edwin DeJongh, M.D., Ldr.	General Motors Corporation
Keiffer Davis, M.D.	Phillips Petroleum Company
Dr. J. H. Knelson	Environmental Protection Agency
Mr. Walter Konn	General Motors Corporation
C. L. Samuelson, M.D.	Marathon Oil Company

CRC-APRAC CAPM-9-69

Effects Of Low Levels Of Carbon Monoxide Upon Humans Performing Driving Tasks

Dr. J. H. Knelson, Ldr.	Environmental Protection Agency
F. J. Biluk, M.D.	General Motors Corporation
Mr. J. M. Colucci	General Motors Corporation
Dr. W. C. Nelson	Environmental Protection Agency
Mr. F. N. Platt	Ford Motor Company
W. Wayne Stewart, M.D.	Sun Oil Company

CRC-APRAC CAPM/10-11/71

Effects Of Low Levels Of Oxidants And/Or NO_x Upon Humans

Dr. D. Calafiore, Ldr.	Environmental Protection Agency
Mr. D. L. Eschelbach	Chrysler Corporation
C. J. Sternhagen, M.D.	Kerr-McGee Corporation
Mr. A. S. Todd	Sun Oil Company
Mr. P. E. Toth	Ford Motor Company

CRC-APRAC CAPM-12-69

Influence Of Carbon Monoxide Levels Upon Incidence Of Motor Vehicle Accidents

H. B. Snyder, M.D., Ldr.	Humble Oil and Refining Company
Mr. Robert Buechley	Environmental Protection Agency
Mr. A. R. Forster	General Motors Corporation
Mr. A. R. Haeusler	Chrysler Corporation
D. C. Laderach, M.D.	Ford Motor Company

CRC-APRAC CAPM-13-69

Effects Of Carbon Monoxide Exposures Upon Myocardial Infarction Fatality Rates

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P. L. Neiswander, M.D.	General Motors Corporation
Harry Sinclaire, M.D.	Mobil Oil Corporation

CRC-APRAC CAPI-1-64

Composition Of Diesel Exhaust

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Mr. R. C. Bascom	Cummins Engine Company, Inc.
Mr. J. M. Colfer	Lubrizol Corporation
Mr. W. F. Deeter	Atlantic Richfield Company
Mr. T. V. DePalma	Universal Oil Products Company
Mr. G. J. Derrig	Allis-Chalmers Corporation
Dr. W. A. Herbst	Esso Research & Engineering Company
Mr. F. J. Hills	Mobil Research & Development Corporation
Dr. E. W. Landen	Caterpillar Tractor Company
Mr. J. G. Ryan	Shell Oil Company
Mr. E. J. Sienicki	International Harvester Company
Mr. E. E. Spitler	Chevron Research Company
Mr. R. C. Stahman	Environmental Protection Agency
Mr. T. H. Stewart	John Deere Waterloo Tractor Works
Mr. T. O. Wagner	American Oil Company

Odor Panel

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Mr. J. A. Bert	Chevron Research Company
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Mr. R. V. Kerley	Ethyl Corporation
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Gaseous Emissions Panel

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Mr. J. M. Colfer	Lubrizol Corporation
Dr. R. D. Fleming	Bureau of Mines
Mr. R. J. Hames	General Motors Corporation
Mr. F. J. Hills	Mobil Research & Development Corporation
Mr. S. R. Krause	Ethyl Corporation
Mr. J. M. Perez	Caterpillar Tractor Company
Mr. E. J. Sienicki	International Harvester Company
Mr. K. J. Springer	Southwest Research Institute
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NO and CO Measurement Sub-Panel

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Mr. J. G. Ryan	Shell Oil Company
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Mr. T. H. Stewart	John Deere Waterloo Tractor Works
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Programs Planning Panel

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Smoke Panel

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Meter Evaluation Sub-Panel

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Mr. T. S. Kinnunen	General Motors Corporation
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PHS Smokemeter Manual Sub-Panel

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Mr. T. S. Kinnunen	General Motors Corporation
Mr. E. Shamah	American Oil Company
Mr. K. J. Springer	Southwest Research Institute

CRC-APRAC CAPI-2-58

Exhaust Gas Sampling And Analysis Techniques

Dr. Basil Dimitriades, Ldr.	Bureau of Mines
Mr. A. W. Crowley	Atlantic Richfield Company
Mr. W. H. Douthit	Sun Oil Company
Mr. J. C. Gagliardi	Ford Motor Company
Mr. L. F. Gilbert	Ethyl Corporation
Mr. S. S. Hetrick	Mobil Research & Development Corporation
Dr. E. S. Jacobs	E. I. Du Pont de Nemours & Company, Inc.
Mr. K. L. Kipp	Chevron Research Company
Dr. H. C. McKee	Southwest Research Institute
Dr. L. W. Mixon	American Oil Company
Mr. J. C. Mulac	Gulf Research and Development Company
Mr. G. J. Nebel	General Motors Corporation
Mr. R. W. Neuzil	Universal Oil Products Company
Dr. H. W. Otto	State of Delaware
Mr. C. D. Paulsell	Environmental Protection Agency
Mr. J. G. Ryan	Shell Oil Company
Mr. Frank Scornavacca	Matheson Gas Products
Dr. D. M. Teague	Chrysler Corporation

Mass Emissions Sampling Panel

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Dr. H. W. Otto	State of Delaware
Mr. C. D. Paulsell	Environmental Protection Agency
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Gas Chromatography Panel

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Mr. J. C. Mulac	Gulf Research and Development Company
Dr. H. W. Otto	State of Delaware
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Oxides Of Nitrogen Panel

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Dr. E. S. Jacobs	E. I. Du Pont de Nemours & Company, Inc.
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Mr. G. J. Nebel	General Motors Corporation
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Mr. J. G. Ryan	Shell Oil Company

Aldehydes Panel

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Dr. Basil Dimitriades	Bureau of Mines
Dr. E. S. Jacobs	E. I. Du Pont de Nemours & Company, Inc.
Mr. G. J. Nebel	General Motors Corporation
Mr. C. D. Paulsell	Environmental Protection Agency

Procedures Manual Panel

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Dr. J. B. Edwards	Chrysler Corporation
Dr. E. S. Jacobs	E. I. Du Pont de Nemours & Company, Inc.

CRC-APRAC CAPI-3-65

Evaporation Losses

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Mr. W. B. Baldwin	Bendix Corporation
Mr. Frank Bonamassa	California Air Resources Board
Mr. H. A. Carlson	Carter Carburetor Corporation
Mr. W. F. Deeter	Atlantic Richfield Company
Mr. W. H. Douthit	Sun Oil Company
Mr. W. E. Drinkard	Chrysler Corporation
Dr. J. L. Ellingboe	Marathon Oil Company
Dr. R. L. Furey	General Motors Corporation
Mr. E. P. Holiday	Ford Motor Company
Mr. D. M. Hollabaugh	Environmental Protection Agency
Mr. K. S. Johnson	Holley Carburetor Company
Dr. J. L. Keller	Union Oil Company of California
Mr. L. W. Manley	Mobil Research & Development Corporation
Mr. P. E. Mizelle	Cities Service Oil Company
Mr. J. C. Mulac	Gulf Research and Development Company
Mr. G. E. Onishi	American Motors Corporation
Mr. J. E. Robinson	Standard Oil Company (Ohio)
Mr. O. L. Spilman	Continental Oil Company
Mr. R. K. Stone	Chevron Research Company
Mr. A. W. Suderman	Phillips Petroleum Company
Mr. H. A. Toulmin	Ethyl Corporation
Mr. C. A. Towne	Shell Oil Company
Mr. T. O. Wagner	American Oil Company

