1969/1970

Eighty-Third Annual Report

Colorado State University

RESEARCH SERVES COLORADO

Eighty-Third Annual Report Colorado State University 1969/1970

Honorable John A. Love
Governor of Colorado
Denver, Colorado

Dear Sir:

In compliance with the Act of Congress entitled "An Act to Establish Agricultural Experiment Stations," approved March 2, 1887, and with Acts supplemental thereto, we hereby present Colorado State University's Eighty-Third Annual Report. This report encompasses research activities of the Colorado State University Experiment Station and of other major divisions of Colorado State University for the fiscal year 1969-70.

Respectfully,

Rue Jensen
Vice President for Research
Colorado State University

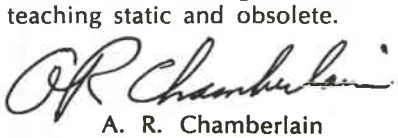
Donald F. Hervey
Director, Colorado State
University Experiment Station

THE UNIVERSITY AND RESEARCH

At Colorado State University research has been a major function since passage of the Hatch Act of 1887 and establishment of the Experiment Station. The activity has become an essential, practical and integral function of all colleges and of most departments. The research efforts generate new concepts and information. Often these suggest significant modifications of old and firmly established theories. Through application of the new methods and new ideas, teaching programs remain dynamic and relevant to current problems and circumstances. Furthermore, research findings help point the way to solving complex problems in industry, in agriculture and in communities, both at home and abroad.

But research does more than solve problems and accumulate facts; its activity is integral with the learning process. The research, therefore, contributes substantially to the continuing education of students and teachers on campus and to citizens throughout the state. By working with faculty personnel on specific research projects, graduate students learn the nature of modern problems and the methods and techniques for obtaining solutions to them. Students also learn to cooperate with other students and other scientists, and students and scientists together observe the public benefits from applying the resources of many disciplines such as biology, engineering, and chemistry to a single complex problem. The many research projects financed by federal agencies provide fellowships that enable students to pursue studies in the Graduate School.

Without research and scholarly study, graduate instruction would become insignificant and undergraduate teaching static and obsolete.

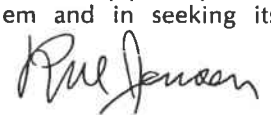


A. R. Chamberlain
President
Colorado State University

RESEARCH AT COLORADO STATE UNIVERSITY

Research and instruction at Colorado State University are fully integrated functions. In general, faculty members conduct research in their specialized fields and also teach classes of undergraduate and graduate students. As a result of this interaction of research and instruction, professors obtain new information for use in classes they teach and students receive the benefits of up-to-date information and concepts. Frequently, the new information, because it has use beyond the classroom, helps in solving problems important to the economy of Colorado and other areas; for example, research information obtained by a teacher-scientist studying the movements of fluids in soil may be used in water conservation programs and in teaching soil science to students. In addition, the integration of research and teaching satisfies and encourages the demands and the pleasures of intellectual stimulation.

Although usually conducted by individual faculty members or by groups and their graduate students, the research is specifically administered by the University through three agencies: The Experiment Station, the Office of Water Resources and Research, and the Office of Sponsored Research. The Experiment Station receives financial support from the Colorado State Legislature and from the United States Department of Agriculture, and it supports research on practical problems of the State in agriculture, natural resources, and community development. The Office of Water Resources Research, financed by money from the United States Department of the Interior, supports specialized research in all aspects of water management and use, including watershed development, groundwater and surface water management, economics of water systems development, and political and legal aspects of project development. The Office of Sponsored Research administers all contract and grant agreements between Colorado State University and outside agencies for the conduct of specific research projects of mutual interests and benefits to Colorado and the agency. Frequently a major problem, wide in geographic range and broad in effect such as air pollution along the front range of Colorado, may be supported by money from the Experiment Station and from a federal agency. Research scientists from each of several related departments may participate in the study of the problem and in seeking its solution.



Rue Jensen
Vice President for Research
Colorado State University

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Associate Dean, College of Forestry
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E. D. Gifford
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J. P. Jordan
Associate Dean, College of Natural Sciences
L. Luoto
Associate Dean,
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R. C. Nelson
Associate Dean,
College of Humanities and Social Science
S. Paranka
Associate Dean, College of Business
D. B. Simons
Associate Dean, College of Engineering
D. D. Johnson
Dean, College of Agricultural Sciences

state board of agriculture

John W. Thimming, D.V.M.
Brighton
W. P. Ball, M.D.
Durango
Carl G. Breeze
Kremmling
Arthur C. Sheely
Fort Collins
John C. Holtorf
Yuma
Carlyle N. Vickers
Denver
Edward C. Hofmann
Littleton
Kenneth W. Monfort
Greeley

Office of Sponsored Research

Office of Sponsored Research. This office, under the Vice President for Research, has the responsibility for administration of research sponsored by outside agencies, both governmental and commercial. It consists of two sections: (a) Proposal Section and (b) Office of Contracts and Grants Administration. These provide administrative support for sponsored research programs, from the early proposal stages through the execution of the research and final closing of the project.

The Proposal Section supports the faculty by providing information concerning potential sponsors. Facilities for preparation of proposals are also available including pricing, typing, reproduction, and distribution. Solicited and unsolicited proposals are sent to a number of organizations that would possibly support a proposed research project. Should a proposal submission result in interest by a sponsor, the Office of Contracts and Grants Administration negotiates the provisions of the agreement, and subsequently handles the numerous details of administration. The Office of Contracts and Grants has responsibility to relieve the research investigator of the contingent mundane details. The prosecution of the research is the responsibility of the principal investigator. Accounting for all research projects is provided by the University Accounting Office under the Vice President for Finance.

In the 1969-70 fiscal year, well over 400 proposals were submitted by the University. During the same time, over 425 research projects were awarded to the University with a value of $15,400,000, an increase of 18 percent above the amount of the previous fiscal year.

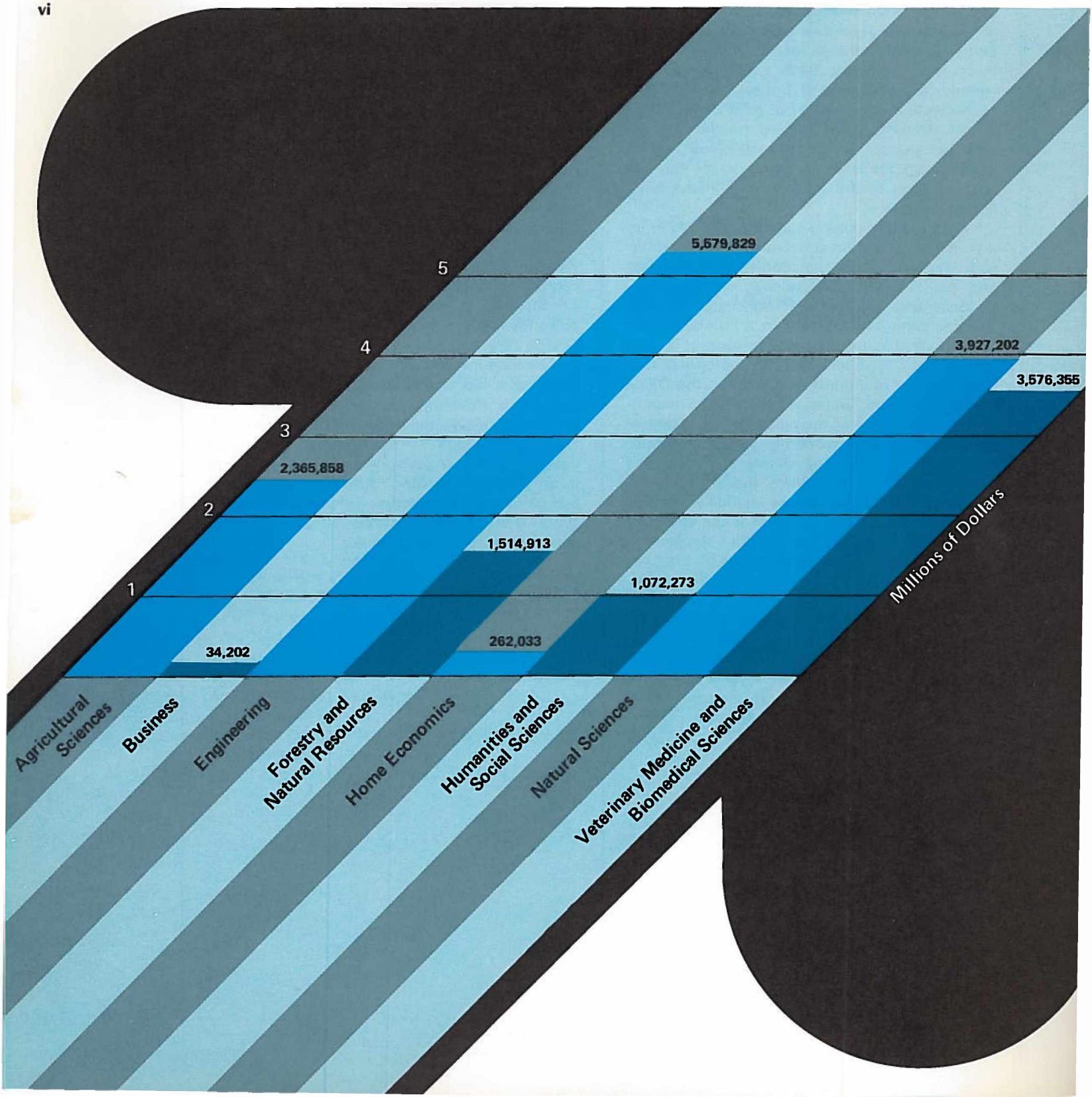
General University Research

Office of General University Research. Four units report to the Vice President for Research through this office: (1) Environmental Resources Center, (2) Office of International Programs, (3) Office of Contract and Grant Administration, and (4) Radiation Institute. Each unit supports and facilitates faculty research and thereby provides essential support in the academic training of students—graduate and undergraduate. Each unit also helps the university faculty to make their experience and knowledge available to the community and state.

During the fiscal year, efforts of faculty through these four units resulted in funding for research, education, and public service in excess of $15,390,000 from non-state sources. Significantly, this supplemental funding enables CSU to serve the people of Colorado more completely than it could otherwise hope to do. New knowledge has been developed and its applications to Colorado problems has been perfected; techniques for extending the campus into the state, through TV for example, have been developed; expert advisory services to state and local governments have been provided; more and better-trained scientists—physical, biological, social—have been produced to challenge the complexities of today's world.

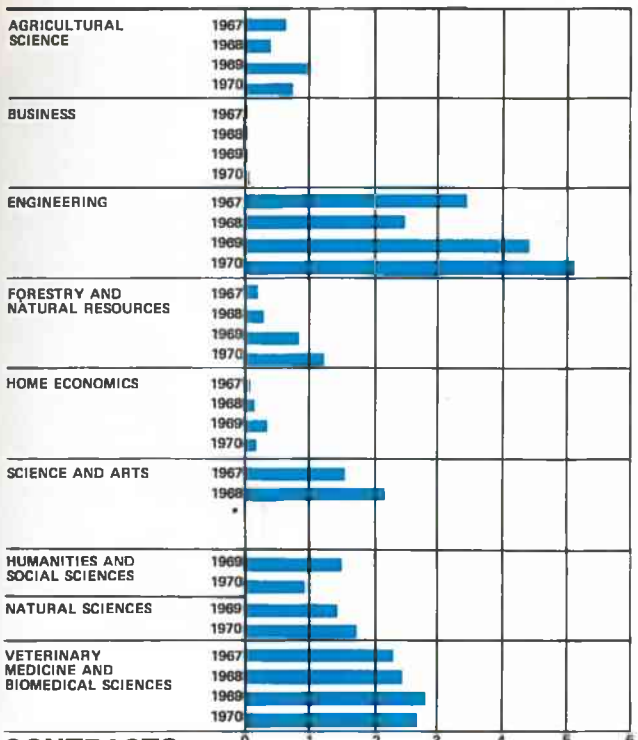
Growth of Research

Total Research Funds Expended by College 1969-1970

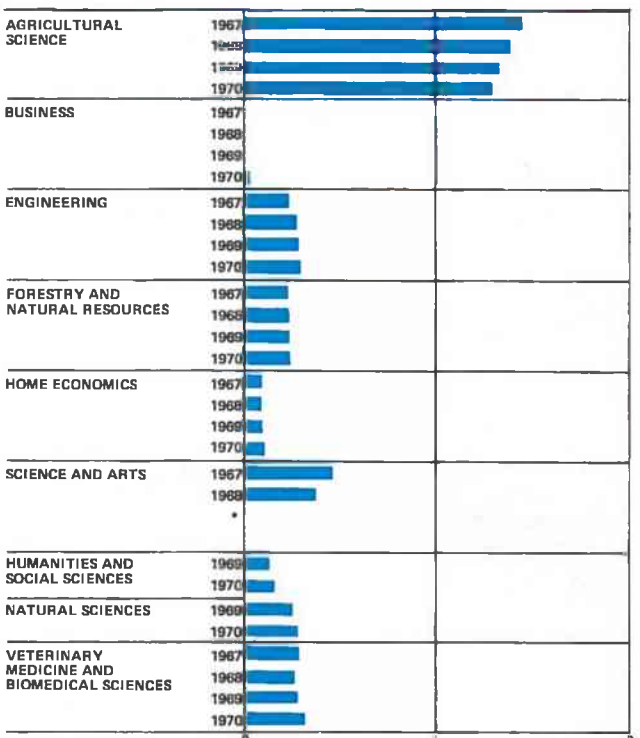


Growth of Research

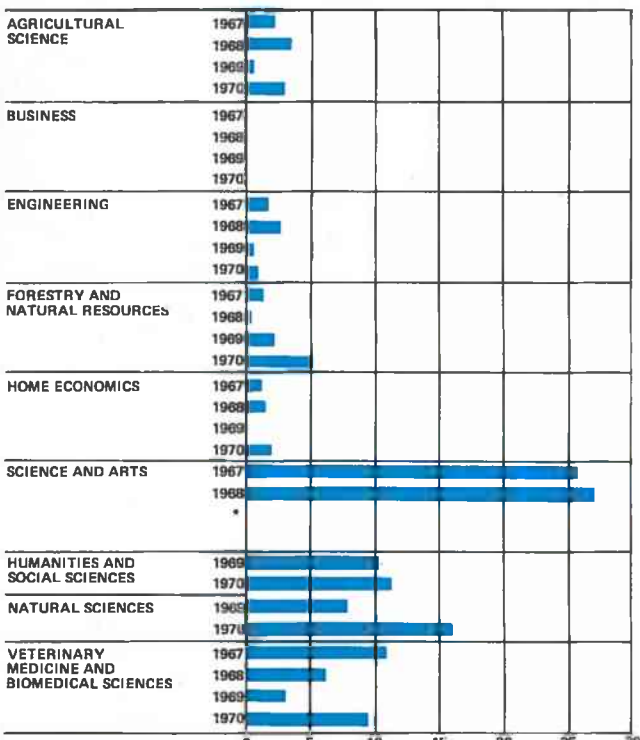
Source of Research Funds Expended by College 1967-1970



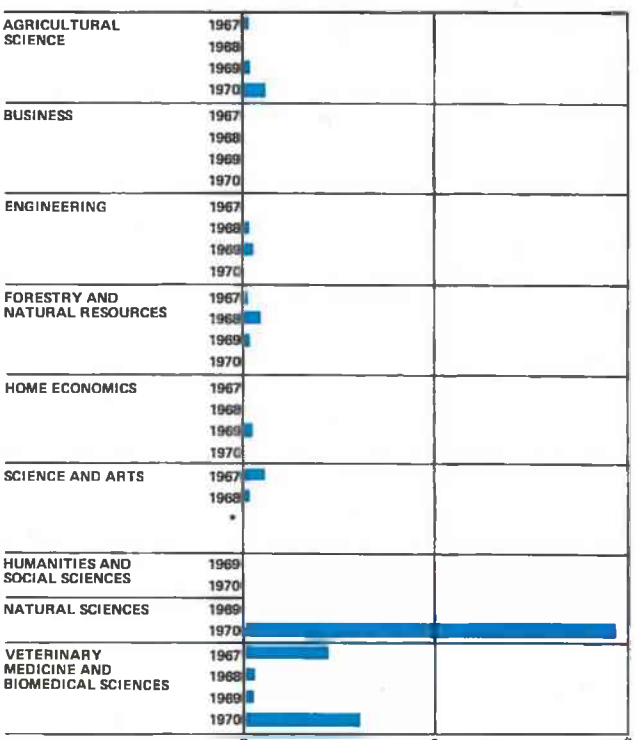
CONTRACTS AND GRANTS



EXPERIMENT STATION



FACULTY IMPROVEMENT COMMITTEE



FACILITIES DEVELOPMENT

Financial Statement, Experiment Station

Research Expenditures

Advanced Degrees Awarded

FINANCIAL STATEMENT, EXPERIMENT STATION Colorado State University Fiscal Year 1969-70

	Hatch	RRF	McIntire-Stennis	Specific Research	State Approp.	Research Sales	Total
Carryover 7/1/69			17,642.55	7,117.80			24,760.35
Receipts 1969-70	523,557.00	300,223.00	49,447.00		2,343,925.00	301,755.70	3,519,500.70
Total Revenue Available	523,557.00	300,223.00	67,089.55	7,117.80	2,343,925.00	301,755.70	3,544,261.05
Expenditure of Revenue:							
Personal Services	508,027.60	266,203.24	39,858.15	6,347.91	1,459,742.82	19,479.52	2,299,659.54
Travel	2,215.91	16,959.73	2,359.46	296.50	60,833.32	6,967.38	89,632.30
Equipment	920.50	1,517.50	4,851.01		83,754.26	13,060.77	104,104.04
Land & Structures					30,215.82		30,215.82
Personal Benefits					126,731.55		126,731.55
Supplies & Materials	12,392.99	15,542.53	6,755.23	473.39	196,508.23	267,928.66	499,601.03
Plant M&O					386,139.00		386,139.00
Total Expenditures	523,557.00	300,223.00	53,823.85	7,117.80	2,343,925.00	307,436.33	3,536,082.98
Balance 6/30/70			13,265.70			(5,680.63)	7,585.07
Total Expenditures & Balance	523,557.00	300,223.00	67,089.55	7,117.80	2,343,332.00	301,755.70	3,543,668.05