CRC-APRAC CAPI-5-65

Vehicle Emissions

Dr. R. S. Spindt, Ldr.	Gulf Research and Development Company
Mr. Frank Bonamassa	California Air Resources Board
Mr. W. J. Brown	Ethyl Corporation
Mr. J. M. Colucci	General Motors Corporation
Mr. T. V. DePalma	Universal Oil Products Company
Mr. R. P. Doelling	Cities Service Oil Company
Mr. W. H. Douthit	Sun Oil Company
Mr. W. S. Fagley	Chrysler Corporation
Mr. F. B. Fitch	Mobil Research & Development Corporation
Mr. J. C. Gagliardi	Ford Motor Company
Dr. J. G. Hansel	Esso Research & Engineering Company
Mr. John Harkins	Scott Research Laboratories, Inc.
Dr. T. A. Huls	Environmental Protection Agency
Mr. R. W. Hurn	Bureau of Mines
Mr. R. Jewel	Atlantic Richfield Company
Mr. H. E. Leikkanen	Texaco Incorporated
Dr. L. W. Mixon	American Oil Company
Mr. D. R. Olson	Olson Laboratories, Inc.
Mr. J. G. Ryan	Shell Oil Company
Mr. W. R. Wotring	Standard Oil Company (Ohio)
Mr. J. E. Yingst	TRW. Inc.
Mr. Joseph Zelson	E. I. Du Pont de Nemours & Company, Inc.

Program Panel

Mr. W. H. Douthit, Ldr.	Sun Oil Company
Mr. J. G. Berry	Gulf Research and Development Company
Mr. J. M. Colucci	General Motors Corporation
Mr. J. C. Gagliardi	Ford Motor Company
Dr. J. G. Hansel	Esso Research & Engineering Company
Dr. T. A. Huls	Environmental Protection Agency

CVS Procedure Sub-Panel

Mr. W. H. Douthit, Ldr.	Sun Oil Company
Dr. J. G. Hansel	Esso Research & Engineering Company
Mr. Joseph Zelson	E. I. Du Pont de Nemours & Company, Inc.

CRC-APRAC CAPI-6-69

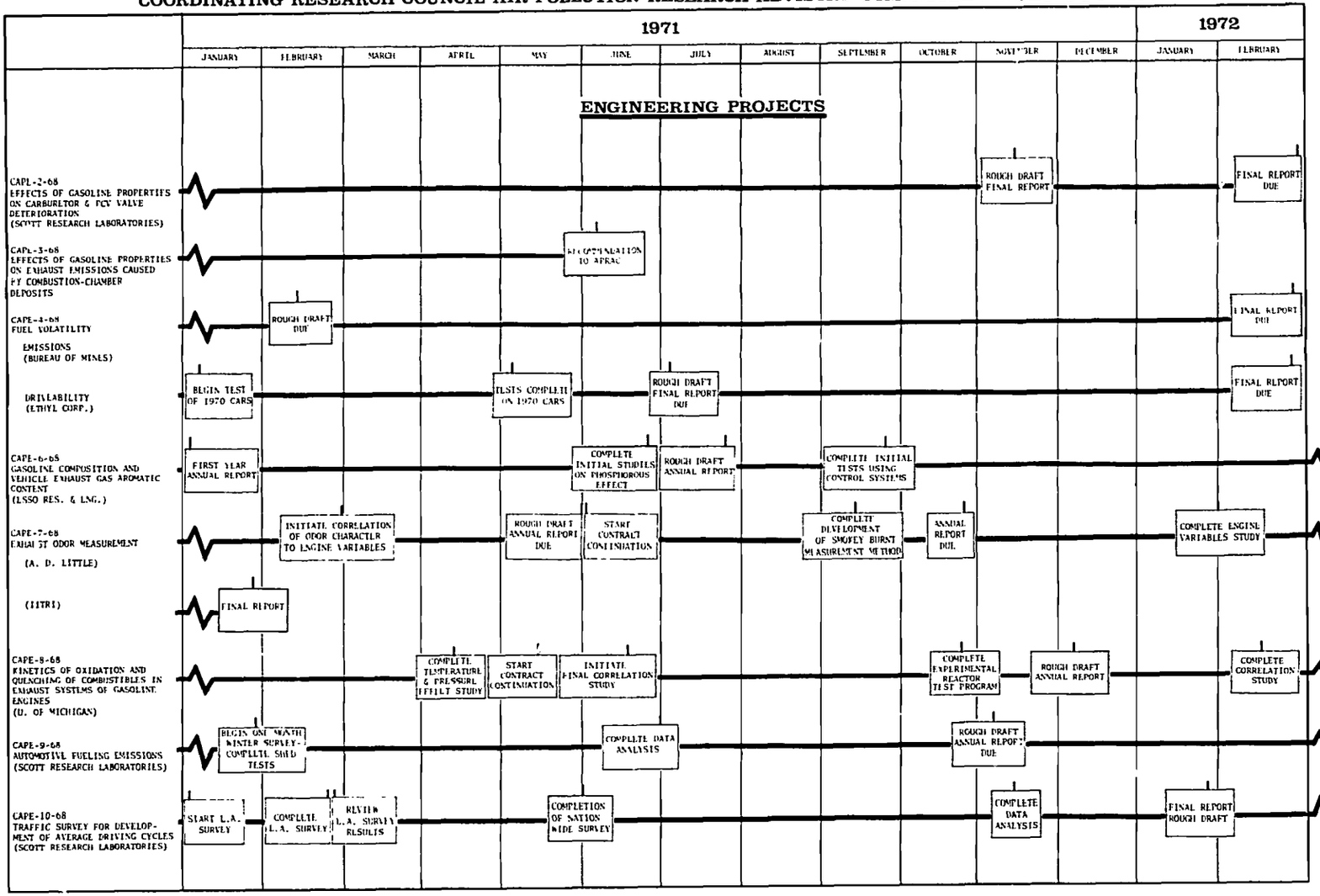
Techniques For Irradiation Chamber Studies

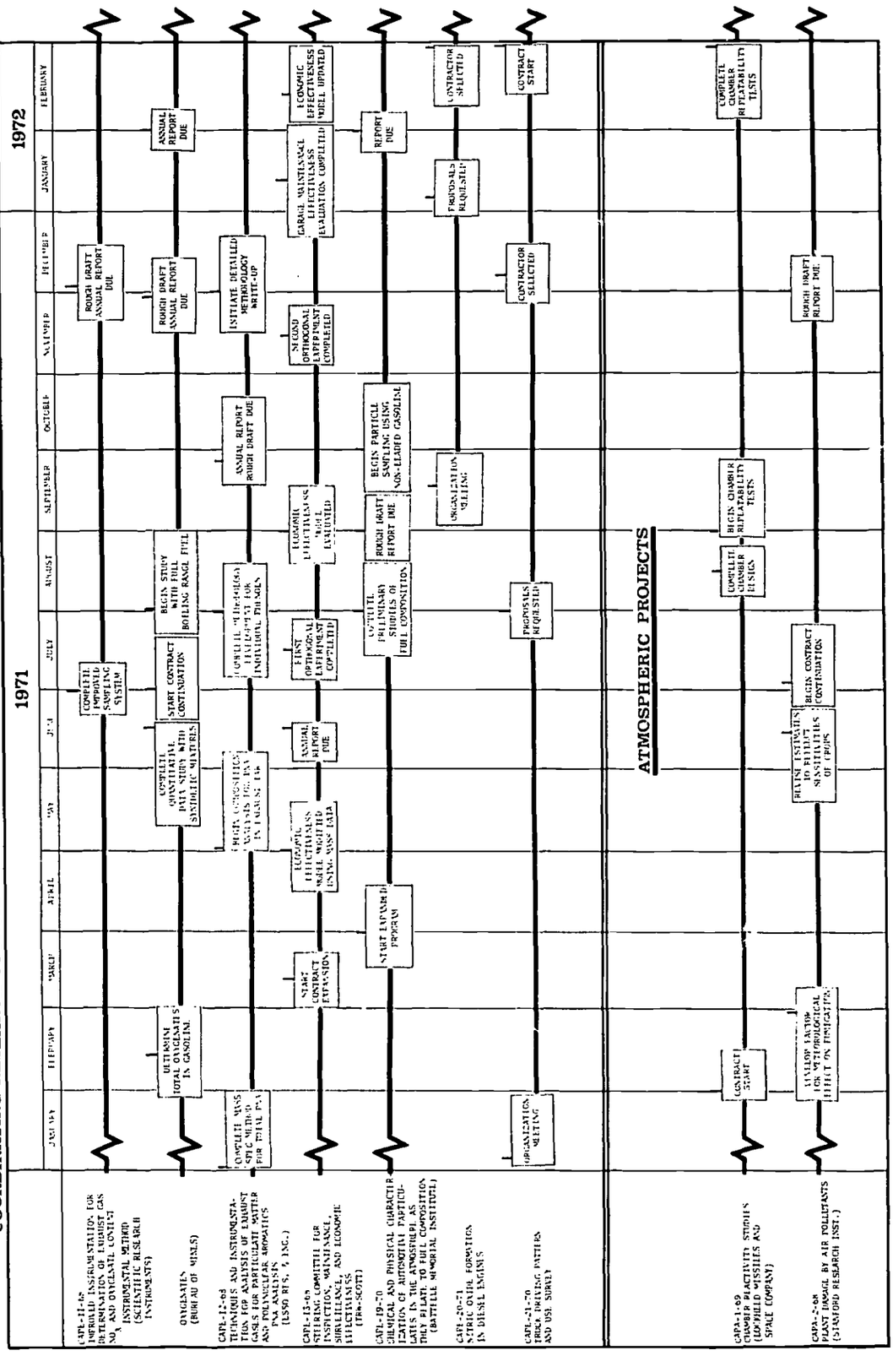
Dr. B. R. Appel	Shell Development Company
Dr. R. P. Ballinger	Chevron Research Company
Mr. Frank Bonamassa	California Air Resources Board
Dr. Basil Dimitriades	Bureau of Mines
Mr. S. Kopczynski	Environmental Protection Agency
Dr. Arthur Levy	Battelle Memorial Institute
Dr. R. S. Spindt	Gulf Research and Development Company
Dr. C. S. Tuesday	General Motors Corporation
Dr. K. W. Wilson	Stanford Research Institute
Mr. D. B. Wimmer	Phillips Petroleum Company

APPENDIX B
Progress Chart for 1971

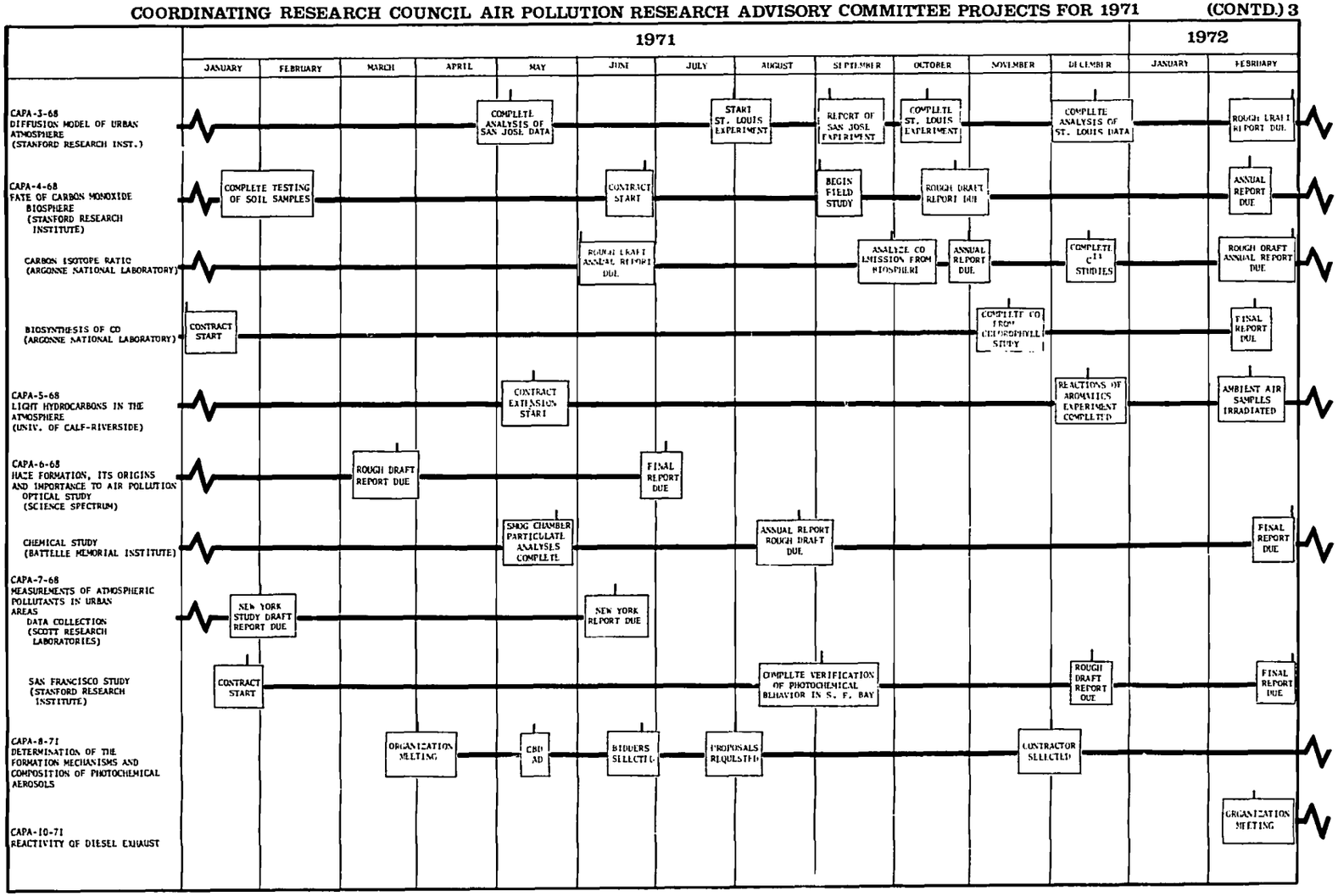
COORDINATING RESEARCH COUNCIL AIR POLLUTION RESEARCH ADVISORY COMMITTEE PROJECTS FOR 1971