RESEARCH EXPENDITURES Colorado State University Fiscal Year 1969-70

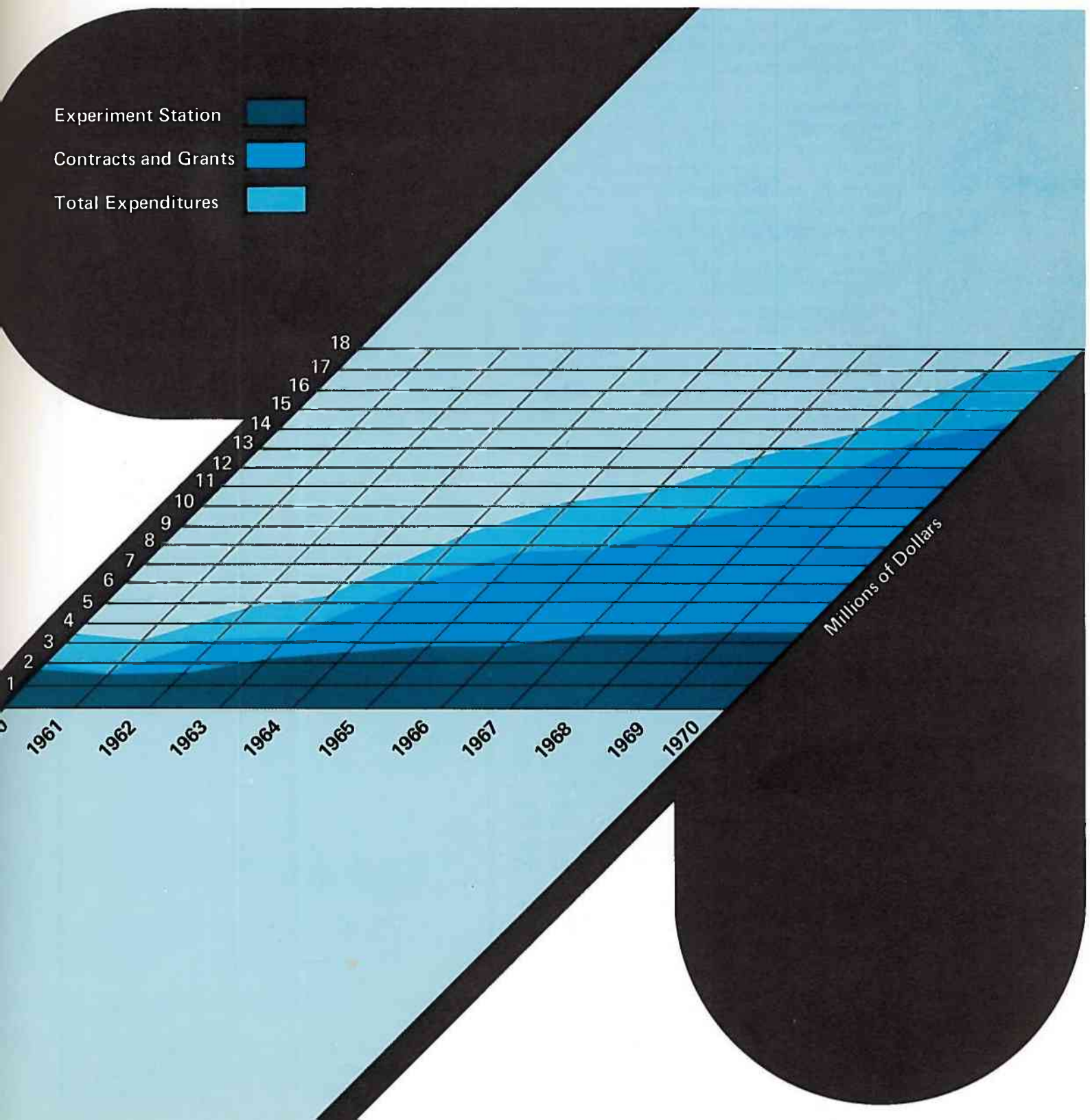
College	Total	Contracts and Grants	Experiment Station	Faculty Improvement Committee	Facilities Development
Agricultural Sciences	2,365,858.35	804,090.35	1,458,618	3,150	100,000
Business	34,202.37	33,311.37	891	....	....
Engineering	5,579,829.90	5,281,880.90	296,949	1,000	....
Forestry and Natural Resources	1,514,913.34	1,281,961.34	227,852	5,100	....
Home Economics	262,033.55	161,768.55	98,230	2,035	....
Humanities and Social Sciences	1,072,273.96	923,527.96	136,761	11,985	....
Natural Sciences	3,927,202.42	1,731,590.42	271,839	16,030	1,907,743
Veterinary Medicine and Biomedical Sciences	3,576,355.88	2,689,533.88	295,022	9,800	582,000
Other*	2,441,715.58	1,465,894.58	749,921	900	225,000
Totals	20,774,385.35	14,373,559.35	3,536,083	50,000	2,814,743

*Includes one or more of the following: President's Office; Dean, Summer Session; Dean, Graduate School; Libraries; Extension Service; Office of International Programs; Colorado State Forest Service, Natural Resources Center.

ADVANCED DEGREES AWARDED

College	Masters	Doctors
Agricultural Sciences	42	10
Business	28	
Engineering	47	23
Forestry and Natural Resources	38	19
Home Economics	18	
Humanities and Social Sciences	293	12
Natural Sciences	58	42
Veterinary Medicine and Biomedical Sciences	33	21
Totals	557	127

Summary of Expenditures for Research 1960-1970



Environmental Resources Center

Radiation Institute

Environmental Resources Center. The Environmental Resources Center coordinates education and research programs dealing with man's use and development of land, water, and atmosphere. The missions of the Center are to stimulate research on natural resources and related environmental problems, to facilitate training of scientists and engineers for the task of natural resources development and environmental qaulity control, and to improve the flow of information between those engaged in research and those engaged in its application.

The Center, through the activities of eleven standing committees and several special committees, has participated in academic activities related to natural and environmental resources, planning for new research or educational programs, coordination of research programs with state and federal agencies, and general public services concerning environmental resources.

In addition, the Center administers a program of water research funded through the Office of Water Resources Research (OWRR), U.S. Department of the Interior. Twenty-three water research projects were conducted during the year supported by $300,000 in Federal funds and $200,000 in University matching funds. An advisory committee of State Water Agency representatives helped select projects having direct applications to Colorado problems. Fifty-four professional research scientists and engineers representing 14 disciplines conducted the work; 54 students gained advanced training through research participation. Thirty-eight technical and professional publications reporting results and new knowledge were issued.

Radiation Institute. A voluntary association of faculty who are interested in all aspects of nuclear science and radiation technology, the Institute provides coordination for research and training in these fields. It serves as an interdisciplinary forum for the many departments and colleges involved.

A part-time director is responsible for operation of the training reactor and for radiation safety on the campus. University compliance with state and federal regulations on use and disposal of radioactive materials and other safety measures is a responsibility of the Institute staff.

International Programs

Contract and Grant Administration

Office of International Programs. The function of OIP is to direct campus attention to world affairs and to develop research and educational activities in appropriate international programs. The office provides liaison internally as well as between sponsor and the University for projects operating abroad; it reviews and approves all contracts for foreign projects; it prepares proposals covering research, training, and operation of foreign projects; it assists foreign students in arrangements for study at CSU and in orientation and adjustment to the campus; and it provides liaison with U.S. agencies and foreign governments in planning and coordinating training visits of short or long duration for foreign personnel.

Office of Contract and Grant Administration. Administrative services in support of sponsored research, for training grants, and for other agreements with outside agencies are provided by this office. Included are assistance to faculty in negotiating terms of agreements, monitoring agreements for CSU compliance with terms, budget control, reminders on report deadlines, changes in agreement, and similar tasks. Faculty liaison with sponsors is expedited by the staff.

Assistance is given faculty in preparation of proposals for research projects and training grants. Potential sponsors may be identified; a proposal may be typed in final form, edited, checked for completeness and compliance with University policies; copies may be made, approved, and submitted to sponsor.

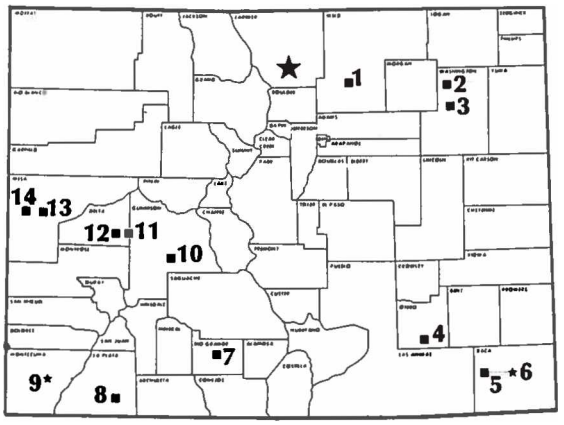
Experiment Station

Experiment Station. The Colorado State University Experiment Station is a complex of faculty, graduate students, technicians, laboratories, and field stations at Fort Collins and 11 other locations scattered throughout the state. Most of the scientists are involved in both research and teaching.

The Experiment Station was created and funded in 1888 by passage of the Hatch Act. Like its counterparts in other land-grant colleges, it was enjoined as an integral part of the institution to promote investigation into the basic principles and useful applications of science relating to agriculture. In 1962 the McIntire-Stennis Cooperative Forestry Research Act expanded the efforts of experiment stations by providing new funding for research in forestry. Since both of these Acts require state matching funds, the Experiment Station is supported cooperatively by both state and federal governments. Over the years the program of the Experiment Station has broadened to encompass research efforts in all eight colleges of the University.

Cooperative research is conducted with U.S. Department of Agriculture agencies on the main campus and at facilities located near Akron and Gunnison.

Research results are made available to the public through bulletins, scientific journals, news media, and field days at the branch stations.



1 Northern Colorado Research Demonstration Center, Greeley
2 Eastern Colorado Range Station, Akron
3 Central Great Plains (USDA) Field Station Coop., Akron
4 Arkansas Valley Branch Station, Rocky Ford
5 Southeastern Colorado Branch Station, Springfield
6 Walsh Experimental Area
7 San Luis Valley Branch Station, Center
8 San Juan Basin Branch Station, Hesperus
9 Yellow Jacket Experimental Area
10 Mountain Meadow Research Center, Gunnison
11-12 Western Slope Branch Station, Austin-Rogers Mesa; Austin
13 Western Slope Branch Station, Orchard Mesa; Grand Junction
14 Western Slope Branch Station, Fruita; Grand Junction

Faculty Improvement Committee

Faculty Improvement Committee. The duties of the Faculty Improvement Committee (FIC) as stated in the CSU Faculty Staff Manual are:

> The Faculty Improvement Committee is composed of faculty representatives. The committee advises on matters of concern to the faculty, including such factors as working conditions, relationships, recognition, advancement, and other matters which may be recommended to improve effectiveness and welfare of the faculty.

In addition, the FIC is responsible for a modest amount ($50,000) in research funds. These funds are distributed by an ad hoc committee of five faculty members chosen by the FIC for their record of research. These research funds are granted to faculty members who submit proposals to this committee for the establishment of new research projects on campus. Sixty-three grants from FIC funds were made to 26 departments for fiscal year 1969-70, with the following distribution:

College	No. of Grants	Amount Granted
Agricultural Sciences	3	$ 3,150
Business	—	—
Engineering	2	1,000
Forestry and Natural Sciences	5	5,100
Home Economics	2	2,035
Humanities and Social Sciences	21	11,985
Natural Sciences	20	16,030
Veterinary Medicine and Biomedical Sciences	9	9,800
Miscellaneous—Libraries	1	900
TOTALS	63	$50,000

The progress reports for these grants, which are on file in the Office of the Graduate School, indicate that the distribution and use of these funds have contributed substantially to the development of new research at CSU.

University Facilities Construction and Utilization

University Facilities Construction and Utilization Office. The Facilities Construction and Utilization Office is responsible for the funding, design, construction, space assignment, and space utilization of the total facilities program. During the last year the following facilities concerned primarily with development of research and graduate training facilities were either completed and occupied or placed under construction contract:

Facility	Sponsor	Amount
Chemistry Building—(Under construction)	HEW (1)	$1,560,743
Anatomy-Zoology—(Final design)	NIH (2) and HEW (1)	795,000
Beef-Cattle Nutrition Research Center (Under construction)	State of Colorado	100,000
Grassland Biome Research Lab (Under construction)	State of Colorado	225,000

(1) Health, Education and Welfare
(2) National Institutes of Health

In addition to the construction program responsibilities the Facilities Construction and Utilization Office works with departmental and administrative committees in development proposals for additional research facilities and related research grant proposals. It also supervises facilities grant funds and administers proceeds from Research Foundation revenue bonds.

The University's present strong orientation to the upper division graduate training and research endeavors is reflected in a Five Year Program that calls for a 110 percent increase in existing research space.

Research Accomplishments

Agriculture

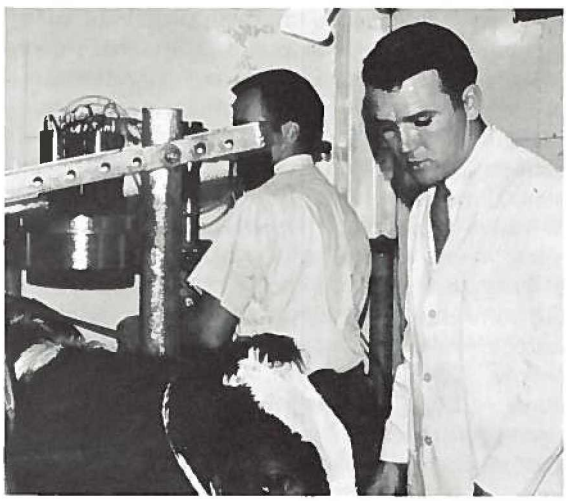
Beef Quality. The "twin-calf project" in the Animal Science Department has just about finished its first year of operation. The project is a study on the development of muscle, fat, and bone in beef cattle during growth with special emphasis on the distribution of fat in the carcass.

The calves are purchased shortly after birth, reared and fattened at the CSU livestock farm, and slaughtered in the Animal Science meat lab. They are weighed, bled, biopsied, counted, somascoped, and injected every month to determine body composition, enzyme activities, and hormone levels. All of these measurements will be plotted as functions of growth and correlated to the cutability and quality of the carcass. Any of the traits that are highly related to superior carcasses can be measured in young animals and used to predict the type of carcass that the calf will produce.

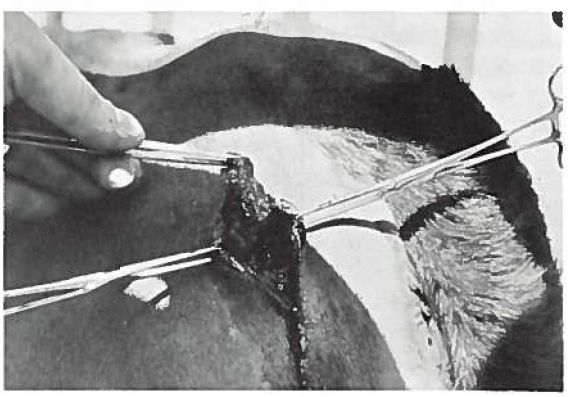
The design of the project includes twin calves so that the results of the research can be used in breeding programs. Twins will provide the information needed to determine how much improvement can be made through better management and nutrition, and which traits should be emphasized in a selection program.

Sixteen sets of Hereford, Angus, and Holstein twins were purchased in 1969 and slaughtered in the fall of 1970. One side of each calf was completely boned and ground for body composition analysis. The other side was cut by standard procedures to determine cutability and retail value of the carcass. Selected cuts were collected from each wholesale cut for chemical analysis and study of how fats are distributed in the carcass. Twelfth rib cuts were saved to determine the eating quality of the meat by organoleptic evaluation.

When all of the analyses and measurements are pulled together CSU animal scientists hope that growth patterns will be revealed in young calves that will indicate their future value as carcass beef and give an estimation of the quality. The development of such tools will provide the cattle industry with the wherewithal to produce better beef for the American people for less of their total food dollar.



Estimating lean body mass in the whole body counter.



Collecting samples of fat and muscle from twin calves by biopsy techniques.

Analyzing samples of twin calf fat and muscle in the laboratory.

Consolidation of Irrigation Systems. The consolidation of irrigation systems involves the operation of an agricultural valley under one man-

agement unit, instead of the practice of many irrigated valleys in the west which contain numerous separate irrigation companies. Among the problems that arise due to numerous companies operating independently are duplication of irrigation structures; more costly operation and management; legal questions regarding priority of water rights and time of use of water supplies; human problems involving the attitude of water users toward the use and development of water; and economic problems concerning water development and the value of the water supply. Consolidation would not only alleviate many of these problems but would increase the strength and effectiveness of the irrigation institution in improving water management and bringing about water development.

The problems associated with consolidating the irrigation companies in a large valley are being evaluated by studying eight irrigated valleys in the west. The eight areas are Poudre and Grand Valleys in Colorado, Ashley and Utah Valleys in Utah, Eden and Riverton Valleys in Wyoming, the Truckee-Carson Irrigation District near Fallow, Nevada, and the Salt River Valley near Phoenix, Arizona. Two of these valleys have been consolidated for more than 50 years; two have only recently been consolidated; two have only limited reasons for becoming consolidated; and two consist of a maze of irrigation companies and would materially benefit by consolidating.

One of the objectives of this study is the determination and evaluation of the engineering characteristics of the system, including the magnitude of time-variation of the water supply, the physical characteristics of the system, its operational methods, and alternative physical and operational systems.

Another objective is to examine the systems and to analyze them from a legal perspective, determining whether or not present laws operate as impediments to consolidation; which institutional arrangements control the use of water; what the legal rights of individual users are; and what legal constraints it may be necessary to include in consolidation proposals.

Finally, the study will attempt to focus attention on the sociological dimension of consolidation, determined by the organizational arrangement of the irrigation companies, and the perceptions of satisfaction and dissatisfaction by persons associated or affected by irrigation companies. Organizational alternatives for consolidation proposals will be explored and delineated.

The engineering aspects of consolidation are being supervised by Gaylord V. Skogerboe in the Agricultural Engineering Department, while George E. Radosevich in the Economics Department is handling the legal aspects, and Bertram L. Ellenbogen and Evan Vlachos of the Department of Sociology-Anthropology are studying the social dimensions of the problem.

Diarrhea in Calves. A newborn calf nursing from his mother or frolicking in the green grass in some mountain ranch setting is a photographer's delight and, for the urbanite, a reminder of the beauty in nature. But, to the rancher who owns the calf it represents a year of work, invested capital, borrowed operating money, and, if he is lucky, a small profit when the calf is sold in the fall of this year or next. The calf represents the only marketed product for most ranchers—the fruit of his labors. Unfortunately 10-25% of the calves never leave the ranch; they die of calfhood diseases. That fact costs the cattle industry 40-60 million dollars each year. These deaths are a serious economic problem for the industry and ultimately mean that every person must pay more for the beef on his table.

The most serious of the calfhood diseases are categorized as "enteric diseases," those intestinal disorders commonly resulting in "scours" or "diarrhea." A number of factors are known to cause the condition. It may be due to bacteria or virus or to poor nutrition. In a joint research effort, scientists from the Departments of Microbiology, Pathology, Animal Science, and Physiology and Biophysics are studying this problem.

Nutritional and physiological problems of prevention and cure are being studied intensively by Dr. Kirvin L. Knox (Animal Science) and Dr. Robert W. Phillips (Physiology). Physiologically the body fluid loss due to diarrhea is a serious crisis for the animal. Depending upon the severity of the diarrhea, the calf may lose 10-15% of its body fluids. This means that the animal is losing body water and also minerals, such as sodium chloride and potassium. The composition of the fluid replacement must be correct. Until now composition-of-replacement therapy was unknown.

These studies have shown that food proteins and energy are critically important to the calf with diarrhea. Because the animal has diarrhea the body metabolism is increased to a

very rapid pace; this reaction further depletes the animal's meager store of available energy. Animals with diarrhea do not absorb sufficient quantities of needed nutrients from their stomachs and small intestines. Furthermore, secondary infections from bacteria may complicate the situation. If the necessary nutrients are not provided, the animal may die or have impaired resistance to other stresses. Dietary supplements to restore energy, protein, and fluid balance are being tested.

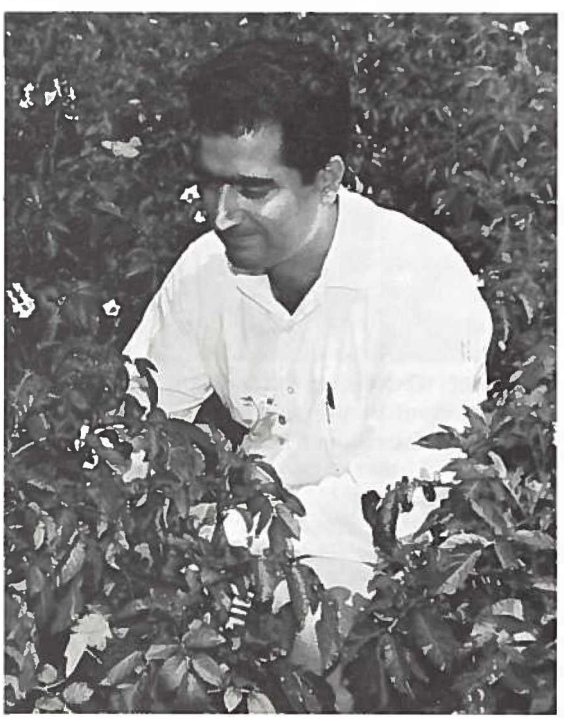
Fruit Disease Research. *Cytospora* canker is one of the worst diseases plaguing peach orchardists in Colorado and other areas of the U. S., and in foreign lands from western Europe to mainland China, including the irrigated desert of Israel. Research work in Colorado on this disease is being carried on by Dr. Norm Luepschen and his assistants of the Botany and Plant Pathology Department at CSU's Western Slope Branch Station at Grand Junction.

Peach canker, a fungus disease, causes a degeneration of the tree's bark tissues resulting in dieback of twigs, branches, and tree scaffolds, with the ultimate death of the entire tree. The disease is associated with wounds, particularly winter injury, pruning cuts, and cultivation and harvesting injuries. The active presence of the *Cytospora* fungus is often witnessed by large drops of gum exuding from infected bark; hence the descriptive name, "gummosis."

In searching for a practical control of peach canker, we have explored various avenues, including tree nutrition, varietal difference in susceptibility, and wound exposure studies. These latter showed that if pruning is delayed until tree growth resumes in the spring, the severity of canker incidence is reduced by more than half, compared with those trees pruned in early winter. Chemical controls are also being sought in the form of wound dressings, post-pruning fungicide sprays, and chemotherapeutants. As a result of research, various protective measures are currently being recommended to peach growers, while chemotherapy and varietal studies are continuing.

In addition to these practical results, some very important basic information has been discovered concerning the *Cytospora* fungus and the nature of the disease. For example, it was found that *Cytospora* pycnidiospores require an external supply of carbohydrate for germination, either as simple sugars or sugar alcohols. These compounds are found in peach bark, with slight seasonal variations. The airborne nature of the spores was first established in 1969. Prior to this, the infectious spores were considered to be spread only by contact, with splashing raindrops, insects, and man as the vectors. The relationship of wind currents and other weather factors in the orchard environment on airborne spore dissemination is now being explored. Researchers in other areas, along with Colorado peach growers, have shown considerable interest in our results.

A Mathematical Model to Predict Nitrogen and Phosphorus Requirements of Potatoes. Many potato farmers are using fertilizers to increase their yields and profits. There is a need to predict fertilizer requirements of potato crops more judiciously because of the danger of over-fertilization, which reduces the profit margin of the farmers and might lead to groundwater pollution and a reduction in tuber quality.



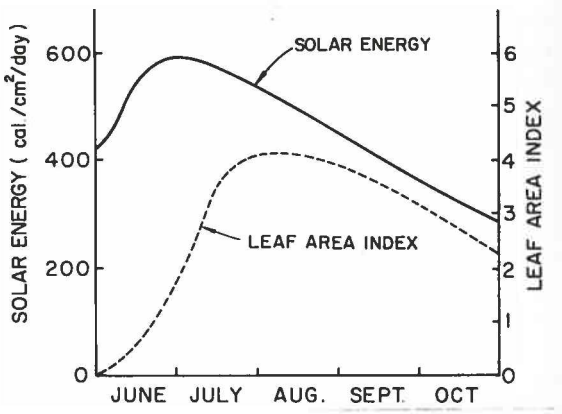
Dr. P. N. Soltanpour, Department of Horticulture, examines potato plants as part of investigation to predict nitrogen and phosphorus requirements of potatoes.

Dr. Parviz N. Soltanpour of the Department of Horticulture, with the cooperation of Dr. John O. Reuss, Department of Agronomy, has developed a mathematical model that relates the yield of potato tubers to the sum of fertilizer and soil inorganic nitrogen, and to the manipulated sum of fertilizer phosphorus and soil phosphorus. This model, which has been verified by field tests, can be programmed on a computer to print out the nitrogen and phosphorus fertilizer recommendations for different potato farmers according to their soil test results and ratios of unit price of potatoes and unit cost of nitrogen and phosphorus.

The results of the research have also indicated that inorganic soil nitrogen is very important in determining the nitrogen requirements of potato crops while the contribution of soil organic matter is about constant. This research project is being supported by the Experiment Station and the San Luis Valley Potato Administrative Committee.

Laboratory technician determining inorganic nitrogen content of the soil samples, San Luis Valley Branch Experiment Station, Center, Colorado.

More Effective Use of Solar Energy for Crop Production. Research at the Department of Agronomy Research Center has shown that sugar beet yields are highly correlated with solar energy and leaf area. The plant's growth pattern, however, does not fit our season for most effective use of the sun's energy. Growth studies reveal that solar radiation maximizes in early July about a month before total leaf area reaches its maximum value. Thus, leaf area should reach a maximum sooner to utilize early season radiation more effectively.



Seasonal radiation in relation to leaf area index. Leaf area index is the ratio of leaf area to ground area.

Sugar beet yields are approaching a production plateau in Colorado, and one of the principal production limitations is the inability of the plant to use the high level of solar energy available early in the season because of insufficient leaf area.

Based on this research, the Agronomy Department is developing new management techniques to increase early-season leaf area. One of the innovations is the use of clear polyethylene plastic over the crop for four to six weeks following planting. This practice increased the yield of sugar 35% over the control in

Increased early season growth of sugar beets (June 7, 1970) resulting from plastic cover. Plot in immediate foreground was planted March 4, then covered with plastic until April 15. Next plot in the background was planted the same date but remained uncovered. Plots on left and right are other treatments, some still covered with plastic.

1968 and 25% in 1969. The plastic-covered treatments germinated sooner and grew more rapidly during the spring than did the conventionally grown beets. The greater leaf area presented by these treatments in early July was associated with greater production of sugar. Seedlings germinated in the greenhouse and transplanted into the field at the normal planting date also enhanced early plant growth and increased sugar production 25 to 35%. With mechanization of the new management practices being investigated at CSU, there is considerable opportunity to raise the level of sugar beet production during the 70's.

Soil Test for Prediction of Nitrogen Requirements of Crops. Prediction of the nitrogen fertilizer needs of crops is important both to the farmer and the public. Without sufficient nitrogen, yields will be low and the crop will not provide an economical return to the grower. Excess nitrogen will reduce the quality of some crops, particularly sugar beets and malting barley. The public must be concerned, because in many soils if excess nitrates are present they may leach downward into the water table causing nitrate pollution that represents a hazard to human and livestock health. The first step in preventing such pollution is the regulation of nitrogen supplied to the crops in such a manner as to provide for the crop needs without unnecessary excesses that present a pollution hazard.

The concept has been widely accepted by agronomists that the amount of readily available nitrogen present in the soil at the start of the cropping season is not an important factor in determining the amount of nitrogen fertilizer that should be applied to the crop. According to this concept readily available nitrate and ammonium nitrogen is present in relatively small amounts compared with the total amount required by the crop. Further, the nitrogen is supposed to fluctuate very rapidly with time due to use by the crop and the soil microflora. Actually the major store of nitrogen in the soil is in the organic matter. Thus, according to the classical concept, the best way to predict the supply of nitrogen that will be available to the crop is to estimate the rate at which nitrogen will be released by the breakdown of soil organic matter. Over the years a great deal of effort by many scientists has gone into attempts to develop methods to estimate this release rate from soil tests.

Recent work by the Agronomy Department has shown that these classical concepts are not valid under present Colorado conditions. Relatively large amounts of nitrate and ammonium nitrogen are often present in our soils at planting time. Under dryland conditions these accumulate from the breakdown of soil organic matter during the fallow period. Under irrigation they may accumulate from previous applications of commercial or barnyard fertilizers in excess of crop requirements, or from the breakdown of residues from leguminous crops. Research has shown that the amount of readily available nitrogen, particularly nitrate, in the soil at planting time is more important in predicting fertilizer needs than are measurements commonly used to provide estimates of release from organic matter. However, these release rate measurements are still useful in refining the prediction. Mathematical models have been developed that describe the response of common crops to the total supply of nitrogen. In order to utilize these models in prediction, it is necessary to estimate readily available nitrogen and nitrogen likely to be released from organic matter by means of soil tests. Sufficient fertilizer nitrogen is then added to attain the proper total supply for a given crop. These estimates give better prediction of fertilizer needs than methods that do not take into account all three sources. Statistical methods were adapted to determine from the research data the relationship between laboratory tests for organic nitrogen and the amount of nitrogen released to the crop in the field. Interestingly enough, values determined by this method are very similar to "rules of thumb" that have been in use by agronomists for many years.

Nitrogen fertilizer recommendations presently being made by the CSU Soil Testing Laboratory are based on this total supply concept and are the direct result of this research. Further studies are under way to refine the methods and provide more accurate recommendations for a wide range of crops.

Accelerated Massed Desensitization Therapy. In what has been termed a "pioneering" work, Dr. Richard M. Suinn, Professor of Psychology, has opened up new hope for people suffering from tensions and anxieties. Until recently, emotional conflicts required months and even years for successful treatment, and during such prolonged therapy, the clients often experienced continued personal distress as they attempted to confront their problems.

Dr. Suinn has been developing a treatment technique based on behavior therapy. Within the past ten years, the realm of psychotherapy has been significantly changed through the discovery of this new mode of treatment. Behavior therapy is based on the belief that symptoms of maladjustment are a result of defective learning rather than of deep, symbolic, emotional conflict. Claustrophobia, for example, is seen as a learned response to the stimuli of closed spaces and not because confinement reflects emotional problems of early childhood.

From this point of view, the behavior therapist can draw from a vast reservoir of proven evidence regarding how normal behaviors are acquired and altered. Laws on normal behaviors can now be applied toward understanding and changing pathological behaviors. Basically the behavior therapist establishes a learning environment that will enable the client to acquire adaptive, healthy behaviors or to extinguish maladaptive ones. Desensitization is one form of behavior therapy found especially valuable in the treatment of anxieties or phobias. The client is trained in relaxation responses, then systematically and gradually exposed to visual scenes that currently arouse varying degrees of tension. The client is soon able to react with relaxed responses instead of fear when faced with the visual stimuli.

Professor Suinn's recent work has been to modify the desensitization technique so as to significantly reduce the amount of treatment time. Although major theorists and therapists have been convinced that desensitization must proceed at a relatively slow pace, Dr. Suinn has challenged this belief. In a series of crucial experiments, the therapeutic time was reduced from eight-ten weeks (the typical time for desensitization as used by behavior therapists), to one week, to two days, and most recently to four hours. Throughout these studies, as results demanded, the desensitization method was modified into the form now called *accelerated massed desensitization*.

Accelerated massed desensitization enables the therapist to treat several clients simultaneously and in an extremely short time. This has the advantage of eliminating maladaptive difficulties before they interfere with further functioning, or before they become more severe. For example, the technique has been used with students suffering from mathematics anxiety. This type of problem prevents the student from successfully coping with any courses that involve numbers or formulas, such as accounting or chemistry. If not treated quickly, the student may miss important foundation courses necessary for his vocation and become more and more deficient in his preparations.

In many cases mathematics anxiety generalizes to other life settings, such as balancing a personal bank account or tabulating a grocery bill. Accelerated massed desensitization was used to treat students with such problems, with the therapy program being completely accomplished in one evening. Significant recoveries were found to occur after therapy in the students' feelings of comfort and in their ability to solve mathematics problems. One student even reported a unique fringe benefit in that he was "actually beginning to enjoy doing mathematics problems in class."

Behavior of Fundamental Materials in Structures. The need for economical, secure, and esthetically pleasing structures to house man's many activities has never been greater. Research on important aspects of engineering of structures and the materials of which they are constructed is progressing through the efforts of the Structural Engineering Program in the Civil Engineering Department.

Drs. J. R. Goodman, Civil Engineering, and J. Bodig, Forest and Wood Sciences, have completed a study of the basic behavior of wood under external loading, under the sponsorship of the National Science Foundation. Four species were studied: two softwoods and two hardwoods including the Colorado grown wood, Engelmann spruce. Developments of the study include an assessment of the degree of error introduced in considering wood to be an orthotropic elastic material. A new testing apparatus developed for

compression testing of clear wood specimens shows promise of improving the accuracy of testing methods. Strength data taken for loading at all angles to grain of the wood specimens have been analyzed and a new formula has been developed to predict the strength of softwood and hardwood species under such loading.

Elastic and strength properties of wood.

The modern design of engineered wood structures depends on an accurate knowledge of the wood's strength and elastic properties. The data developed by this study will materially aid the designer in making use of wood in building and construction. Additional funding for continued study has been obtained to further the work begun on this grant.

Dr. M. D. Vanderbilt, Civil Engineering, has completed a study of the shear strength of continuous reinforced concrete floor slabs. The study, sponsored by the National Science Foundation, utilized a new type of test specimen which more closely simulates continuous structures than have previous specimens. The study produced additional insight into the behavior and strength of continuous slabs.

Future research efforts are expected to include continuing studies of fundamental materials behavior and studies of the analysis and design of complex structural systems. The structural staff members are participating in the study of stochastic methods in engineering under the aegis of the Civil Engineering Departmental Grant. As competence in this area is gained, the staff expects to initiate studies dealing with the determination of random loadings on structures, fatigue strength of structural joints under random loadings, and probabilistic load factors for design.

Basic Combustion Studies. The combustion of hydrocarbon fuels is often the primary step in the production of useful power in our technolgy. For example, the automobile, turbojet airplane, fossil-fuel electrical power plant, and diesel locomotive are all dependent on such combustion processes.

If the importance of hydrocarbon combustion is obvious, then it is more distressing that the mechanisms by which such combustion processes occur are only understood in a rudimentary and general way. It is apparent that a more thorough understanding of these processes might well lead to a more efficient utlization of our energy resources. In addition, such an understanding would undoubtedly aid in the control and reduction of the pollutants produced in these combustion processes.

The work of Dr. C. E. Mitchell and Dr. P. J. Wilbur of the Mechanical Engineering Department is directed toward the analysis of nonsteady burning mechanisms in combustors using liquid hydrocarbons. Examples of such nonsteady burning are automobile engine knock and rocket engine instability. Physical and mathematical models are being developed to explain in detail the nature of these unsteady phenomena. These models are then compared with the existing body of experimental data in order to evaluate their accuracy and effectiveness. It is hoped that the end result of this program will be increased insight into how combustion takes place and, additionally, a reasonably simple mathematical representation of the combustion process that will be of use to the future designer of hydrocarbon-burning devices. The work is being conducted with the aid of grants from the National Science Foundation and the National Aeronautics and Space Administration.

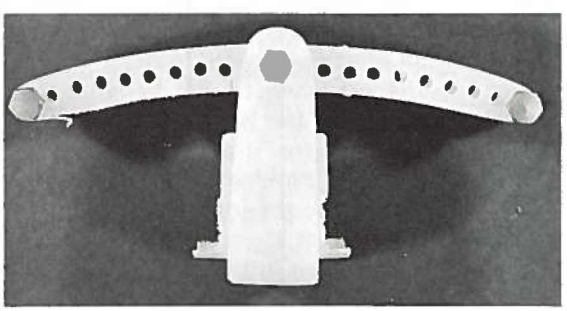
Diffusion about Isolated Structures of Simple Geometry. In the atmospheric boundary layer, the dispersion of gases released from an elevated source may be predicted on the basis of some semiempirical model, but very little research has been accomplished for dispersion within the cavity-wake region. Problems, for instance, include situations where the leakage of radioactive gases in the vicinity of a reactor building causes a serious contamination in the downwind region. Another familiar case is that the expanding edge of a plume may reenter the wake region and produce a secondary source.

Only a few systematic quantitative studies of dispersion in the wake region have been completed. Due to the difficulty of producing an analytical prediction, it is hoped that the use of wind-tunnel experiments to estimate the distribution of concentration as aggravated by buildings will be proven to be a reliable prediction procedure.

A set of experiments has been completed in the Fluid Dynamics and Diffusion Laboratory at Colorado State University in both neutral and inversion meteorological conditions.

These experiments were designed by Dr. R. N. Meroney, a member of the Fluid Mechanics Program, Department of Civil Engineering, in cooperation with the meteorological group of the Idaho Falls Nuclear Reactor test site. Geometrically and dynamically similar experiments for diffusion of gases in building wakes both in the atmosphere and in the meteorological wind tunnel have been planned. The two sets of data will provide a foundation of confidence for using the wind tunnel as an engineering tool for nuclear reactor station analysis. In addition, the wind tunnel information will complement prototype data for those situations difficult to study in the atmosphere.

Lumbar Vertebral Prosthesis. Prosthetic replacement of damaged or diseased vertebrae in man may be commonplace in future years. At the Surgical Laboratory, Drs. W. V. Lumb and T. H. Brasmer have successfully replaced the second lumbar vertebra in dogs with a plastic vertebra made of polyvinylidine fluoride. Dogs with prosthetic vertebrae have been maintained as long as ten months postoperatively with excellent function of the hindquarters. A patent has been issued to the University on the prosthesis.