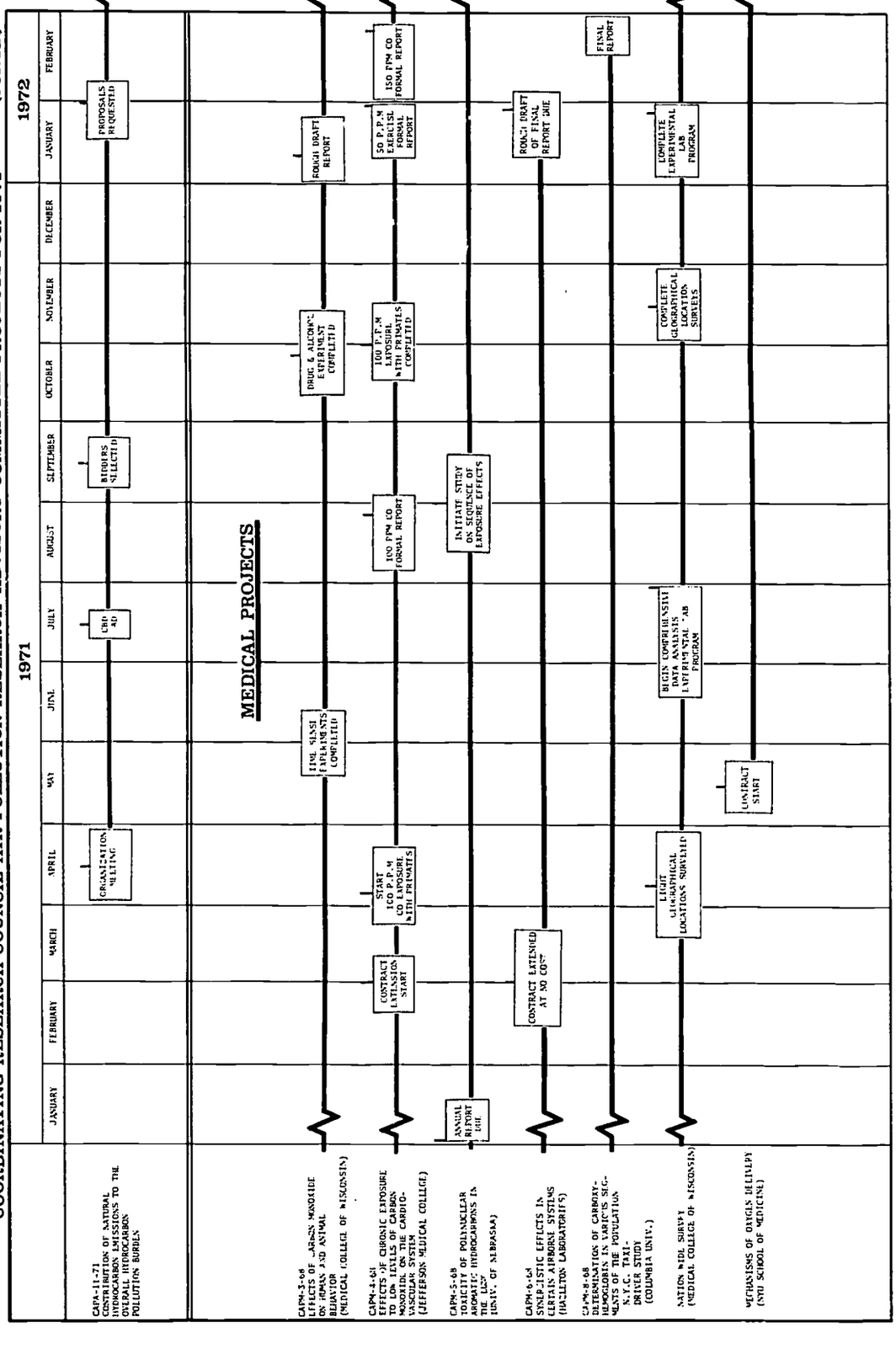
1



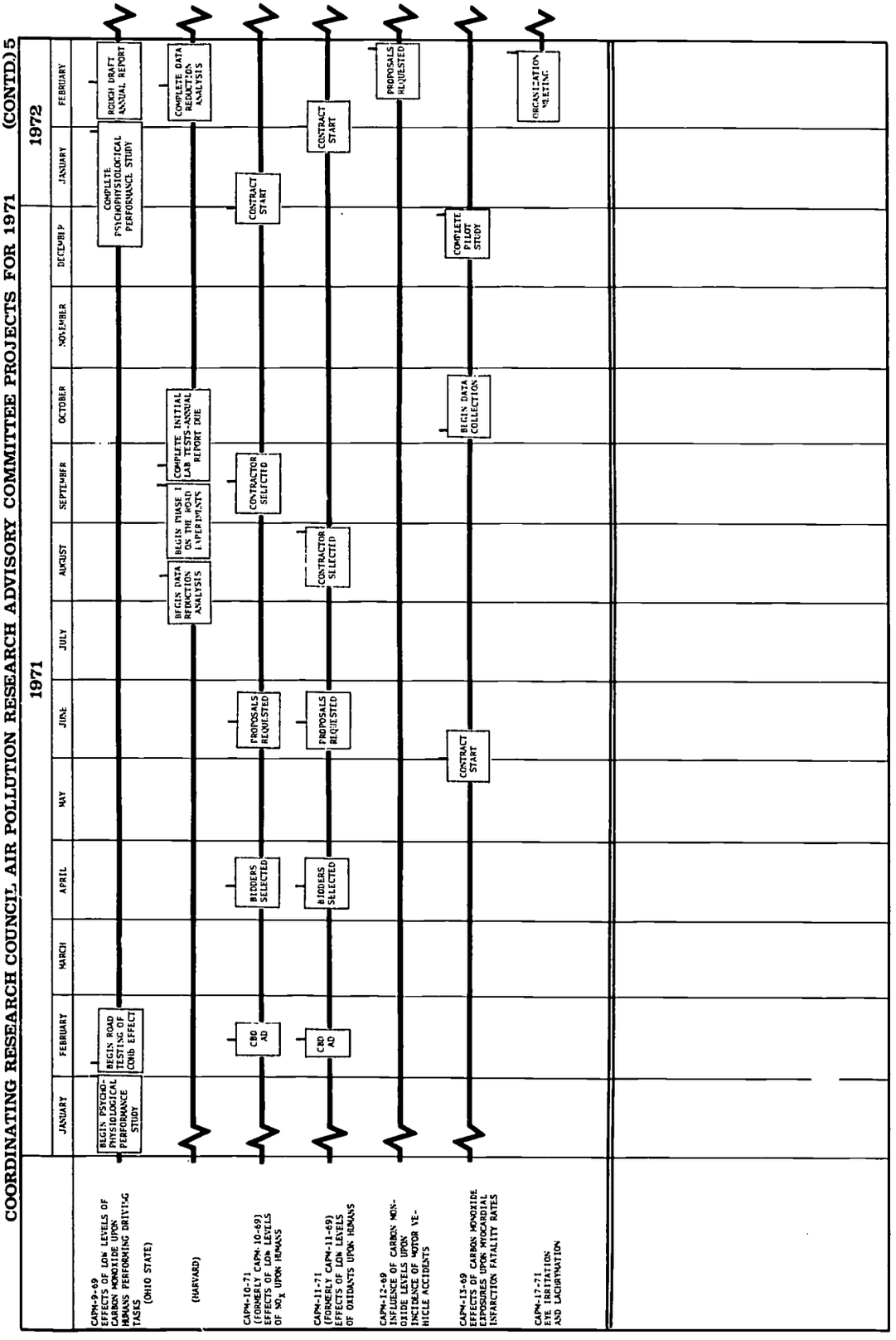

COORDINATING RESEARCH COUNCIL AIR POLLUTION RESEARCH ADVISORY COMMITTEE PROJECTS FOR 1971 (CONTD.)2
1971
1972
JANUARY
FEBRUARY
ATMOSPHERIC PROJECTS