Prosthetic vertebra made of polyvinylidine fluoride.

Potential uses for this device in man include treatment of cancer and cysts of the vertebra, spinal fractures and dislocations, tuberculosis, and spinal cord injuries.

A further outgrowth of this work is development of a new method of spinal plating for stabilization of the spinal column. This has been used successfully in dogs with fractures of the vertebrae and appears to have application in man. A patent application is pending on this device also.

Dog with second lumbar vertebra replaced with prosthetic vertebra.

Modeling Cohesive Soil Structures. An experimental study is nearing completion to develop new techniques for modeling homogeneous cohesive soil prototype using granular cohesionless materials in small scale laboratory models. The study has been directed by Dr. James M. Bell of the Department of Civil Engineering and supported by the National Science Foundation.

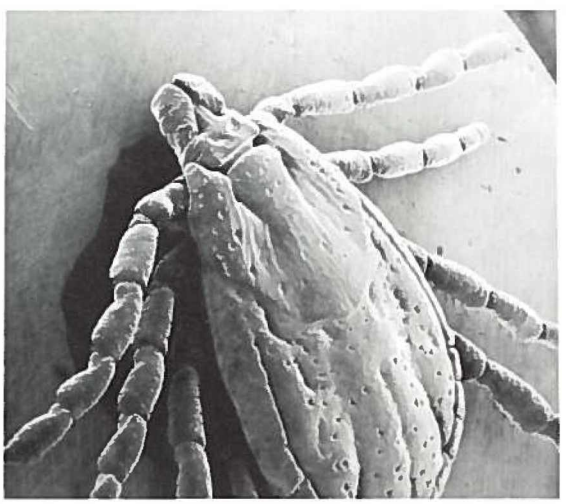
Quartz sand was subjected to all-around external confinement using internal vacuum and the frictional properties of the medium to simulate cohesion. New granular materials composed of lead and glass beads coated with teflon were developed to simulate the low frictional characteristics common to clay soils. A laboratory investigation of the strength of quartz sand under the extremely low pressures encountered with small structures yielded new and valuable information on material behavior.

Detailed model studies included both earth slopes and buried anchors. The slope stability study, when compared with available theoretical methods, indicated that use of the newly developed modeling techniques resulted in an excellent quantitative description of the prototype failure. The ultimate pullout capacity of buried anchors was much more difficult to assess because theoretical methods thus far have proved inadequate with respect to describing the failures which have occurred. Work is being continued to better explain model test results related to three-dimensional problems.

Scanning Electron Microscopy. SEM is a new technique of scientific investigation that cuts across many disciplines. Although the first scanning electron microscope (SEM) was constructed in 1935, the instrument has been available commercially only since about 1965, and the development of several different brands of instruments has greatly expanded the information resulting from its use. Biology, nearly all phases of engineering, metallurgy, paleontology, chemistry, physics, and medicine have profited by the development of this instrument. The prospects for its use and the predictions of information yet to be discovered through its use are unlimited. Standard SEM instruments and some accessories make it available as a teaching device through a fast-scan TV. It is also used as an analytical instrument through Auger and X-ray diffraction analysis. It can be used as a detector of the function of electrical microcircuits and semiconductors. It can be used as a means of determining surface structure in mechanical engineering, metallurgy, and biology, as well as the study of health-oriented objects and materials; elucidation of structure in biological forms is easily extrapolated to function.

The most striking effects of studies with the SEM are the outstanding micrographs obtained. The depth of field is 300 to 500 times greater than the best observed in the best light microscopes. Micrographs thus obtained are not only aesthetically beautiful, but easily interpreted, and are demonstrably useful for indicating or verifying interpretations of structure and function.

The scanning electron microscope is different from the conventional reflection or transmission electron microscopes. It produces a magnified image without any lenses between the object being observed and the cathode-ray tube viewing screen where one sees the image. In the case of the SEM, this image is seen on the cathode-ray tube and appears three-dimensional. The optical system of the SEM is used to focus the electron beam directly on the specimens. Compared with the light microscope, the SEM has better resolution, a much greater depth of field (though this is not unlimited), and a broader range of magnification. The images are produced by the traversing of the electron beam over the surface of the specimen; the emission of the secondary electrons from different areas of the specimen results in a contrast below the surface of the cathode-ray tube so that the specimen is viewed in the three-dimensional aspect. This depth of field (300 to 500 times what can be seen with light microscopy) and magnification range (20X to 50,000X) make it possible to use this important tool in studying microfauna, microfossils, mites, pollen, protozoa, bacteria, cellular structures of plants and animals, external structures in mites and insects, electrical microcircuits, chemicals, alloys, metals, powders, and a variety of textile surfaces.



A Female Rocky Mountain Spotted Fever Tick, Dermacentor andersoni, 22X.

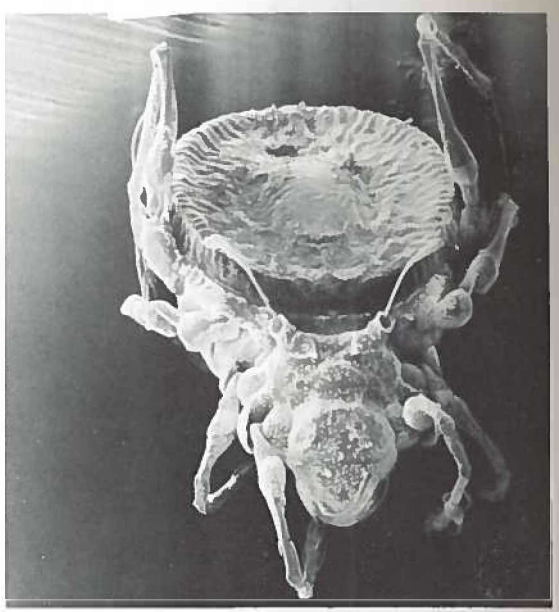
Dr. Tyler A. Woolley of the Zoology Department became interested in scanning electron microscopy in 1967 when he attended the Second International Congress of Acarology in Sutton-Bonington, England. Since that time he has extended his training in the use of this instrument and has obtained a number of different

micrographs, particularly of mites, which are the principal objects of his research. The sensory organs of ticks have been studied in SEM to determine if control of ticks is possible. Other features of the ticks are made more useful in their classification when observed in SEM. The structural details of oribatid (soil) mites have also been observed in the instrument. Several articles have been published in professional journals; others are in press. The accompanying micrographs are examples of the type of observations that can be made with the scanning electron microscope and they show the details of the structures of the mites in magnification as indicated.

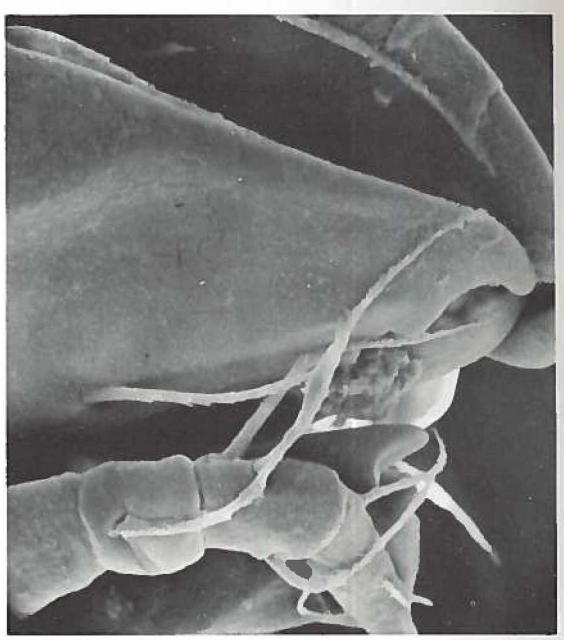
Amblyomma americanum hypostome (head of the tick), 300X.

Drs. Wilber and Woolley of the Zoology Department have developed a proposal for the use of a scanning electron microscope on a multidisciplinary basis within Colorado State University and on a cooperative basis within the region, including participation by Colorado schools and the University of Wyoming. CSU has promised matching funds for any support this proposal receives from granting agencies to obtain an instrument at CSU. Specific plans for the accommodation of such an instrument were designed and included in the blueprints of the Anatomy-Zoology building. In this day of rapid advances in science, CSU will be in the forefront of this new development within microscopy, if the University is successful in obtaining a SEM.

Like the transmission electron microscope, the SEM is a marvelous tool: for the elucidation



A soil mite, Gymmodaemaeus sp., 100X.



The mouth parts of a soil mite, Liacarus cidarus Woolley, 1000X.

of details that cannot be seen otherwise; for better understanding basic microanatomy; and for elucidating related structures and functions in engineering, physics, and chemistry. From the number of studies being conducted with the use of the SEM it is markedly evident that its usefulness will greatly expand in a good many facets of biological and physical science, and it will give science an ever-increasing expansion of the intricacies of the natural sciences.

Statistical Laboratory. Many university research projects are served directly or indirectly by the personnel of the Statistical Laboratory—members of the faculty regularly assigned to the Department of Mathematics and Statistics, but with the additional responsibility of providing research and consulting services in the field of statistical data analysis. The work of the Statistical Laboratory is reflected in the research efforts of virtually every department on the campus through the consulting work done for researchers in those departments. In addition, the laboratory provides its services directly to government and other agencies under research contracts.

One of the larger research programs now underway in the Statistical Laboratory under contract from the U. S. Bureau of Reclamation is assisting in the design and evaluation of cloud-seeding experiments. The importance of research in this area is obvious, not only from the standpoint of increasing overall precipitation in selected areas, but because of the opportunity for using seeding to reduce the danger of destructive hailstorms. Less obvious to the layman, however, is the difficulty and importance of statistical data analysis in such research. Because of the fundamental variability of meteorological phenomena, it is always difficult for the experimenter to determine the effectiveness of his actions, and this difficulty has been the source of considerable controversy regarding the effectiveness of cloud-seeding operations. The purpose of statistical analysis is to help the experimenter in his investigations by providing more precise quantitative data in place of relatively vague qualitative information; by suggesting different methods of analyzing the data in an effort to detect the important factors; by studying the data to separate the relevant and significant information from the irrelevant and random fluctuations; and by assisting in the design of seeding experiments to provide a basis for future analysis.

The objectives of weather modification studies are, first, to understand the physical processes in the clouds which culminate in precipitation; second, to assess the effects of experimental programs on the weather; and third, to identify those atmospheric conditions under which modification efforts are most likely to be successful. The analyses of these experiments are complicated by many problems. For example, in planning a seeding experiment, it is important to avoid confusing (or "confounding") the effect of seeding with the ordinary daily variation in precipitation patterns. By working with the experimenter in planning the seeding schedules, the statistician can help generate an experiment that will minimize or eliminate such unwanted complications of the data. Other aspects of the statistician's role in such experimentation include selecting the size of the experimental program that is necessary to discover a specified effect; allocating the available time between seeding and nonseeding periods in order to provide comparative "benchmark" data; and selecting the relevant atmospheric variables (such as temperature profiles, wind velocities, pressure conditions, weather activity in surrounding areas or on previous days, etc.) that should be monitored in order to determine their interaction with the seeding effects.

Conglomerates: Economic Conduct and Performance. Dr. R. G. Walsh and Dr. A. G. Madsen have made an evaluation of the behavior and performance of conglomerate enterprises. The practices used by these firms to promote good will and encourage the public to purchase stock are reminiscent of those which led to serious problems in the past. Reciprocal trading among conglomerates leads to practices that seriously restrict the operation of the competitive system. The use of the "long purse" in market subsidization can also cause adverse results to small efficient competitors.

The economic performance of conglomerates has not been all positive. The largest 200 conglomerates appear to have had a negative effect on the growth of the economy. The high profits sustained by conglomerates is not consistent with the expected lowering of price from decrease of risk. Considerable evidence shows that nonprice competition has replaced much price competition and that advertising has replaced product innovation that might otherwise be encouraged.

Contingent Liability on Time Payment Contracts for Large Equipment Dealers. Implement dealers, automobile dealers, mobile home dealers, and appliance dealers sell merchandise essentially on long-term (as distinguished from open account) contracts, both single-payment and installment, which are turned over to banks, finance companies, and other financial institutions with the dealers as effective cosigners with the customers. The accounting procedures that reflect the amount of this contingent liability are believed to be generally inadequate. This inadequacy represents a significant lack of pertinent information for management and other parties.

Professor Paul Spencer of the College of Business is conducting a study on this problem. His basic methodology is direct person-to-person inquiry of dealers in Larimer County. He has set out to determine thoroughly the procedures now used, to find better procedures if possible, to find the information being provided by the financial institutions to dealers, and to determine the significance of this information.

Economic Development and Human Capital Formation. Research on the long-term economic development of nations indicates that less than 50 percent of output growth is explained by changes in quantities of conventional production factors (capital and labor). Substantial efforts have been devoted in recent years toward developing a concept of human capital as well as analysis of its quantitative characteristics, particularly in relation to social and economic development, educational planning, and economic growth.

Dr. Ronald A. Wykstra of the Economics Department reported in a recent issue of the *Journal of Developing Areas* that is is necessary to recognize that educational economic planning is the genesis of manpower and human capital development. There are several reasons for the relative importance of human capital and educational planning as a pipeline system. First, lead-time requirements in the production of human capital are lengthy, perhaps longer than all but the rarest physical capital investment options elected. In addition, human capital production lacks the permanency of most physical capital assets, which tend to exhibit some short-run immobility. Third, given adequate resources, it may be relatively easier to acquire technologically endowed physical capital than it is to "borrow" a similar degree of embodied modernism in human capital. Fourth, human capital development through education possess spill-over qualities that have sociocultural qualities of potential extension far beyond effects in GNP. The innate reaction capability of human capital is one type of externality that can be channeled in directions favorable or unfavorable to future development. Finally, tolerance for error is less in the case of human capital production and development than is true in the case of physical capital. Physical capital assets may be antiquated in terms of modern industrialized society and nevertheless make significant interim contributions to productivity. That this is less true in the case of human capital needs little elaboration.

Areas of ignorance in human resource economics investigated include: the extent of substitution between human capital and physical capital and intrahuman capital substitution as well; possible supply-demand interdependencies for educated manpower; the efficiency issues surrounding general or specific training, as cur-

rently illustrated by the academic vs agricultural training debate; the interplay of ability, education, and health and welfare; sociological, cultural, and economic determinants and complements of increased human resource productivity; and problems centered around the coincidence or noncoincidence of private and social human capital development needs.

Economics of Hunting and Fishing in Colorado. A study, entitled "The Economic Impact of Hunting and Fishing in Colorado," was completed during June 1970 by D. D. Rohdy, Professor of Economics, and R. E. Lovegrove, Graduate Research Assistant. The study was funded by the Colorado Division of Game, Fish and Parks. Also, Colorado State University personnel involved with extension activities in the Department of Economics and in Grand County contributed to the study by assisting with the collection of data and dissemination of results.

The purpose of this study was to determine both the primary and secondary economic effects on a local economy in Colorado of sportsman expenditures for hunting and fishing. Primary economic effects are the original expenditures made by sportsmen. Secondary economic effects are the sum of all additional economic effects resulting from the original expenditures. For example, when a fisherman eats at a local restaurant and spends a night in a motel, his expenditures are called primary. However, the restaurant and the motel managers must make certain purchases in order to provide these goods and services to the fisherman; it is these additional purchases for labor, food, electricity, gas, etc., that make up the secondary economic effects.

Because of the expense involved in securing the kinds of information needed for an impact analysis, the study was limited to only one county. Grand County was chosen for two reasons: the county has at least average quality hunting and fishing, and additional research was already underway in the county that could complement this study.

The analytical framework for this study contained three basic parts. The first was a model of the Grand County economy; the second was estimation of hunting and fishing expenditures by sportsmen in Grand County; and the third involved the use of the model of the county's economy to determine the secondary economic effects of the hunting and fishing expenditures. The objective of the study required the use of an analytical method that would permit the measurement of secondary economic effects. The method chosen was interindustry or input-output analysis.

The results of the study indicate that approximately $400,000 was spent in Grand County by hunters during 1968. Also, it was estimated that fishermen spent an additional $2,600,000. The total amount of economic activity generated by this $3,000,000, including household income effects, was estimated to be $5,950,000. This amount represents about 12 percent of the total economic activity of approximately $50,000,000 in Grand County during 1968.

Economics of the Sugar Beet Industry. The Colorado sugar beet grower seldom realizes that an increase in the consumption of cane sugar in tropical and semitropical regions of the world could result in a higher acreage allotment (or proportionate share, in the language of the Sugar Act) for him. Analysis of changes in international demand was one objective of a cooperative research project, conducted by C. Richard Creek of the Department of Economics, of cane and beet sugar producing states plus Puerto Rico.

The study of demand indicated a probable increase in consumption in the developing nations in the tropical climate zones. This would mean fewer tons of cane sugar available for export to the U.S., hence an increase in the proportionate share for the U.S. sugar beet growers and mainland sugar cane growers. Puerto Rico has considerably less acreage of cane than in 1960 and Hawaiian plantations have almost reached the limit of land suitable for sugar cane. Residential and industrial construction are competing for limited acreage in the Islands.

In the mainland sugar beet areas the analysis of response in acres planted to an increase in price per ton varied from state to state. Processing capacity of the beet sugar factories was a limiting measure in the acreage contracted in many areas. Competition from other crops that require less intensive labor or less costly mechanization has been a factor in the response of growers.

Sugar beets at present cost-price relationships with other crops are still the most profitable crop. But the amount of capital required

for production on a large scale with mechanical equipment poses a management decision. Many older growers do not take the risk of high machinery investment and turn to growing corn for grain and silage on a contract basis with nearby commercial cattle feedlots. The farmer performs the production activities while the feedlot owner harvests and hauls the chopped corn to the feedlot.

Some former beet growers now produce potatoes on a contract for processing plants and potato chip companies. Alfalfa dehydrators add to the alternatives available to the farmers with contracts. In most cases the grower has an opportunity to grow a crop under some type of contractural arrangement that reduces the risk of price changes for the product, as was true of sugar beets.

In Colorado the response of growers in acreage planted in 1969 was 205,000 acres, or 14 percent more than in 1967, for about a $2 per ton increase in contract price. After the disastrous harvest season of 1969 many growers discontinued sugar beets. The indicated acreage for Colorado in 1970 was 166,000 acres, or 81 percent of the previous year. Alternative crops became more attractive to those growers who could shift acreage.

Sugar beet production has been shifting in eastern Colorado from the smaller acreages per farm in the irrigated river valleys to the much larger acreages on farms in the high plains counties. Deep wells, high capacity pumps, and rotating sprinklers have changed the use of land from dryland wheat to irrigated intensive row crops, including corn, field beans, and potatoes as well as sugar beets. This shift in land use has occurred on the eastern border from Phillips south to Baca county.

A modern high-capacity sugar factory has operated for two years at Goodland, Kansas to process beets from these larger farms in Colorado and Kansas. Growers in those counties expanded their planted acreage beyond the factory capacity in 1969. Many carloads of beets were hauled to other factories in the South Platte Valley, some as far as the Denver area, at considerable cost to both the growers and the sugar company.

These shifts and expansions in acreage indicate that many younger, industrious, innovative, and capable farm operators have the management skills and credit rating to use modern technology and nonfarm sources of capital for a highly profitable farm operation.

Interjurisdictional Cooperation in the Control of Collective Violence on Campuses. Dr. Douglas Benton of the College of Business is developing model procedures and organizations for interjurisdictional cooperation between criminal justice agencies in the control of collective disorder and violence on campuses. The development of a model is meant to be a feasibility study and a step toward further (nationwide) development. The study will define some of the obstacles confronting law enforcement agencies and make recommendations on the resolution of these obstacles.

The field of management theory and practice provides an analytical framework for the resolution of problems and obstacles in interjurisdictional cooperation among law enforcement agencies. Both classical and behavioral theories of organization will be examined in developing model procedures.

Corollary to the main objective of the study are several others including the application of management theory and practice: to identify the problems of law enforcement administration and organization on our campuses and in surrounding communities; to identify the means by which various law enforcement agencies can be managerially integrated to control collective campus violence; to determine if basic management principles, such as unity of command and span of control, are being utilized in the management and organization of the respective law enforcement units; to determine, in general, what improvements can be made and, in particular, what deficiencies (if any) exist in the present organizational structures on campus security units; to determine if these law enforcement units have plans of action for the contingencies of collective campus violence; to determine what other managerial steps can be taken to diminish the impact of collective campus violence; and to make recommendations to improve the management, organization, and mobilization capabilities of these law enforcement agencies.

Thus, the major goals of this study are to conduct managerial research and begin to prepare law enforcement agencies to the point that the **impact** of violent disorder is diminished on campus and in surrounding communities.

Legitimate Marketing Theory and the Traffic in Stolen Goods. Dr. Ted Roselius of the College of Business is investigating the potential benefits of using legitimate marketing theory as a tool for studying the traffic in stolen and illegal merchandise. The study will serve as the foundation for design of specific methods for reducing the traffic in stolen goods.

Persons faced with the disposal of stolen or illegal merchandise must do so under time, cost, and risk constraints. Thus, they must solve many of the same major problems faced by legitimate sellers. These problems are not trivial ones—it requires abundant resources and great effort for a legitimate seller to distribute a truckload of cigarettes, a shipment of clothing, a tray of jewelry, etc.

There is an established and extensive body of marketing knowledge which guides legitimate sellers when they design systems for the distribution of goods. This theory of marketing states rather precisely the functions and activities which **must** be performed if **any** type of goods is to be distributed. This formal marketing theory has been proved sound enuogh and flexible enough to be applicable in underdeveloped and foreign markets, as well as in the market for a wide variety of industrial and consumer products in the United States.

Since legitimate and illegal distributors both face many of the same problems, it is believed that dealers in stolen goods are likely to apply many of the same principles of marketing used successfully by legitimate dealers. If they do in fact solve problems in the same ways, then conventional marketing theory can provide much insight into the traffic in stolen goods.

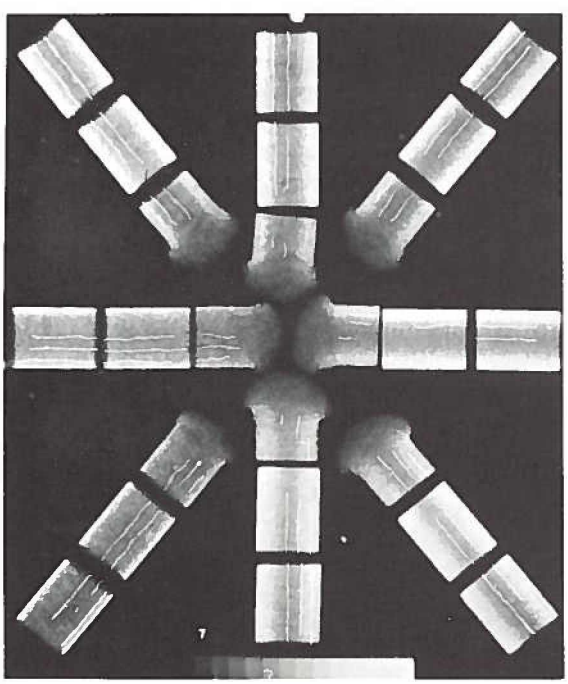
Two specific problems are addressed by this research. First, a major problem in deterring professional thievery of goods is the belief that dealing with stolen goods is a reasonably profitable venture. Second, a major problem in tracing stolen goods is that of linking together the random pieces of evidence related to a particular case.

Law enforcement agencies have a real need for a more complete understanding of the traffic in stolen merchandise. Legitimate marketing theory provides a systematic way of studying the distribution of stolen goods and for generalizing the findings.

New Forest Products for Colorado. Researchers in the Department of Forest and Wood Sciences have been determining the characteristics of particleboard manufactured from Engelmann spruce and lodgepole pine. These two species can provide a source of raw material from presently little-used slabs, edgings, trim, sawdust, and shavings now being produced in the state. Results show that no technical problems should arise in using these materials. Their light color, relatively low density, and ease of furnish preparation are desirable attributes of these species.

Since 1967, information has been collected from over one thousand study panels. These panels have provided a basis for assessing the effects of species, particle size, press time, moisture content of furnish, and resin content on heat transfer, moisture permeability, density gradient, and springback characteristics.

To study the heat movement in the panels, temperature-sensing elements were embedded in the furnish as the loose particle mat was formed prior to pressing and curing the resin. The exact locations of the elements had to be determined after completing the process. Further, it was important to know the density gradient



Density gradients in particleboard shown by X-ray absorption patterns.

through the cross section at several locations. An X-ray technique was employed to provide the needed information. Three cross sections cut from eight different panels are shown in the accompanying photograph. The panels represent three levels of moisture content of the raw material (5, 9, and 12 percent) and three levels of panel density (30, 40, and 50 lb/ft^3). At the bottom of the photograph is a calibration wedge, made from a casting resin, to permit determination of particleboard densities by comparison with known values. This technique accurately located the temperature-sensing elements, and also dramatically illustrated the variation which exists in the panel density profiles. The dark to light areas illustrate low to high density zones for which specific values can be accurately measured from the X-ray film by using a pinpoint photodensitometer.

Heat transfer characteristics were observed through time-temperature relationships which were recorded simultaneously from nine locations in particleboard panels during hot pressing. Results indicate that temperature rise in the interior of the panel was regulated by the flow of water vapor through the porous structure of the board. Flow in the direction normal to the surface early in the press cycle accelerated the temperature rise, while that in the lateral direction later in the press cycle retarded temperature rise by consuming thermal energy as heat of vaporization.

This research was conducted in the Wood Utilization Laboratory by Michael E. Bowen, who earned his Ph.D. degree under the direction of Harry E. Troxell, Professor of Wood Science and Technology, and R. D. Haberstroh, Professor of Mechanical Engineering.

Amino Acid Utilization as Affected by Vitamins. It is generally acknowledged that most nutritional deficits do not occur as clear-cut entities, but rather as multiple deficiencies. The interactions among deficiencies of different nutrients are therefore of considerable current interest. Dr. Inez Harrill of the Food Science and Nutrition Department has been participating in a Western Regional Research Project on the interaction between vitamins and amino acid metabolism. Dr. Harrill's work during the last year has involved the effects of vitamins A and E on phenylalanine metabolism.

Current interest in phenylalanine metabolism is related to the inborn error of metabolism, phenylketonuria, or PKU. This condition results from a failure to hydroxylate phenylalanine to tyrosine and is characterized, if untreated, by high plasma levels of phenylalanine and irreversible mental changes. Treatment consists of early identification and dietary restriction of phenylalanine.

The interaction of vitamins with phenylalanine metabolism is of obvious interest. The influence of dietary phenylalanine, vitamin A, and vitamin E on plasma phenylalanine concentrations, hepatic phenylalanine hydroxylase, and brain serotonin levels was studied in rats. Vitamin E did not significantly affect any of the factors determined for animals fed either a basal diet or one supplemented with phenylalanine. Expressed in terms of body weight, hepatic phenylalanine hydroxylase activity was significantly decreased when vitamin A was omitted from the diet. Since specific activity of the enzyme was not affected by vitamin A, the effect of the vitamin on activity of phenylalanine hydroxylase apparently was mediated through protein, suggesting that vitamin A is needed for synthesis of the protein component of the enzyme system. Further work is needed to clarify the specific effect of vitamin A on the hydoxylase system and to determine whether these factors can be utilized in a practical manner to change values of plasma phenylalanine.

Bluetongue Disease of Cattle and Sheep. The development and improvement of vaccines to control infectious diseases is a never-ending process. The work and responsibilities of scientists do not stop with the introduction of a

vaccine for use by the medical professions. Consequently, Drs. T. L. Chow and Alfred Strating, Department of Microbiology, have been studying the safety and efficacy of two commercial vaccines that are available in the United States for immunization of sheep against bluetongue disease. Bluetongue has been a continuing problem in sheep in Colorado and other western states since 1952. The disease condition leads to weight loss, weakness, lameness, decreased wool production, and sometimes death. The indirect economic loss in surviving animals is greater than the actual death loss. In recent years bluetongue also has been recognized as a significant disease problem in cattle. The disease is not transmitted by direct contact between animals, but through the bites of insects, particularly flies or gnats.

Control of bluetongue disease in sheep has been accomplished through the use of live virus vaccines and measures aimed at eliminating the insect vectors. However, elimination of the vectors, especially in range sheep, is often impractical or impossible.

The two vaccines now in use to control bluetongue in sheep are produced by two different methods. One (designated vaccine A) is produced by growing the modified virus in embryonating chicken eggs, while the other vaccine (vaccine B) is grown in animal tissue culture. In testing the vaccines it was found that vaccine A apparently has not been weakened in the laboratory to the same extent as vaccine B. Therefore, it has retained more of its original capacity to produce disease syndromes in susceptible animals. Under controlled experimental conditions vaccine A inoculated into sheep usually produced fever and a decrease in white blood cell count. When vaccination was done during periods of stress, including exposure of animals to intense sunlight, both vaccines A and B produced ulcers around the muzzle, a syndrome associated with bluetongue disease as it occurs in field outbreaks.

Vaccination of cattle with the live bluetongue virus vaccine was attempted for the first time. The results of the experiments showed that the response of cattle to the vaccine was similar to that of sheep, both in terms of the reaction to the vaccine and the amount of antibody produced against the virus. These preliminary studies indicate that, if needed, the presently available vaccines used to control bluetongue in sheep could also be used in cattle.

The researchers also found that after inoculation of vaccine A the vaccine virus was found to be present in the blood of both sheep and cattle. Inoculated animals could serve as a source of transmission of the virus to unvaccinated animals by the natural vectors of the disease simply by establishing new foci of infections. This condition does not appear to be a problem when animals are given vaccine B, since only small amounts of virus could be detected in the blood stream following vaccination.

A virus was isolated from naturally occurring cases of bluetongue in cattle in Colorado and from diseased sheep in Utah. The virus preparation was then inoculated into sheep that had been vaccinated. The vaccinated sheep were not protected against attack by the virus. The results indicate the need to incorporate new virus strains into the present vaccines to insure protection against all bluetongue disease in the field. The work reported above is another example of unbiased university research leading to improvement of products already available to the consumer.

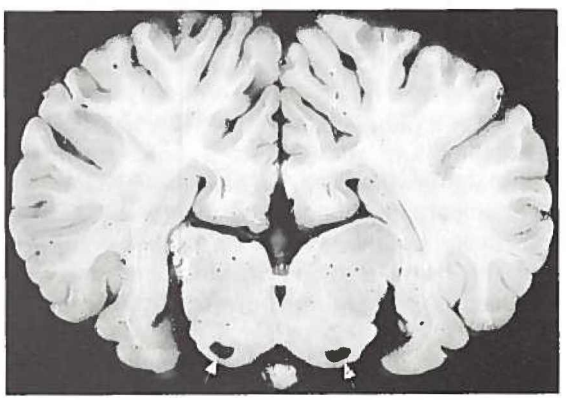
Centaurea Weeds and Horses' Brains. For many years, horse owners and practicing veterinarians in northern California have been familiar with a disease of horses known colloquially as "chewing disease." Occasionally the condition has been seen in other Pacific coastal areas. The disease is a rather characteristic one in its clinical expression and most affected horses suddenly show signs without prior warning. The mouth is held partially open; feed cannot be grasped effectively by the mouth or properly chewed, and the horse is often unable to drink except by deeply submerging the muzzle and nose in a bucket.

The occurrence of "chewing disease" was associated, at first circumstantially, with access to the plant Yellow Starthistle *(Centaurea solstitialis* L.). Later, in 1954, Dr. D. R. Cordy of the University of California restricted three horses experimentally to a diet consisting solely of freshly cut Yellow Starthistle, and produced the disease in them in 33, 61, and 81 days.

More recently, the disease has been positively identified by its characteristic clinical features and specific brain lesions in horses in western Colorado. There is evidence that at

least 26 horses have been affected on six ranches in our region in the past ten years. In that area, however, Yellow Starthistle was not found to be a common weed, if it occurs there at all. On the other hand, Russian knapweed *(Centaurea repens* L.) was abundant on these ranches and had been actively grazed by horses that subsequently became affected.

Russian knapweed, Centaurea repens.



Destructive changes in the substantia nigra of a horse caused by ingestion of Russian knapweed.

This disease is now under study at Colorado State University by Drs. Stuart Young, William Brown, and F. H. Chow of the Department of Pathology, and Professor Bruno Klinger of the Department of Botany. In a feeding trial, freshly cut Russian knapweed was fed as the principal component of the diet of three horses; all these animals developed characteristic signs of the disease in 28, 28, and 35 days respectively.

Russian knapweed, like Yellow Starthistle, is a member of the plant family Compositae and was introduced into North America from Europe. It is a bushy, branching, perennial plant that grows abundantly in dry, wasteland areas, particularly along ditches and fence lines. Distributed by seeds or achenes, the weed becomes locally established in patches that increase in size annually by the development of a system of root stalks. In midsummer, the flower of Russian knapweed is pink to purple in color, differing from the yellow flower of Starthistle and lacking the latter's characteristic spiny thorns. Although not apparently palatable to horses, it may be eaten when other forage is in short supply; and, once accustomed to eating it, horses may lose their distaste for it.

The characteristic and rather dramatic clinical signs of the disease are attributable to the presence of very specific and destructive changes or lesions that occur in certain centers of the horse's brain stem. The nerve cells and supporting tissues of these centers are selectively killed, and their place is taken by an accumulation of cellular debris that soon becomes liquefied to leave a sharply circumscribed cyst. The process is remarkable in that it consistently occurs in two paired centers called *substantia nigra* and *globus pallidus*. The lesions may exist in one or both of these areas and may be unilateral or bilateral in either of them. As a result of this highly selective involvement of these centers, "chewing disease" is known to veterinary pathologists more accurately as *nigropallidal encephalomalacia*.

The importance of the disease lies in more than just the hazard that it represents to horses and the economic loss to horse owners. The peculiar capacity of Centaurea weeds to produce such selective effects on brain stem centers has significance in the broader context of the neurological sciences. In medical neuropathology, the problem of selective vulnerability to injury of certain parts of the brain has been the subject of intensive study for almost a century. Similar destructive changes occur selectively in various centers of the human brain in a variety of specific diseases for which, in the main, no cause is known.

The active principal component of Centaurea weeds that causes *nigropallidal encephalomalacia* in horses remains unknown. The mechanism that accounts for its selective effects on *substantia nigra* and *globus pallidus* is presently under study. Present information does not suggest that the plant has delayed or cumulative effects, but there is some indication that prior exposure of horses to subcritical "doses" of the plant may endow them with some protection against later critical doses. An elucidation of the nature of the plant's active principal ingredient, and of the way in which it produces its destructive effects, may have significance for the general problem of factors responsible for the selective vulnerability to injury of centers of the human brain.

Dietary Fat and Cholesterol. Age, sex, and dietary fat are the experimental variables in studies of cholesterol metabolism in rats being conducted by Jacqueline Dupont and Melvin M. Mathias in the Department of Food Science and Nutrition. These three aspects of life can be exposed to experimental manipulation in the rat as a model for man.

As the U.S. male ages he becomes highly susceptible to atherosclerosis, and diet seems to be a contributory factor. Measurements of many aspects of cholesterol and fatty acid metabolism are being made on rats fed a diet like man's or one modified in fat content. The rats are fed these diets for months (which correspond to many years in man) and measurements are made at intervals into old age. Blood lipids are studied and their relationships to metabolism in liver, heart, and other tissues are explored. Heart, lungs, and arteries are perused with the light and electron microscope to find minute changes in their structure which might give clues to deterioration related to diet.

Changes in organ structure will be related to diet and lipid metabolism measurements made on rats of different ages. It may be possible to find a measure which can be made early in life that will predict undesirable structural changes which may occur in old age.

In the search for clues to unfavorable development changes in lipid metabolism it is necessary to explore basic aspects of the use of fat as body fuel. The saturated fatty acids of animal fats are used differently from polyunsaturated fatty acids in oils. The difference is clearly shown by the finding in this laboratory that polyunsaturated fatty acids do not cause ketosis while saturated fatty acids do. Ketosis is a defect resulting from inability to use fat for energy rapidly enough to meet the body's needs.

Drs. Mathias and Dupont have discovered a basic difference in pathways of oxidation of these two kinds of fatty acids. Unsaturated fatty acids appear to be oxidized in such a way that three-carbon rather two-carbon fragments are produced. Such three-carbon fragments are gluconeogenic, i.e., they are convertible into glucose, and this observation may explain the antiketonemic properties of unsaturated fatty acids. The question of net synthesis of carbohydrates from fat has been debated many years. It appears possible that the answer to the question may depend on the particular type of fatty acid that is involved.

Mammalian Studies in Biomechanics. Detailed studies of mammalian cardiovascular biomechanics are being conducted by mechanical engineers in liaison with physiologists and biophysicists. It is extremely important to discover causes and cures of cardiovascular disease, since the normal functioning of the heart and blood vessels is germane to the maintenance of human life. Often cardiovascular disease can be traced to mechanical dysfunction of tissue and can be mitigated by mechanical therapy, such as implanted assist devices or artificial tissue.

Measuring blood pressure and flow characteristics in an excised canine aorta.

Dr. Ronald Wemple developed a mathematical model of the aorta and associated vasculature to aid in the assessment of cardiac assist

devices, such as the intra-aortic balloon or the left heart bypass. His research indicates that the balloon offers the most effective assist to a damaged heart if the periodic inflation and deflation of the balloon are phased properly using an electrocardiogram. Dr. Michael Histand is examining the details of blood flow in the aortic arch to determine pressure and flow effects caused by the curved trajectory of the blood. Resulting cross-sectional pressure gradients may augment cerebral perfusion pressures. Mental incapacity associated with advancing age is often traced to attentuated blood flow to the brain, and new ways to increase brain blood flow are being sought to alleviate this difficulty.