COORDINATING RESEARCH COUNCIL AIR POLLUTION RESEARCH ADVISORY COMMITTEE PROJECTS FOR 1971 (CONTD.) 3



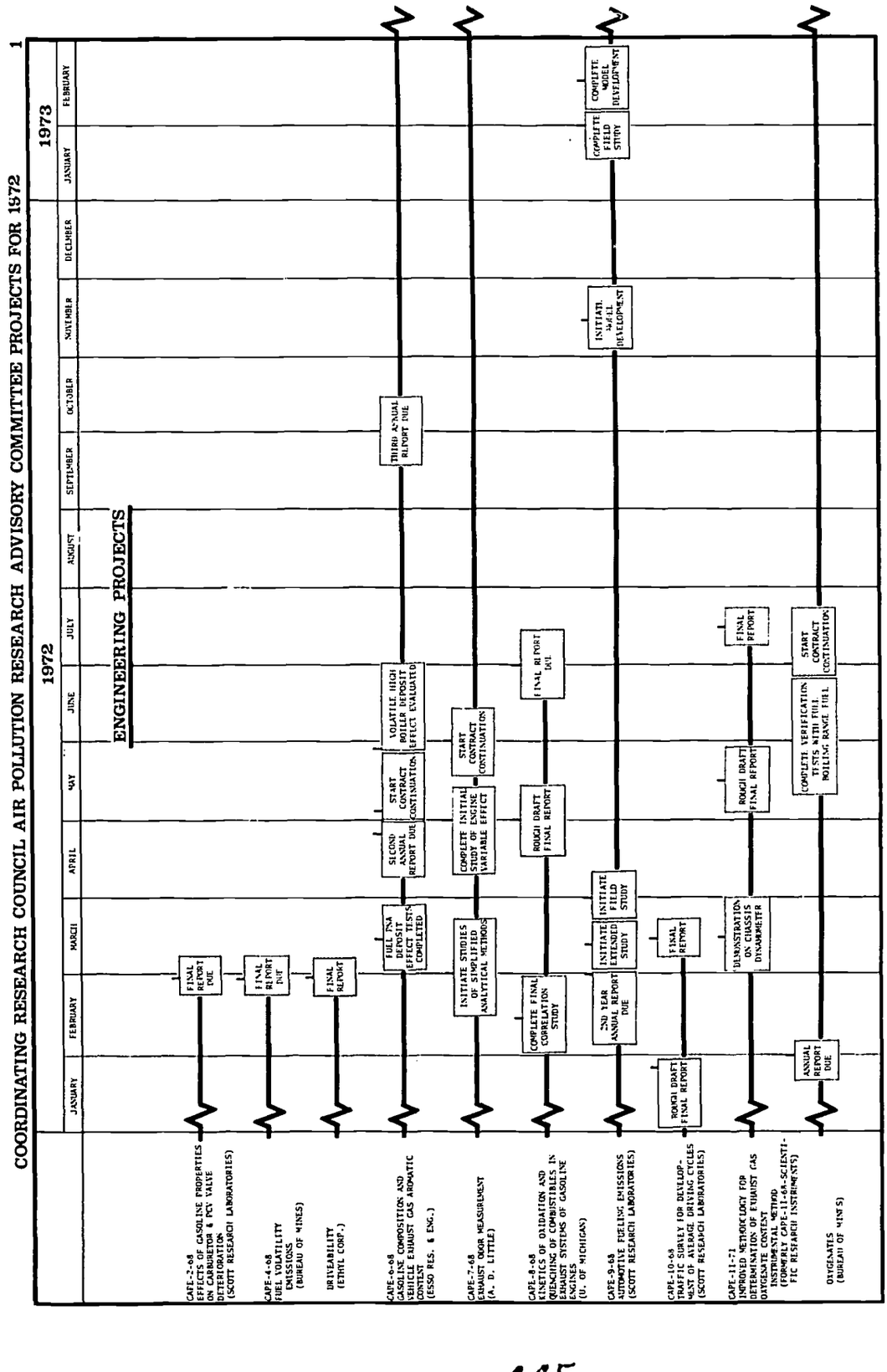

COORDINATING RESEARCH COUNCIL AIR POLLUTION RESEARCH ADVISORY COMMITTEE PROJECTS FOR 1971 (CONTD.)4
1971
1972
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
CAPA-11-71
CONTRIBUTION OF NATURAL HYDROCARBON EMISSIONS TO THE OVERALL HYDROCARBON POLLUTION BURDEN
PROPOSALS REQUESTED
MEDICAL PROJECTS
CAPM-3-68
EFFECTS OF ARGON MONOXIDE ON HUMAN AND ANIMAL BEHAVIOR
(MEDICAL COLLEGE OF WISCONSIN)
GRGANIZATION MEETING
CBH-40
BIDDERS SELECTED
FINAL TEST ANALYSES COMPLETED
DRUG & ALCOHOL EXPERIMENT COMPLETED
ROUGH DRAFT REPORT
CAPM-4-68
EFFECTS OF CHRONIC EXPOSURE TO LOW LEVELS OF CARBON MONOXIDE ON THE CARDIO-VASCULAR SYSTEM
(JEFFERSON MEDICAL COLLEGE)
CONTRACT EXTENSION START
START 100 P.P.M CO EXPOSURE WITH PRIMATES
100 P.P.M CO FORMAL REPORT
100 P.P.M EXPOSURE WITH PRIMATES COMPLETED
50 P.P.M EXERCISE FORMAL REPORT
150 PPM CO FORMAL REPORT
CAPM-5-69
TOXICITY OF POLYNUCLEAR AROMATIC HYDROCARBONS IN THE LUNG
(UNIV. OF NEBRASKA)
ANNUAL REPORT DUE
INITIATE STUDY ON SEQUENCE OF EXPOSURE EFFECTS
CAPM-6-69
SYNERGISTIC EFFECTS IN CERTAIN AIRBORNE SYSTEMS
(HAMILTON LABORATORIES)
CONTRACT EXTENDED AT NO COST
ROUGH DRAFT OF FINAL REPORT DUE
CAPM-8-68
DETERMINATION OF CARBOXY-HEMOGLOBIN IN VARIOUS SEGMENTS OF THE POPULATION
N.Y.C. TAXI-DRIVER STUDY
(COLUMBIA UNIV.)
FINAL REPORT
NATION WIDE SURVEY
(MEDICAL COLLEGE OF WISCONSIN)
LIGHT GEOGRAPHICAL LOCATIONS SURVEYED
BEGIN COMPREHENSIVE DATA ANALYSIS EXPERIMENTAL LAB PROGRAM
COMPLETE GEOGRAPHICAL LOCATION SURVEYS
COMPLETE EXPERIMENTAL LAB PROGRAM
VETERANS OF OMEGA DELINEPT
(NYU SCHOOL OF MEDICINE)
CONTRACT START