Additional efforts in biomechanics include Dr. Addison Hardee's study of morphological differences in human spermatozoa in an effort to differentiate male- and female-producing gametes. Dr. Knox Millsaps is investigating mathematically the glucose regulatory system to explain more satisfactorily the glucose-insulin balance.

The efforts in biomechanics will be intensified next year by the addition of Dr. Lawrence Hooks and Dr. Terry Vander Werff to the Mechanical Engineering and Physiology and Biophysics faculties.

National Speech and Hearing Survey. The collection of speech and hearing data on a modified random sample of 38,884 public school children was completed in June 1969. The sample consisted of approximately 3,200 subjects from each of the grades 1-12. Subsequently, several phases of data analysis were initiated. A number of these preliminary analyses have yielded results that indicate trends regarding the quality of speech and hearing performance levels among the school-age population.

Preliminary results of the subjective rating of connected speech patterns indicate that about two percent of the subjects tested deviated extremely from a predetermined standard of speech articulatory performance; about three percent of the subjects manifested extreme voice deviations; and less than one percent were judged to be stutterers. As expected, the results reveal that the prevalence of all categories of judged speech deviations was greater for males than for females. Further, there is strong evidence that speech performance in general improves markedly from the first to the third grade. Beyond grade three, the rate of improvement is reduced measurably at each advancing grade level.

Results of the hearing evaluations show that about 89 percent of the subjects exhibited bilateral superior hearing sensitivity (0-20 dB, ISO-1964) for all five pure tones tested. Thus, approximately 11 percent of the subjects deviated from the 0-20 dB criterion. Except for the first grade, a slightly higher percentage of females, as opposed to males, was found in the bilateral superior hearing group.

In addition to the phonemic analysis, which is now in progress, two newly developed analytical techniques are being used to describe the data. One of these is a linguistic analysis that will investigate the phenomic production differences between males and females, age levels, and speech dialect regions. The other technique employs a computer-programmed analysis of several physical characteristics of selected vowel phonemes uttered by the subjects.

Forrest M. Hull, Professor of Speech Pathology, is the project director.

Physiological Mechanisms of Brain Functions. During the past year a research project concerned with thermo-regulation, under the direction of Dr. David D. Avery, has been underway in the Physiological Psychology Laboratory in the Department of Psychology at Colorado State University. One of the least understood regulatory systems in man is temperature control, particularly stability under varying environmental conditions. Thus, the project is centered around inquiries of the ways in which chemicals located in specific brain structures control both physiological and behavioral aspects of this normal regulation of internal body temperature.

A relatively new technique that allows for repeated administrations of minute amounts of chemical substances to specific sites in the brains of laboratory rats is being utilized in these investigations. First, a multiple tube system is constructed from hypodermic needles. This cannula is then lowered to the desired brain location and fixed in place on the animal's skull with dental cement. After recovery from surgery, small amounts of chemical solution are injected into the brain via the hypodermic tubing.

It has been shown that increasing the amount of one class of chemicals normally found

in the brain causes temperature to rise, whereas injections of another similar class of substances lower body temperature. Furthermore, injections of these same substances differentially affect the animal's daily food and water intake.

Another series of investigations centers around the administration of these same chemicals and concommitant observations of the animal's behavior in a "heat escape" chamber. In this type of experiment, animals are first taught to turn off an overhead heat lamp by pressing a bar in order to reduce uncomfortable heat stress. After the behavior has been well learned, chemicals known to alter body temperature are injected into the brain. It has been found that following such injections animals will compensate behaviorally for the change in their body temperature; for example, if the centrally applied substance raises body temperature, then the animals turn off the heat lamp at a greater rate, indicating that they "feel" warmer.

Recently, a project has been initiated to investigate the ways in which aspirin reduces fever. First a substance that is known to produce fever is injected into the body cavity and then a very small volume of aspirin solution is applied to the brain area shown in the earlier studies to be involved in temperature regulation. Preliminary findings from this project indicate that this area of the brain is in fact a site at which aspirin acts to prevent or reduce fever. Other studies are being designed to determine how the aspirin exerts its influence. It is suspected that salicylates in general interact in some way with the normal brain chemicals to block the fever-inducing effect. Further experiments are being planned to determine the effects of aspirin on food and water intake and behavioral thermoregulation, and to determine the central site for analgesic action.

It is hoped that these experiments will contribute to our understanding of how the brain works to control regulatory systems in general and in particular how the mechanisms underlying thermoregulation operate. We also hope to better understand the ways in which the most commonly used drug, aspirin, exerts its influence in relieving man of fever and pain.

Accountability for Instruction. Problems of student unrest, lack of motivation, use of drugs, disinterest in education, and communication failures (in the school and home) assail the public school. Furthermore, schools find themselves unable to meet the promises implied in their objectives. One promise of the school is that students will learn to read; another is that many students will possess sufficient knowledge and skills to hold a job. Still another promise is to prepare youth to support a rational way of life. There is mounting evidence that these and other promises of public education are not being fulfilled.

So great is the national concern for the effectiveness and quality of American education that a National Assessment of Educational Progress program has been initiated by the Education Commission of the States.

It has been suggested that if the objectives of education are stated in behavioral terms, communication among students, educators, and parents would be greatly repaired. In addition, assessment of the achievement of educational objectives could be more effectively made. This project builds on previous efforts of psychologists and educators; its new contribution is the conversion of an analysis of a job, occupation, or profession into performance statements clearly recognizable and measurable by students and educators. The result is that schools through educators can become more accountable than in the past for the objectives of education.

In cooperation with the Research and Development unit of McGraw-Hill Book Company, Harry Huffman, Professor of Vocational Education, built a preliminary systems model for producing performance statements for educational objectives. The model was given to nationally known educational authorities in the fields of agriculture, home economics, health, distribution, technology, office procedures, and industry, each of whom prepared five prototypes. The 35 resulting prototypes were analyzed to produce a comprehensive systems model. For an analysis in any job area, the systems model can produce a factorial 12 of performance statements if desired, since 12 conditions are typically found in the analysis. Normally only 15 or 20 statements are needed to develop a unit of instruction. The model has already been tried with 90 Colorado vocational teachers who have prepared performance statements for their specialties.

Schools and colleges that have produced performance statements for their courses have observed three advantages: they permit any student to select the material or instructional content he needs on the basis of his present knowledge and skill for learning each new topic; they permit educational objectives and tests or examinations to be precisely correlated; and they permit the development of well-defined short learning sequences and curricula, and identifiable conditions of learning, as well as clearly defined relevant goals, opportunities to achieve, and unambiguous evaluations stated in performance terms.

Cooperative Mathematics Program. With the increased emphasis on students beginning their college career at the two-year college, the problems of the transfer student at CSU have become more acute. In order to find some solutions to these problems, CSU and five Colorado two-year colleges (Arapahoe, Mesa, Northeastern, Otero, and Trinidad) initiated a Cooperative Mathematics Improvement Program with a two-fold purpose: to bring university and two-year college mathematicians together to discuss curricular and other common problems, and to provide additional subject matter course work for two-year college staff members by means of summer institutes and academic year courses via video tape.

The program has been given financial support by the National Science Foundation for a period of three years under the Cooperative Science Improvement Project program. The curricular part of the program is to consist of an initial conference at Mesa College plus two one-to-two day conferences each year for the next three years.

The first meeting was held at Mesa College in August 1969, at which time the curricula at some of the schools were discussed, and two guest lecturers explained the recommendations made by the Committee on the Undergraduate Program in Mathematics (CUPM). Two more meetings were held during the year. The first was devoted to finishing the discussion of the curricula as they presently exist. In addition, the future of technical mathematics in the two-year college was considered by the Director of the Franklin Institute in Boston, Louis J. Dunham, Jr. The topic of the second conference was the Importance of Linear Algebra and Its Applications in the Two-Year Curriculum, with the speaker being Dr. Ben Noble of the University of Wisconsin.

The topics to be discussed at future conferences are:

1. The role of statistics in the two-year college curriculum.
   Lecturer: Dr. Franklin Graybill of Colorado State University.
2. The role of the computer in the two-year college curriculum.
3. Teaching of calculus.
   Lecturer: Dr. William Fuller of Purdue University.
4. Panel discussion involving several students, who have transferred from the five two-year colleges in this program, attending Colorado State University at the time.

The academic portion of the program to provide subject matter course work for the two-year college staff members is accomplished by means of summer institutes and academic-year courses via video tape. A number of the junior college staff members have been teaching in the junior colleges for several years and have not had a chance to continue their education. These courses allow them to take courses during the academic year from CSU via video tape while teaching at their own school.

The video tapes are prepared by filming a live class at Colorado State University. Immediately after the class session, the tapes are shipped to the five schools where they are viewed (usually two days later). After use, they are returned to CSU, where they are erased and used again to record future lectures. Tests are administered by an official at the participating institution. Each participant receives the same credit as the students on campus.

Each summer, one or more courses taught specifically for the junior college teachers is offered at an Institute.

The program was begun with five two-year colleges; however, several more have been involved in various phases, and it is hoped that all two-year schools in the state will be participating in the near future.

Intermedial Instruction in Anatomy. Drs. R. D. Frandson and R. A. Kainer in the Department

of Anatomy are correlating the use of television tapes, 16-mm motion pictures, 35-mm slides, and 8-mm film loops and audio tape recorders in self-learning centers for students in the anatomical sciences.

Most of the media employed are directed toward the learning of "concepts" of anatomy—general principles that can be applied to many areas. However, some are applied to very specific intensified study.

By the use of both individual and group carrels, individual study (at the student's own pace), and group interaction and large assembly presentations are possible. Photographic, voice, and television recordings of studies from the electron and light microscopes and laboratory cadavers, and of line drawings and living individuals, can all be unified in teaching. It is even possible to conduct examinations with some of the same equipment used for instruction.

Teachers are not completely replaced by these techniques, but enrichment and enhancement of learning do occur when students are exposed to such methods. Learning has been shown to be equivalent to or better than that using self-learning centers only.

Although the use of these media has been on a small scale in the recent past, it is expected to increase greatly. The Department of Anatomy intends to intensify such use as it moves into new quarters two years from now.

This study is one form of educational research being carried out in the College of Veterinary Medicine and Biomedical Sciences.

Systems Analysis of the Modern University. Current sociological problems, such as environmental pollution, urbanization, and problems within the university, are not readily amenable to conventional systems analysis because of the difficulty of characterizing human elements and functions in a quantitative manner. The generalized systems approach to problems relies heavily upon the technique of modeling, which abstracts the important characteristics of the system and relates them in some mathematical fashion so that quantitative analysis may be conducted. With the increasing involvement of the university in the American social system, it is important to study the essential features of the university structure in an objective manner. Accordingly in the summer of 1969 an interdisciplinary team of faculty and students began to analyze the components of the university, such as the academic department, the student residential situation, and decision making at various levels within the university structure.

Some of the difficulties involved with classical systems analysis have been overcome through the use of graph theoretic principles to delineate the informal structure, inherent though not explicit, in social systems by means of pattern identification based on interpersonal relationships identified by computer analysis of sociometric data. This "clique analysis" represents a unique method of characterizing systems by relating the informal structure to the formal line-diagram of the organization representing levels of authority and lines of communication.

The program was initiated by Dr. R. J. Churchill, Professor and Head of Electrical Engineering, in conjunction with Drs. W. Lord and L. M. Maxwell from Electrical Engineering, E. F. Sharp from Sociology, and R. N. Hubbell from Education. Undergratuate students from Electrical Engineering and Sociology have contributed to the success of the program.

Awareness of Air Pollution and its Causes. How do people in Colorado perceive the problem of air pollution? Do they rank it as a major community problem? What do they feel are the sources of pollution and which measures of control are most popular? Finding answers to questions like these is part of a research project on attitudes toward air pollution in Colorado supported by the Colorado State University Experiment Station. The first phase of this research, currently in progress, is designed to compare responses of Colorado residents in three kinds of communities: rural, small city, and urban suburb, wtih earlier findings obtained from communities known to have serious air pollution problems.

The three kinds of communities have been sampled in eastern Colorado. In each community interviewers inquired about the resident's awareness of specific air pollution problems; his opinions as to the causes and cures of air pollution and the cost of pollution; and then additional questions concerning air quality. Questions were similar to those asked in other investigations. Answers given to the interviewers are being compared across different occupational, educational, and geographic groups. Opinions of air pollution experts are also compared with those of the general public interviewed in the survey. With this basic kind of information as background, additional surveys will be made in order to relate physical measures of air quality to public perception of the amount of air pollution. This work will be concerned with determining the amount of change in air quality that is noticeable, and specific cost/effectiveness ratios (in terms of attitude change) that are tied to particular pollution control efforts.

Future goals of the investigation are to look at the community decision-making process that leads to acceptance of pollution controls. In line with this, communities with successful programs of pollution abatement could be studied in greater depth and contrasted with communities experiencing difficulty in controlling pollution.

Another goal of the investigation is to trace the communication process involved in community awareness and action on air pollution. Typical questions to be answered involve assessing where major gaps exist between technical and lay knowledge about pollution problems and how information is best disseminated to close these gaps. The role of the communications media and various community groups in providing pollution information also needs to be more completely understood.

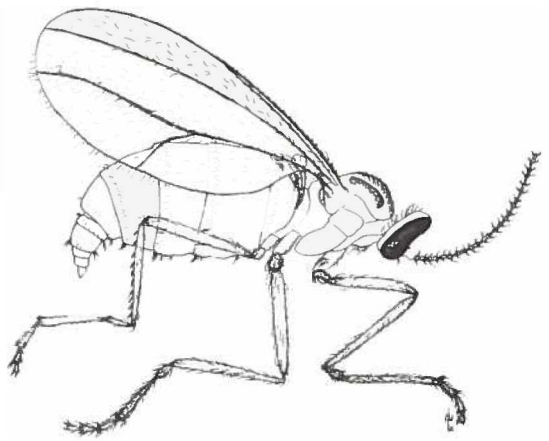
Biology of Pinyon Gall Midges. Pinyon as a landscape tree is rapidly gaining popularity in Colorado. Native stands of this slow-growing pine are found throughout the arid regions of southwestern United States with isolated stands ranging as far as northern Colorado.

In its native habitat pinyon is attacked by several gall-forming insects. However, these pests seldom damage the tree. Under natural conditions the tough, dry pinyon apparently is not conducive to the buildup of high insect populations. When the tree is moved into a landscape situation, however, the entire habitat is changed. Water and nutritive materials provided by the homeowner keep the tree healthy, succulent, and subject to heavy insect attack. Needle galls found rarely in natural areas become very common in landscape trees and often cause serious defoliation.

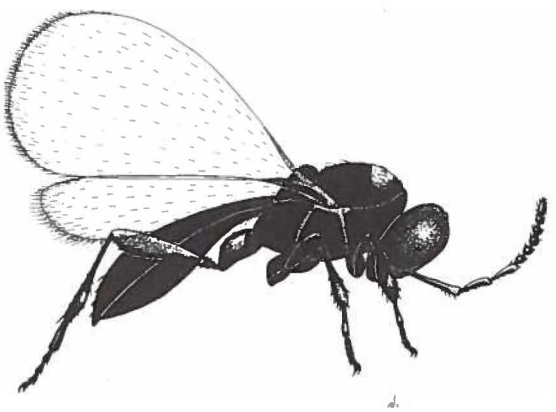
Research being conducted by Dr. J. W. Brewer and graduate student Mark Houseweart, of the Department of Entomology, is directed toward determining the life cycle and control of needle gall midges attacking pinyon. Previously it was believed that only one insect species caused needle galls on this plant, but investigations have uncovered at least five different insects, four of which appear to be new species. One of these has recently been described as a new genus.

Two of the gall-formers, both *Cecidomyiidae* midges, are now being studied in detail. These insects have the appearance of small gnats. Both of these midges overwinter as larvae inside the gall. In early spring the larvae pupate and shortly after emerge as adults. The adults mate and the female lays 40-80 eggs on the new needles. Eggs hatch in 7-10 days and the young larvae immediately enter the base of the developing needles. The adults, which apparently do not feed, live only a few days.

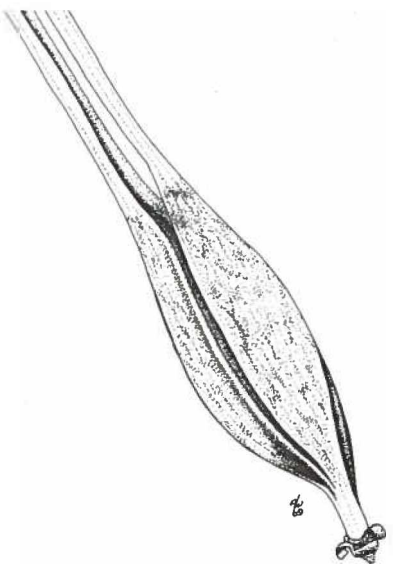
Both species of gall midge are parasitized by small wasps. Each midge is attacked by a separate species of wasp. The wasps oviposit



Gall midge female.



Wasp parasite of gall midge.



Needle gall on Pinyon.

in the eggs shortly after they are laid. Development of the parasitic wasp is delayed, however, until the midge is a full-sized larva. The parasite then develops rapidly, feeding on the midge larva and emerging about the same time as the adult midge would normally emerge.

Brewer and Houseweart are investigating the possibility of using these parasites as biological controls for the gall midges. Investigations are also being conducted on the use of chemicals for control of the gall midge. Because of the extremely short emergence period of the adult and the fact that the immature stages live protected inside the gall, the investigators are working on the use of systemic insecticides so that application timing would not be as critical.

Deer Food Habits. Trained mule deer are being used as sampling tools to determine the forage preferences and grazing habits of deer on Colorado summer range. The questions of what plant species are deer forage and where these plants occur can be answered by observing the tame deer as they graze. The forage species judged to be major components of the deer's diet are collected and analyzed in an attempt to determine why certain species are preferred by deer.

The deer are hand-raised from birth. A bottle-fed fawn soon learns to rely on and trust its trainer. After a mutual trust has been developed between the deer and trainer, the deer is trained to load into a pickup and to graze beside the trainer without physical restraint.

During the summer months the deer are taken to a spruce-fir and lodgepole pine forest study area near Frasier, Colorado. Timber on the study area was harvested in 1956 in a pattern of alternate clear-cut strips.

The deer are released for grazing trials of two hours duration and allowed to graze and travel about as they wish. The observer follows closely behind the deer (5-15 feet) and records what plant species are eaten and the type (cut or uncut) of area from which the plant was taken. Upon completion of the grazing trial the observer trots back to the pickup; the deer will be close behind because it becomes frightened when left alone in the forest. After completion of several grazing trials, plants which composed the major portion of the diet are collected from the same site they were eaten. Analysis for chemical composition and digestibility is con-

ducted to determine the nutritive value of the forage species.

Preliminary results indicate that a larger quantity of deer forage and additional plant species occur in the logged areas than in the virgin forest. Blueberry *(Vaccinium scoparium)* is the most abundant plant on both areas and constitutes the major portion of the trained deer's diet. The areas of logged forest provide a diversified array of lush forbs which are important for good deer nutrition.

This study is being conducted under the supervision of Dr. Julius G. Nagy, Department of Fisheries and Wildlife Biology, Colorado State University, and Dr. O. Charles Wallmo of the Rocky Mountain Forest and Range Experiment Station, USDA Forest Service. Don Reichert of the Forest Service and Wayne Regelin, Colorado State University graduate student, do the training of deer, data collection, and nutritive analysis.

Trained deer under food habits trial. The observer records on tape the kinds of plants deer is eating. Later the same kinds of plants will be collected and analyzed for chemical composition.

Foundations of Federal Reclamation Policies. In 1968, Professors Kenneth C. Nobe, George E. Radosevich, and Alan R. Dickerman of the Department of Economics undertook a study to examine and to evaluate changes in the public objectives pursued by the Bureau of Reclamation from its creation in 1902 to the present. The study revealed the policies of the Bureau of Reclamation to be consistent with national water objectives through the course of its history.

This study entailed a historical investigation and documentation into the implicit and explicit Federal objectives as observed from project reports, Congressional hearings and records, Presidential orders, basic laws and project authorization laws, resources policy review commissions, speeches, and other references. Extensive legal and economic history research and analysis were required.

During the early stages of research four values were identified, which, for the most part, are held by Americans individually, and which, taken as a concept of what is right, form the basis for collective national objectives. The four values are liberty and individual freedom of action; improvement in the individual's well-being; equality of persons and groups; and stability in all occurrences affecting the individual. These values emerged individually as priorities at various times throughout reclamation's history to affect the Bureau's goals and policies.

The objectives of reclamation derived from this study are development during the Progressive Era, conservation during the Great Depression of the 1930's, and environmental quality emerging after World War II—implicity through the changing national concept of individual improvement and explicitly by water resources management.

The goals of reclamation have grown in response to generally held beliefs about the attainment of objectives and the satisfaction of values. Reclamation began by identifying irrigation as nearly synonymous with development. Hydroelectric power became a goal, during the post World I era, of "business normalcy." The objective of conservation brought two new goals to the reclamation program: fish and wildlife preservation was a planning goal imposed upon reclamation from other agencies' pursuit of the conservation objective; and flood control was viewed as the major conservation goal of reclamation, so the Bureau was allowed to include flood control features in projects as a nonreimbursable benefit. During the second World War, municipal and industrial water use became a goal to be pursued in the achievement of wartime objectives associated with the newly established defense plants in the West.

The environmental quality objectives created a multitude of goals for the reclamation program. Recreation enhancement was established as a result of growing awareness that improved qualitative aspects of life also contributed to individual well-being. Pollution control and recreation enhancement became goals of reclamation by virtue of their obvious relation to water projects and, as such, provided the basis for adding the objective of environmental quality for reclamation programs. From this objective also follows the new goal of historic and scenic area preservation. While this goal may appear similar to fish and wildlife preservation, it differs as to its basis for justification, because a historic or scenic site is unique and is therefore not subject to the stock or flow concepts usually associated with conservation.

The project was completed and the report published in January 1970. Its importance is the illustration of the interrelationships between national values and objectives, and the agency's goals and policies.

Model Study of River Meanders. The changing climates of the last million or so years of earth history have significantly altered both valley slopes and the type of sediment load moved through river channels. It has been proposed that certain characteristics of modern rivers reflect these past events, and an attempt is being made to reproduce these changes by modifying the slope on which a model river flows as well as the type of sediment introduced into the model. Thus we hope to demonstrate by a model study the influence of geologic history on modern river channels.

The experiments are being performed in a flume 100 feet long by 24 feet wide located at the Engineering Research Center, Colorado State University. The first series of experiments was designed to evaluate the influence of valley gradient on the tendency of a river to develop a sinuous course. The experiment indicated that with constant discharge of water and sediment there is a critical valley slope, above which the model river tends to meander and below which it remains straight. At a higher critical slope the meandering pattern is replaced by a braided pattern, which appears to be the most efficient channel for the transport of large quantities of sediment.

A further observation is that anomalously sinuous sections of a river may reflect steeper portions of an alluvial valley. This conclusion has been substantiated by measurements of channel pattern and valley slope for several rivers of western U.S.A. and especially for sections of the Mississippi River below the junctions of the Arkansas and Red Rivers. Below the Arkansas River junction, the Mississippi River was very sinuous before recent realignment; here the valley slope is also greatest, as suggested by the experiments. This new explanation for apparently random variations in river pattern may be of practical use to the river-control engineer, for the sections of a river that appear to require realignment are, in fact, least suited to this purpose. Therefore, in many cases, straightening a river's course on the steeper reaches of the valley will induce major bank erosion and channel instability.

A second series of experiments was performed in which the type of sediment transported by the model channel was changed from predominantly sand or bedload to clay or suspended load. The overall effect was to convert a wide, shallow, relatively steep, straight channel to a narrow, deep, less steep, sinuous channel. The straight channel was induced to meander by changing the type of sediment load from sand to clay. Based on these experiments, we conclude that a complete change in river morphology will follow a major change in the type of sediment transported through the system. It appears that similar changes may be anticipated along many of our rivers as the coarser sediments are deposited in reservoirs. The net effect may be long periods of channel instability as rivers attempt to adjust to man's manipulation of the hydrologic regimen. The results of this

experimental series are similar to those documented changes of river morphology that have occurred naturally during the past 15,000 years along many major river systems in response to climate change. The experiments provide some basis for prediction of long-term river response to altered river flow and sediment yield.

Modeling of Groundwater Resources. Groundwater is one of Colorado's most important resources. Because of this, the groundwater program under the direction of R. A. Longenbaugh and D. K. Sunada has developed a finite difference model to predict the origin, movement, and distribution of water in an aquifer. This model has been used to predict movement of pollutants in aquifers (Reddell, 1969) and the amount of water lost to the Fox Hill formation in the Black Squirrel Basin (Goeke, 1970).

The finite difference model is currently being used to model the degradation of water quality in the Severence Basin. In addition, work has been started on modeling the movement of contaminants originating from the Rocky Mountain Arsenal site. Studies of this type lead to better management of our water resources.

^{210}Po - Pollution Source. Polonium-210 is a radionuclide that has been considered for use as a heat source for compact electrical generators. These generators, called Systems for Nuclear Auxiliary Power (SNAP), have been suggested for use in space missions. In this application there is a small chance that a large quantity of ^{210}Po might be released to the environment if an accident occurred. Polonium-210 also is present in the environment in small quantities as the last radionuclide in the radium decay chain, which acts as a low-level contaminant in many types of vegetation, including tobacco. As a tobacco contaminant it has been implicated as a possible causative agent in lung cancer.

The movement of ^{210}Po through soil and the subsequent uptake by plants has been the subject of a research project sponsored by the U.S. Atomic Energy Commission. As an outgrowth of this work, additional projects on the foliar absorption of ^{210}Po and on the movement from pasture into dairy and meat supplies are in progress. These studies are performed both at high ^{210}Po concentration levels to evaluate the potential radiological hazards of SNAP applications and at the natural background level to gain knowledge about the mechanisms by which naturally occurring ^{210}Po is deposited in the human population.

Studies are being conducted on the rate of movement of ^{210}Po in a variety of soils from agricultural and watershed areas. Results so far indicate that the radionuclide is retained by the soil and does not move rapidly enough to reach potable water supplies as a significant pollutant. This slow movement, however, means that ^{210}Po will remain in an agricultural soil for a sufficient time to be available to plants.

Agricultural studies with ^{210}Po.

For comparative studies edible plants were grown in contaminated soils and in soils with natural ^{210}Po concentrations. Results show that a small but measurable fraction of the radionuclide is absorbed through the roots. The highest concentrations were found in the foliage of fast-growing plants while the seeds and fruit of long-growing plants had concentrations lower by a factor of 100. Calculations based on the estimated diet of teen-agers indicated that local deposition of a large ^{210}Po source on a truck garden area could produce a limited radiological hazard to a population whose vegetable diet was exclusively from the contaminated area.

The study of the natural background level of ^{210}Po in plants and soils when compared with the results of plants grown on artificially contaminated soil showed much higher apparent transfer coefficients for plants with the natural exposure. Further study has shown that these higher values are due to foliar absorption following aerial deposition rather than root uptake from soil.

Experiments are presently underway on the

transfer of ingested ^{210}Po to milk and meat in cows and goats. The data indicate that this source of food for human consumption presents the greatest potential for radiological hazard in case of a ^{210}Po environmental release, although it still appears to be relatively small.

This research is directed by R. L. Watters of the Department of Radiology and Radiation Biology and Dr. J. E. Johnson of the Departments of Radiology and Radiation Biology and Animal Science.

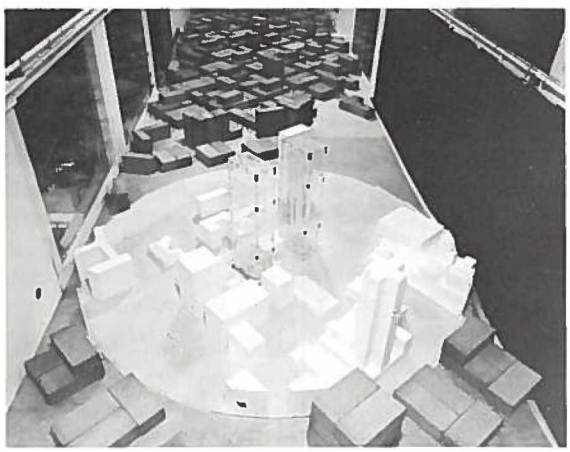
Recycling Animal Wastes and Diptera. Solid metabolic wastes of animals are natural breeding sites for many insects, including the common house fly. Research studies have demonstrated that fly larvae during their development from egg to pupa remove approximately 55 percent of the total wet weight of fresh poultry droppings. During this development period, 60 percent of the moisture in the waste is evolved. Two percent of the fresh manure weight can be harvested as dried fly pupae, which contains in excess of 60 percent protein, 9 percent fat, and 11 percent ash. The amino acid balance of fly pupae is comparable to fish meal, which is very desirable as a protein supplement in poultry diets. Proper processing of the pupae would destroy any pathogenic organisms that might be present so no disease would be transmitted via the animal ration.

The waste residue that remains after catabolism by fly larvae is easily dried and stabilized and granular in consistency. It contains 2.5 percent nitrate, 3.5 percent phosphoric acid, and 3.5 percent potash as well as all micronutrients needed for the growth of most plants.

Feeding trials with young chickens have indicated that fly pupae could effectively be substituted for all protein supplements in the ration. Body weight, feed efficiency, and mortality were comparable between chicks fed a ration containing 30 percent fly pupae and chicks receiving the control ration.

A poultry operation of 100,000 laying hens could produce 400 pounds of dried fly pupae daily. At a price of 10 cents per pound, this could give a return of $40 per day above the fertilizer value of the manure residue and effectively reduce the accumulation of large quantities of manure and associated pollution problems.

Urban Air Pollution Study. The concept of aerodynamic modeling that helped perfect airplanes has been extended to include the investigation of environmental problems. This development has been pioneered through 15 years of basic research by staff members of the Fluid Mechanics Program in the Civil Engineering Department. The addition of a large environmental wind tunnel to the facilities of the Fluid Dynamics and Diffusion Laboratory now permits modeling of airflow over entire cities. The first such investigation to study diffusion over a typical city is being made on the model of Fort Wayne, Indiana, which is constructed to a scale of one to 4,000. Fort Wayne was selected for this pioneering study because extensive field data on wind and diffusion are available to provide a basis of comparison to check the validity of pollutant concentration data measured in the model.



Atlantic-Richfield Towers in Los Angeles (1:200 scale).

Two main features that significantly affect atmospheric motions and aerosol dispersion have been incorporated into the model of Fort Wayne. One is the surface roughness in the form of buildings, and the other is the so-called "heat island effect" that results from heat generated by the city. Heating of the model city is accomplished by placing nichrome wires in different electrical circuits over the city area and applying a predetermined voltage. This arrangement enables formation of temperature distributions in the model city that are similar to those measured in the field. A traversing system carrying a continuously emitting source of Krypton-85

was installed upwind from the city to simulate the aircraft releases of fluorescent particle tracers in the field.

Measurements of "winds" over the model confirmed that the atmospheric flow conditions upwind and the vertical temperature gradients over the city were simulated. The measured concentrations of source materials over the city have proved that it is indeed possible to obtain laboratory data that are comparable to those obtained through field measurements, which are usually prohibitively expensive. This investigation opens the way for studies of air pollution problems for purposes of urban planning. The location of industrial sites relative to major topographical features, the location of freeways through existing cities, the grouping of tall buildings in an urban development program, or even the geometrical features of an entirely new city can be studied systematically to minimize air pollution potentials under adverse meteorological conditions.

This study was sponsored by the Atmospheric Sciences Laboratory of the Army Materiel Command and was guided by Dr. J. E. Cermak, Professor-in-Charge, Fluid Mechanics Program. Dr. Fazil Chaudhry, Research Civil Engineer, Mr. S. Sethuraman, Graduate Research Assistant, and Mr. James A. Garrison, Laboratory Supervisor, designed the model and collected the experimental data.

Visitor Carrying Capacity of the National Parks.

The continuing population growth in the United States has placed the National Park Service in a dilemma.

To make the parks available for use and enjoyment and at the same time to protect them from overuse and abuse was not too difficult a matter in 1916 when the National Park Service was established. There were then an estimated 3.56 visits per 1,000 population; the total population was only approximately 100,000,000; and there were 13.3 acres of parkland for every visitor. But by 1969 the parks had long since been "discovered" by the American public. They were no longer as inaccessible as they were in 1916. The visitation rate was a vastly greater 208 visits per 1,000 population; the total population had more than doubled; and although new parks had been added to the system, there was approximately .03 acre of parkland per visitor. Because of the road systems and circulation patterns in the parks, and the fact that there are large areas of parkland that are relatively inaccessible to persons in automobiles, there tends to be a concentration of use on relatively small parts of the total land and water area.

The National Park Service has recognized that upper limits on use must be established. It also recognizes that a careful balance is required in establishing such limits. The resources of the parks require adequate protection but visitation must not be unduly restricted. The research problem was that of studying the situation to determine how such a balance between objectives might be attained and to suggest practical techniques that might be employed for determining appropriate levels of visitor use.

The study was carried out by Drs. R. Burnell Held and Arthur T. Wilcox of the Department of Recreation and Watershed Resources. They were assisted by Stanley K. Brickler, a doctoral candidate in the department.

The problem was basically one of producing the greatest possible net benefits. Benefits in this case are the product of the value of a visit and the number of visits. Costs are the losses to the biota and natural features of the area caused by the unavoidable wear of use, and the losses in the quality of the visitors' experience that occur with crowding, the necessity of waiting in line, and the general limitations on freedom of choice and movement which are required wherever large numbers of visitors must be accommodated.

The objective of the study was to develop effective yet relatively simple techniques that could be used by National Park Service employees to determine the visitor use capacity of specific natural areas in the parks. As the study proceeded, it became evident that an objective of that type was premature. Understanding and information of a more fundamental nature were actually needed. For example, the impact of recreation use on the biota had long been recognized and documented, but little or no work has been done to determine the extent of damage associated with various known levels of use under known physical conditions. Further, although other studies have emphasized the growing dissatisfaction of park users with the crowded conditions encountered in some of the major parks, studies were not available to determine at what level of use and under what

circumstances conditions actually became intolerable to visitors. Thus, costs could not be determined until such data were available.

The researchers recognized that any level of visitation is likely to cause some change from its original condition in a park's natural area. The National Park Service and the interested public would probably quickly agree that levels of use which threaten to eliminate major portions of the desired plant and animal species of the area or which would greatly damage the physical features should not be permitted and that a ceiling on use should be imposed before that point has been reached. Similarly, visitors would probably agree that crowding is undesirable. But it would likely be extremely difficult to obtain widespread agreement as to what level of use is desirable.

Because of these difficulties, the researchers proposed procedures to measure the impact of various levels of use on vegetation and to determine the reactions and preferences of visitors and park service administrators to them. Further, the procedures would test visitor reaction to different degrees of crowding and no crowding. Recognizing, however, that there is not one clientele of the parks but rather several, the study recommended procedures that might be used to identify members of particular clientele groups with relatively homogeneous values and expectations. Rates of use and types of use might then be adjusted to provide park experiences which are compatible with National Park Service objectives and which encourage particular types and levels of use in certain areas of the parks. Visitors could be directed to those areas which would yield the satisfactions they seek while minimizing the unavoidable wear and other losses to park resources.

Water Pollution Control. Effective control of water pollution requires that state and local laws and administrative procedures be attuned to the problems of a dynamic society. Gaylord V. Skogerboe and Russell Freeman are working in close cooperation with the State Water Pollution Control Commission to evaluate the scope and effectiveness of the state's water pollution control program.

In the first year of a three-year study, attention has been directed to the general organization and content of the program. As a result of this effort, the Commission is considering a program reorganization and the addition of new staff capabilities in the areas of biological sciences and planning and program development. Future work will include analysis of the elements of the state program, especially the methods of collecting, analyzing, reporting, and using data and the procedures for establishing and enforcing water quality standards, orders, and other rules and regulations. This study will also determine the public perception of the water pollution control program. The attitude of the general public will be determined and compared to the attitudes of two smaller interest groups: those responsible for the water pollution control program and those who have been directly affected by it.

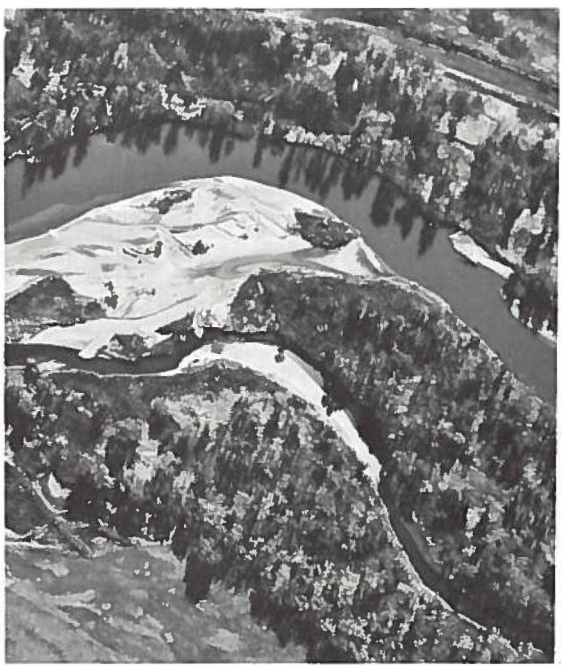
Water Quality and Quantity. Through basic and applied research several members of the Civil Engineering Department at CSU are studying the movement of water in rivers and channels, its measurement, and its relation to the environment. Their studies benefit water managers, farmers, highway engineers, city managers, and home owners—in short, the entire community. In order for the benefit to be realized, certain fundamental or basic phenomena must be understood. To obtain this understanding hydraulic engineers at CSU are engaged in basic water research to develop new ways to analyze and to measure basic hydraulic phenomena.