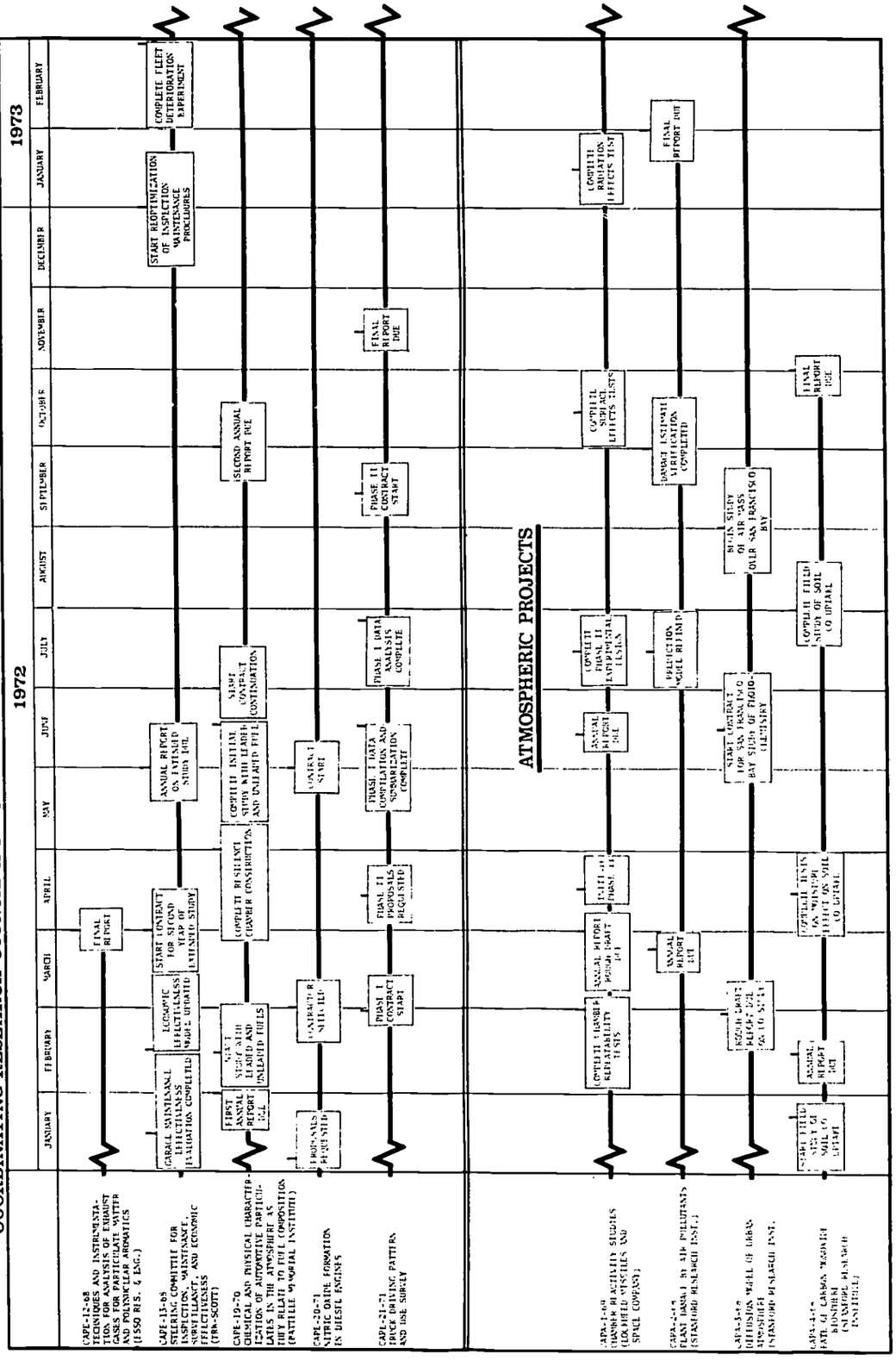
Appendix B

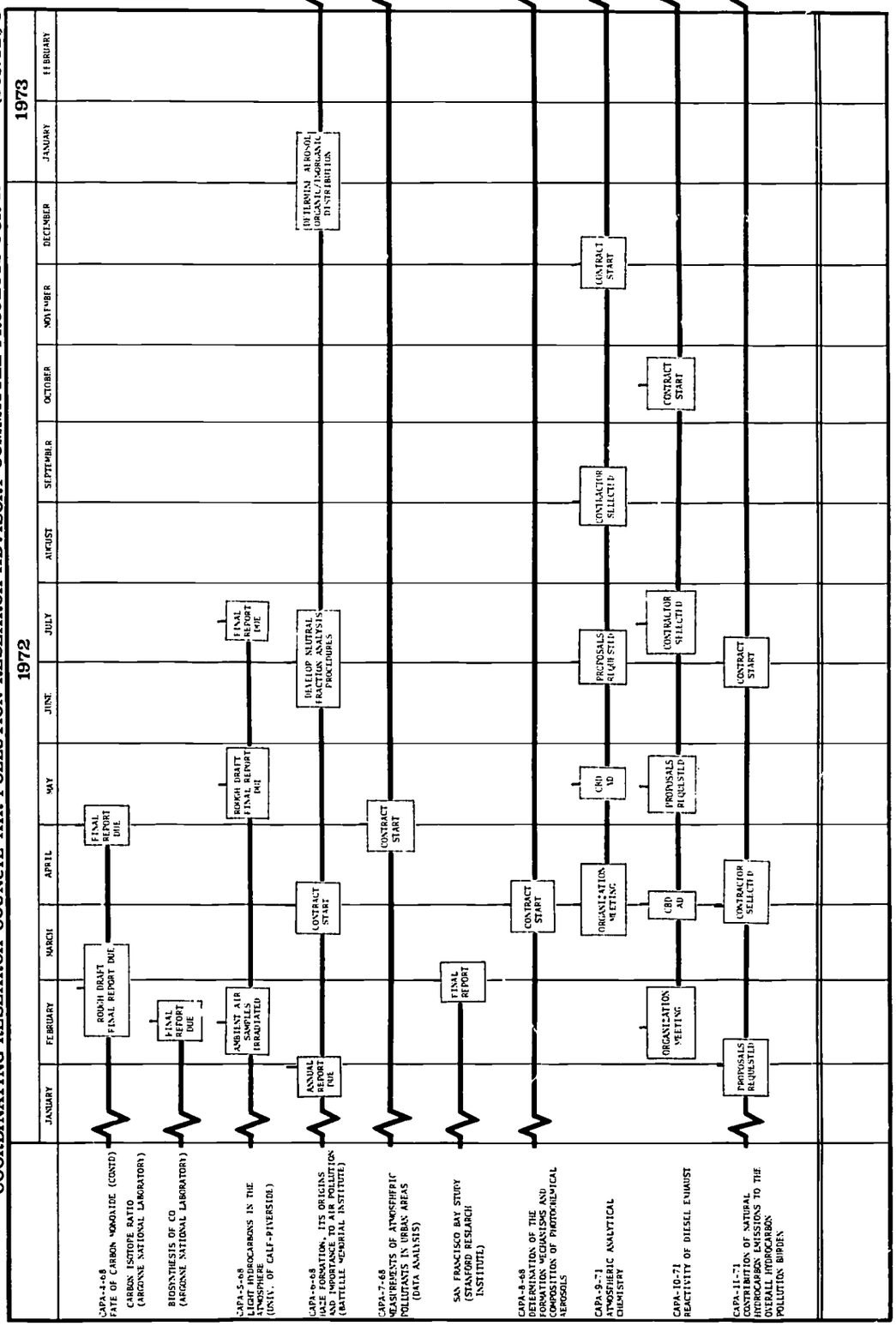

COORDINATING RESEARCH COUNCIL AIR POLLUTION RESEARCH ADVISORY COMMITTEE PROJECTS FOR 1971 (CONTD.)5
1971
1972
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
CAPM-9-69 EFFECTS OF LOW LEVELS OF CARBON MONOXIDE UPON HUMANS PERFORMING DRIVING TASKS
(OHIO STATE)
BEGIN PSYCHO-PHYSIOLOGICAL PERFORMANCE STUDY
BEGIN ROAD TESTING OF CoHb EFFECT
(HARVARD)
BEGIN DATA REDUCTION-ANALYSIS
BEGIN PHASE I ON THE ROAD LAYER IMPLANTS
COMPLETE INITIAL LAB TESTS-ANNUAL REPORT DUE
COMPLETE PSYCHOPHYSIOLOGICAL PERFORMANCE STUDY
ROUGH DRAFT ANNUAL REPORT
COMPLETE DATA REDUCTION-ANALYSIS
CAPM-10-71 (FORMERLY CAPM-10-69) EFFECTS OF LOW LEVELS OF NO_2 UPON HUMANS
CBD AD
BIDDERS SELECTED
PROPOSALS REQUESTED
CONTRACTOR SELECTED
CONTRACT START
CAPM-11-71 (FORMERLY CAPM-11-69) EFFECTS OF LOW LEVELS OF OXIDANTS UPON HUMANS
CBD AD
BIDDERS SELECTED
PROPOSALS REQUESTED
CONTRACTOR SELECTED
CONTRACT START
CAPM-12-69 INFLUENCE OF CARBON MONOXIDE LEVELS UPON INCIDENCE OF MOTOR VEHICLE ACCIDENTS
PROPOSALS REQUESTED
CONTRACT START
COMPLETE PILOT STUDY
BEGIN DATA COLLECTION
CAPM-13-69 EFFECTS OF CARBON MONOXIDE EXPOSURES UPON MYOCARDIAL INFARCTION FATALITY RATES
CAPM-17-71 EYE IRRITATION AND LACHRYMATION
ORGANIZATION MEETING

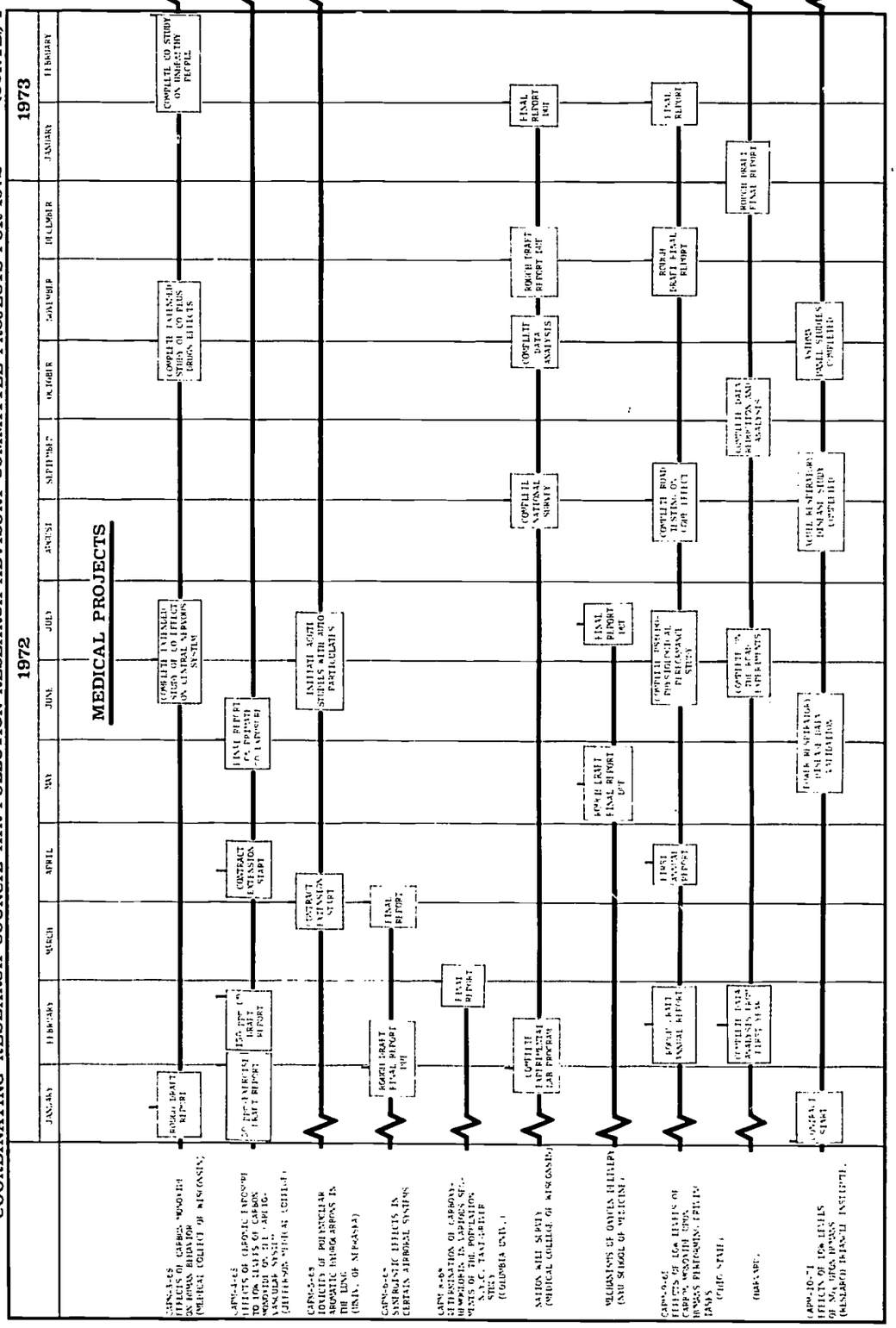
119/120

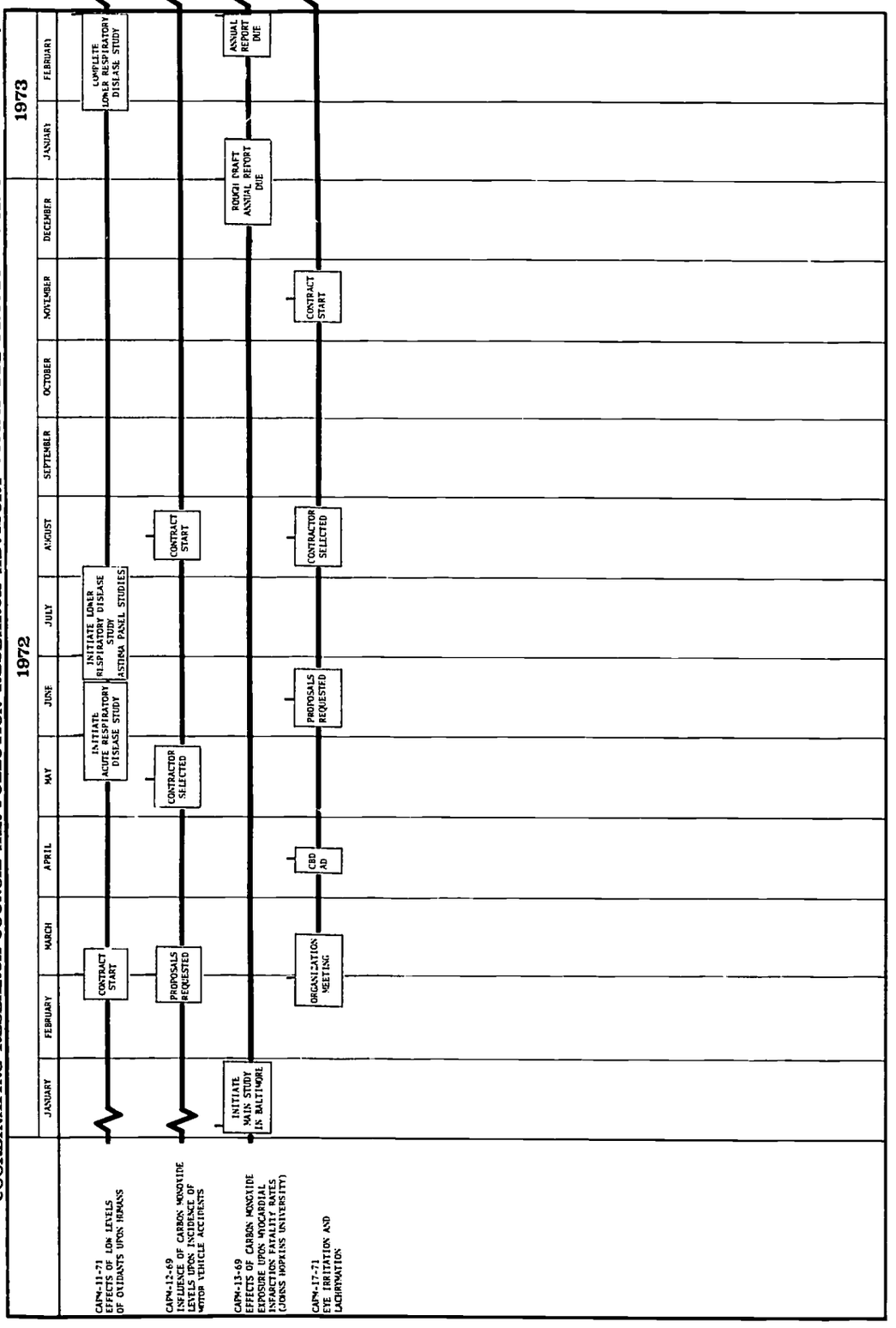
APPENDIX C
Anticipated Schedule of Progress During 1972


COORDINATING RESEARCH COUNCIL AIR POLLUTION RESEARCH ADVISORY COMMITTEE PROJECTS FOR 1972
1
1972
1973
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
ENGINEERING PROJECTS
CAPE-2-68
EFFECTS OF GASOLINE PROPERTIES ON CARBURETOR & PCV VALVE DETERIORATION
(SCOTT RESEARCH LABORATORIES)
FINAL REPORT DUE
CAPE-4-68
FUEL VOLATILITY EMISSIONS
(BUREAU OF MINES)
FINAL REPORT DUE
DRIVEABILITY
(ETHYL CORP.)
FINAL REPORT
CAPE-6-68
GASOLINE COMPOSITION AND VEHICLE EXHAUST GAS AROMATIC CONTENT
(ESSO RES. & ENG.)
FUEL TSA DEPOSIT EFFECT TESTS COMPLETED
SECOND ANNUAL REPORT DUE
START CONTRACT CONTINUATION
VOLATILE HIGH BOILER DEPOSIT EFFECT EVALUATED
THIRD ANNUAL REPORT DUE
CAPE-7-68
EXHAUST ODOR MEASUREMENT
(A. D. LITTLE)
INITIATE STUDIES OF SIMPLIFIED ANALYTICAL METHODS
COMPLETE INITIAL STUDY OF ENGINE VARIABLE EFFECT
START CONTRACT CONTINUATION
CAPE-8-68
KINETICS OF OXIDATION AND QUENCHING OF COMBUSTIBLES IN EXHAUST SYSTEMS OF GASOLINE ENGINES
(U. OF MICHIGAN)
COMPLETE FINAL CORRELATION STUDY
ROUGH DRAFT FINAL REPORT
FINAL REPORT DUE
CAPE-9-68
AUTOMOTIVE FUELING EMISSIONS
(SCOTT RESEARCH LABORATORIES)
2ND YEAR ANNUAL REPORT DUE
INITIATE EXTENDED STUDY
INITIATE FIELD STUDY
INITIATE VAPOR DEVELOPMENT
COMPLETE FIELD STUDY
COMPLETE MODEL DEVELOPMENT
CAPE-10-68
TRAFFIC SURVEY FOR DEVELOPMENT OF AVERAGE DRIVING CYCLES
(SCOTT RESEARCH LABORATORIES)
ROUGH DRAFT FINAL REPORT
FINAL REPORT
CAPE-11-71
IMPROVED METHODOLOGY FOR DETERMINATION OF EXHAUST GAS OXYGENATE CONTENT
INSTRUMENTAL METHOD
(FORMERLY CAPE-14-69)
(SCIENTIFIC RESEARCH INSTRUMENTS)
DEMONSTRATION ON CHASSIS DYNAMOMETER
ROUGH DRAFT FINAL REPORT
FINAL REPORT
OXYGENATES
(BUREAU OF MINES)
ANNUAL REPORT DUE
COMPLETE VERIFICATION TESTS WITH FULL BOILING RANGE FUEL
START CONTRACT CONTINUATION


COORDINATING RESEARCH COUNCIL AIR POLLUTION RESEARCH ADVISORY COMMITTEE PROJECTS FOR 1972 (CONTD) 2
1972
1973
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
CAPE-12-68
CAPE-13-65
CAPE-19-70
CAPE-20-71
CAPE-21-71
ATMOSPHERIC PROJECTS
CAPE-1-69
CAPE-2-69
CAPE-3-69
CAPE-4-69


COORDINATING RESEARCH COUNCIL AIR POLLUTION RESEARCH ADVISORY COMMITTEE PROJECTS FOR 1972 (CONTD) 3
1972
1973
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
CAPA-4-68 FATE OF CARBON MONOXIDE (CONTD)
CARBON ISOTOPE RATIO (ARGONNE NATIONAL LABORATORY)
ROUGH DRAFT FINAL REPORT DUE
FINAL REPORT DUE
BIOSYNTHESIS OF CO (ARGONNE NATIONAL LABORATORY)
FINAL REPORT DUE
CAPA-5-68 LIGHT HYDROCARBONS IN THE ATMOSPHERE (UNIV. OF CALIF-RIVERSIDE)
AMBIENT AIR SAMPLES IRRADIATED
ROUGH DRAFT FINAL REPORT DUE
FINAL REPORT DUE
CAPA-6-68 HAZE FORMATION, ITS ORIGINS AND IMPORTANCE TO AIR POLLUTION (BATTELLE MEMORIAL INSTITUTE)
ANNUAL REPORT DUE
CONTRACT START
DEVELOP NEUTRAL FRACTION ANALYSIS PROCEDURES
[OPTIONAL AEROSOL CHEMICAL ANALYSIS DISTR(BRITAIN)
CAPA-7-68 MEASUREMENTS OF ATMOSPHERIC POLLUTANTS IN URBAN AREAS (DATA ANALYSIS)
CONTRACT START
SAN FRANCISCO BAY STUDY (STANFORD RESEARCH INSTITUTE)
FINAL REPORT
CAPA-8-68 DETERMINATION OF THE FORMATION MECHANISMS AND COMPOSITION OF PHOTOCHEMICAL AEROSOLS
CONTRACT START
CAPA-9-71 ATMOSPHERIC ANALYTICAL CHEMISTRY
ORGANIZATION MEETING
CBD AD
CBD TO
PROPOSALS REQUESTED
PROPOSALS RECEIVED
CONTRACTOR SELECTED
CONTRACT START
CAPA-10-71 REACTIVITY OF DIESEL EXHAUST
ORGANIZATION MEETING
PROPOSALS REQUESTED
CONTRACTOR SELECTED
CONTRACT START
CAPA-11-71 CONTRIBUTION OF NATURAL HYDROCARBON EMISSIONS TO THE OVERALL HYDROCARBON POLLUTION BURDEN
PROPOSALS REQUESTED
CONTRACTOR SELECTED
CONTRACT START


COORDINATING RESEARCH COUNCIL AIR POLLUTION RESEARCH ADVISORY COMMITTEE PROJECTS FOR 1972 (CONTD) 4
1972
1973
MEDICAL PROJECTS
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY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1972
1973
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
CAPM-11-71
EFFECTS OF LOW LEVELS OF OXIDANTS UPON HUMANS
CONTRACT START
INITIATE ACUTE RESPIRATORY DISEASE STUDY
INITIATE LOWER RESPIRATORY DISEASE STUDY (ASTHMA PANEL STUDIES)
COMPLETE LOWER RESPIRATORY DISEASE STUDY
CAPM-12-69
INFLUENCE OF CARBON MONOXIDE LEVELS UPON INCIDENCE OF MOTOR VEHICLE ACCIDENTS
PROPOSALS REQUESTED
CONTRACTOR SELECTED
CONTRACT START
CAPM-13-69
EFFECTS OF CARBON MONOXIDE EXPOSURE UPON MYOCARDIAL INFARCTION FATALITY RATES (JOHNS HOPKINS UNIVERSITY)
INITIATE MAIS STUDY IN BALTIMORE
ROUGH DRAFT ANNUAL REPORT DUE
ANNUAL REPORT DUE
CAPM-17-71
EYE IRRITATION AND LACRIMATION
ORGANIZATION MEETING
CBD AD
PROPOSALS REQUESTED
CONTRACTOR SELECTED
CONTRACT START