An analytical model that water managers can use to ensure the most economical delivery of water is being developed under the guidance of Dr. E. V. Richardson. The model takes into consideration such factors as snowmelt forecasts, channel seepage losses, and legal constraints of priority. The project is funded by the Colorado State University Experiment Station.

Dr. Herman J. Koloseus, using numerical analysis, is to investigate phenomena related to irrigation. Part of his work deals with the hydraulic jump, which is useful in dissipating energy in order to decrease the eroding potential of open channel flow.

Irrigation and other free surface water distribution systems involve both parallel and radial flows. Dr. Koloseus's work on the circular hydraulic jump calls attention to the differences between parallel and radial systems and extends equations of the hydraulic jump to diverging

channels. This information could improve design criteria for hydraulic structures and irrigation systems. Dr. Koloseus is also analytically investigating the effects of pressure fluctuations on stilling wells—auxiliary devices for measuring the depth of flow in a channel or ditch over a continuous period of time.



Aerial view of river with sediment deposition; used in conjunction with remote sensing.

Dr. V. Yevjevich and Dr. A. H. Barnes recently completed an analytical investigation of depth, volume, and discharge as a function of time for both gradually varied and rapidly varied unsteady flow in an open channel. Numerical solution of the problems could lead to improved designs of urban, airport, and highway drainage systems. Related data have led to improved understanding of flash floods and the results of a sudden release of water from a reservoir. The analytical data the two investigators obtained were tested and verified under field conditions. The U.S. Bureau of Public Roads funded this basic research.

Dr. Barnes is also analyzing the interrelationship of variables related to water resources management in another way. This time, instead of a mathematical model, he is creating a water resources game which links industrial, agricultural, and urban uses of water. Individuals with only a minimum of understanding of water resources will be able to play what is hoped to be a fun and educational game.

In association with others, including the U.S. Geological Survey (USGS), Dr. H. W. Shen is engaged in analytical work pertaining to basic research in flow mechanics. He and Dr. Petar Todorovic are studying sediment transport rate by stochastic models for a project sponsored by the National Science Foundation. To verify the models, they are tracing radioactively tagged sediment particles under different flow conditions. Using empirically collected data, Professor Shen has also developed a multivariable regression technique to determine the relation between sediment transport and flow conditions. This technique correlates well with laboratory results. It is now being tested in the field.

Remote sensing equipment used to detect thermal energy.

The USGS is studying the development of river bed roughness under various flow conditions by collecting data using an echo sounder developed at the engineering research laboratory in cooperation with Automation Industries of Boulder, Colorado.

Dr. Johannes Gessler recently completed a research project for the Experiment Station in which a new and different approach was used to analyze and to measure the eroding action of water on clay soil. Part of the problem with an irrigation canal that runs through clay soil is that there is both a mechanical and physicochemical eroding interaction between the water and clay. In a unique attempt, Dr. Gessler separated the effects of these two phenomena. To isolate the mechanical aspects he replaced the water with a nonpolar liquid agent; to study

Model of radial gate used in the Tarbela Dam.

the physicochemical interaction, he added chemicals to the clay. Depending on the chemicals, the clay either separates or binds together; binding properties reduce physicochemical erosion, thereby stabilizing the canals.

Other hydraulic research is being conducted to find methods of measuring seepage losses from canals and methods of reducing it; inexpensive lining techniques have been developed and are being improved.

Dr. D. B. Simons, Associate Dean for Engineering Research, Assistant Professor Morris M. Skinner, and Dr. Richardson are investigating new ways to analyze and measure phenomena pertaining to rivers.

The three techniques they are emphasizing are analytical photogrammetry, multi-band photography, and thermal infrared imagery. These techniques are based on the principle that all objects reflect or emit characteristic intensities of electromagnetic energy which can be recorded.

Photogrammetry, in simplified terms, is taking measurements from photographs. Two overlapping aerial photographs of a meandering river are placed in a stereocomparator. Using the principles of parallax, the x, y, and z coordinates of the bends in the river are determined. The space locations of these points are fed into a computer and the radius of the bends and meander pattern are calculated. This information is then used to form a mathematical representation of the river. Repeating this procedure periodically and comparing the results could indicate the erosion and deposition pattern and other critical changes in channel geometry.

Multi-band photography, which depends on the proper selection of camera filters and film sensitivity, detects both visible electromagnetic energy and invisible reflected energy. This technique can be used to identify flow patterns in a river, to map vegetal patterns on a flood plain, and to detect sewage outlets and submerged sandbars.

The technique of using thermal infrared imagery is similar to using multi-band photography except that the sensing apparatus measures emitted energy rather than reflected energy. This technique is useful for detecting potential slide areas along river banks and in levees, thermal pollution, and so forth.

Both analytical photogrammetry and multi-band photography already have been used on the Beaverhead River near Dillon, Montana. It is expected that thermal infrared imagery will be used in the near future. All three remote sensing techniques should prove to be useful for monitoring conditions and changes in rivers in a new context of continuity, interrelationship, and detail.

A basic research project to study the interaction between hydrology and meteorology was conducted in Venezuela in cooperation with the Venezuelan government. Meteorological and hydrological data were collected to study the basic phenomena of precipitation and the corresponding surface flow or flood response. The tropical test area, covering 5,400 miles of rivers, provided an opportunity to test existing hydrologic models against tropical conditions. Investigators, under project leaders Dr. Herbert Riehl, Professor of Atmospheric Science at CSU, and Dr. Simons, were able to correlate the amount of rainfall with the stream response in an area relatively unaffected by man. The hydrologic phase of the study focused on measuring soil moisture, stream flooding, and the general effect storms had on roads in the test area. Other benefits of the South American study include the development of a new technique for computing discharge in wide, shallow, sand-bed channels, directional simulation of the time-space character of storms, and the response of a stream under known inputs of precipitation.

Other basic research involving measurements is being done by Dr. Richardson and Dr. Raul S. McQuivey of USGS. They are measuring turbulence and how it relates to diffusion of solutes in a stream.

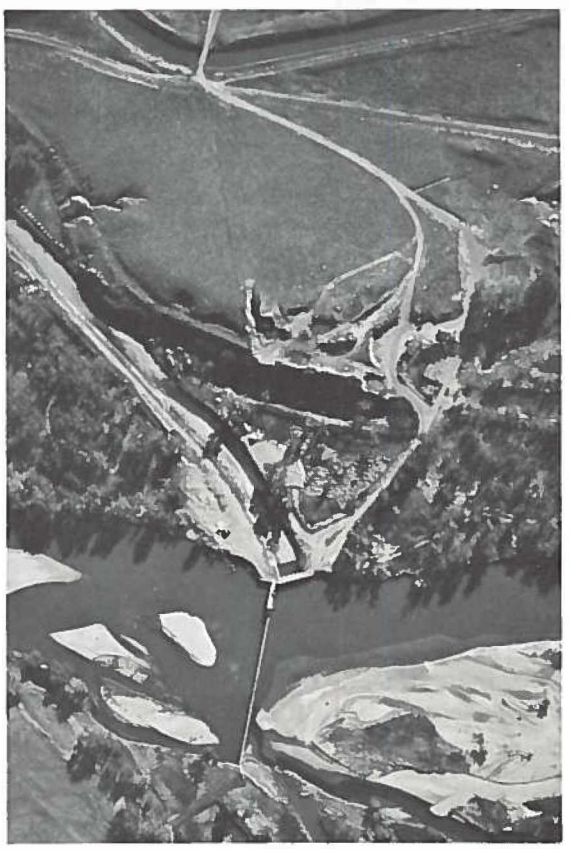
Once basic hydraulic phenomena are known and understood, engineering research can be applied to practical problems. In an attempt to improve safety procedures for filling pipelines, Dr. M. L. Albertson is working with the Johns-Manville Sales Corporation to establish safe filling rates and safer methods for testing pressure stress in filled pipelines. Results of the work will provide criteria that construction crews in the field can use to fill and test pipelines.

Dr. A. G. Mercer is also involved in activity related to industrial use of flow. The operational characteristics of four pumps used for pumping mine slurry for the Denver equipment division of the Joy Manufacturing Company are being tested under his leadership. The data collected will provide information on the efficiency of the pumps, the effects of cavitation, and the amount of flow the pumps can deliver against a given head. The pumps are lined with rubber which increases their life by reducing abrasion.

Public as well as private agencies also take advantage of applied hydraulic research. The Colorado State University Experiment Station is sponsoring a study to determine the advantages and disadvantages of consolidating irrigation ditch companies, and Dr. Simons is directing research to improve flood protection at waterway crossings such as bridges and culverts for the Wyoming State Highway Department. The investigation of how to protect bridge abutments with inexpensive rock riprap is nearing completion. Factors such as depth of flow, discharge, and channel geometry and their relationship to the size of riprap needed to protect bridges have been analytically computed and are now being verified by a physical model in the laboratory.

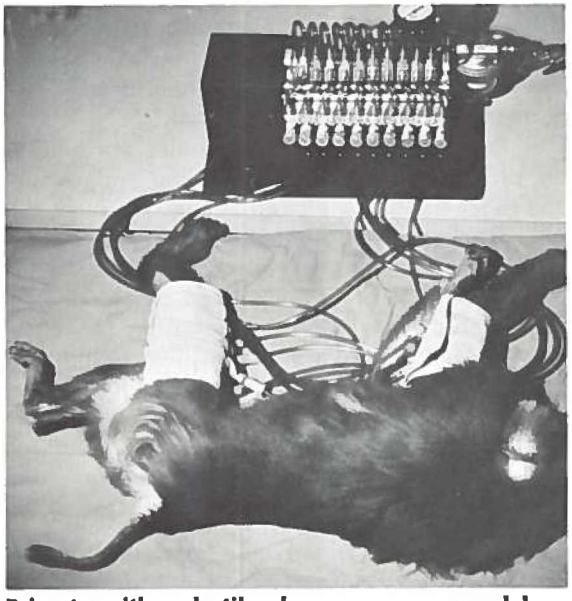
Hydraulic research is not only applicable to the water resource problems of the United States, but it is also important to the water problems of emerging countries. For example, a two-part study of irrigation problems in West Pakistan is being conducted by personnel in the hydraulics program at CSU. The first part of the study is computer simulation of the water conditions in this arid country. The second part is the laboratory testing of the sediment-removing characteristics of control structures used to deliver water to farms in West Pakistan. Drs. Mercer, Richardson, and Albertson are working on this project, which is funded by the U.S. Agency for International Development.

Another project for West Pakistan is a recently completed model study for Tarbela Dam. Hydraulic model studies of the radial gate and appurtenant works for tunnels 3 and 4, which divert water for irrigation, were performed at CSU under contract with Tippetts-Abbett-McCarthy-Stratton of New York. The heads against the gates may vary from 183 feet at low reservoir level to 433 feet at full reservoir. With these large heads, standard seals for radial gates located on the edge of the skin plate would be inadequate; therefore, caisson-type seals were placed on the face of the skin plate in the form of a picture frame. After modification the entire outlet works were made hydraulically satisfactory for all conditions of flow. This work was directed by Dr. S. S. Karaki.



Aerial view of river with sandbars; used in conjunction with remote sensing.

Cardiovascular Adaptability During Prolonged Space Exposure. Astronauts returning to earth's gravity after long exposure to weightlessness have experienced circulatory problems, including orthostatic hypotension, tachycardia, reduction in blood volume, lowered cardiovascular reflex response to shifts of blood to the extremities, and syncope or fainting. These same problems are shared by patients with long bed confinement when they are suddenly subjected to a standing upright position.



Primate with pulsatile sleeves on arms and legs for venous blood pooling.

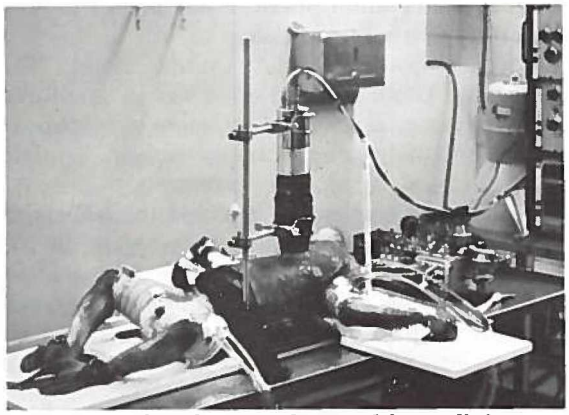
The causes of these conditions are complex, but in general they develop because the heart gets "flabby" since it does not have to work as hard pumping the blood through the body.

Development of a new technique for stimulating the cardiovascular system of subhuman primates is the object of this research conducted at the Surgical Laboratory, Colorado State University. The results may be extrapolated to man under conditions similar to those of the primates.

Intermittent venous pooling of blood in the distended lower vessels triggers and stimulates the vascular reflex mechanisms of the cardiovascular system and can have significant benefits in keeping the circulatory system in top performance tone.

Pulsatile sleeves, fitting from the shoulder to the wrist on each arm and from the upper thigh to the ankle of each leg, provide a sequential occluding of the venous return as a "rippling" action. The sleeves are actuated by compressed air through programmed valves to deliver from 40 to 90 mm Hg pressure at ten declining points along each arm and leg. The "ripple" effect, while pooling blood in the extremities, produces a soothing massage and is quite acceptable to the recipient.

The potential of these devices is evaluated by monitoring cardiovascular responses. The significance of the investigation is that it is directly aimed at the man-in-space program and at the same time, may prove to be of real therapeutic value to bedridden patients with circulatory disease.



Cardiovascular changes detected by radioisotope techniques.

Environmental Sensor Systems. In the study of the environment it is necessary to develop sophisticated instrumentation systems to gather the required data and to establish data reduction techniques to aid the scientist in the interpretation and evaluation of the results obtained. Because of the complexity of modern measuring devices such as microwave radiometers, electroacoustic probes, and lasers, it becomes essential to analyze the total sensor system performance including the effect of the environment on the instrumentation. This is the central concept in an interdisciplinary research program sponsored by the Air Force Cambridge Research Laboratories under Project THEMIS. Scientists and engineers from the department of Electrical Engineering, Mechanical Engineering, Physics, and Watershed Sciences are currently studying problems in spacecraft reentry communications,

satellite platforms for remote sensing of natural resources, laser measurements of atmospheric properties, ionospheric modeling, plasma turbulence, signal processing, and system optimization.

The program is under the general direction of Dr. R. J. Churchill in cooperation with Drs. D. F. Edwards, G. L. McAllister, F. L. Smith III, J. P. Rybak, C. B. Winn, H. E. Wilhelm, and W. E. Marlatt.

How Shall We Breathe in Space? Man takes his environment for granted most of the time. Little does he realize the importance of the air he breathes. Yet when circumstances, such as space travel, place man in an uninhabitable environment, he must take his own with him or perish. Man's atmosphere, a mixture of oxygen and nitrogen, was too heavy to use in the first spacecraft flown by the United States. The weight we could place in orbit was so small that oxygen alone at reduced pressure was chosen as the breathing gas for the astronauts. To date it is still used by all U.S. spacecraft.

Very early, scientists realized the effects of breathing high concentrations of oxygen. In 100 percent oxygen at normal pressure, test animals die within four days. Even though the oxygen pressure in the space capsules is low, the percent of oxygen is still about one and one-half times as great as in normal air. The National Aeronautics and Space Administration (NASA) began research to determine the effects of 100 percent oxygen at reduced pressure, not because the short-duration flights would show an effect, but because of the plans for longer flights, a week, two weeks, and more. Information was critically needed to determine the effects of this moderately high concentration of oxygen over a prolonged period of time.

Six years ago the Laboratory of Aerospace Biology, directed by Dr. J. P. Jordan, was funded by NASA to determine the metabolic effects of high concentrations of oxygen on laboratory animals. While some alterations in metabolism were observed, the test animals appeared to adapt to the stress well enough so that, overall, no harmful effects appeared. The equipment built to perform these studies has since been enlarged so that this laboratory now has the capability of maintaining an environment at any pressure, gas composition, temperature, or duration. Research is currently being conducted with this equipment to determine the best diluent gas to be used with oxygen for very prolonged space flights. Test animals have been kept in environments of oxygen mixed with helium, neon, nitrogen, and argon in an attempt to ascertain the effects of these gases on metabolism.

These experiments have produced data which show, in respect to air, that argon slows metabolism and neon increases it. Changing the gaseous atmosphere from the normal does not appear to alter metabolism in any detrimental way, therefore opening many avenues of metabolic control. It may be possible to slow an astronaut's metabolism during the long voyage to another planet by reducing what he consumes and then increasing his metabolism when he arrives at his destination to have him at peak performance physically and mentally.

Data collected in these studies are helping to produce a computer modeling program of the bioenergetic state of an animal. Through this tool it is hoped a prediction index can be developed in which, given a few simple tests, the metabolic state of an animal can be ascertained. Future study may allow its extension to human beings, perhaps as a very sensitive monitor of health. During a one to two years-long space voyage to Mars, it is imperative that we be able to measure the astronauts' physical condition and predict when an illness might be forthcoming. With advance warning, the mission could be terminated and the astronauts brought home safely before a major catastrophe could occur.

Applications of this research to medicine would be most benefical as a diagnostic tool, by which it might be possible to be made aware of an illness months or years before it occurred. Long-range preventive steps could then be taken to remove the possibility of its occurrence. The importance of this monitor should not be underestimated; it is long overdue.

The Planet Jupiter. An intriguing object in the sky is the subject of research for Drs. J. Raich, R. Etters, and R. Culver, three faculty members in the Department of Physics. This object is Jupiter, the largest planet in the solar system. It possesses an unknown source of periodic high power microwave radiation in addition to the wellknown "Red Spot." (Both of these attributes were utilized in the moving picture, "2001 - A Space Odyssey.")

Hydrogen is a major constituent of this planet, but because of its large gravitation it is almost

certain that the hydrogen (a gas here on Earth) becomes metallic at the high pressures that exist in the interior. This metallic condition admits the possibility of the hydrogen becoming superconductive, a quantum-mechanical phenomenon in which all electrical resistance essentially disappears. Calculations being performed to determine the likelihood of this happening would help in the understanding of how Jupiter has acquired a magnetic field many times greater than that of Earth, but without the preponderance of metallic constituents.

Another aspect of the planet's behavior is its influence on the motion of its dozen moons. In particular, the perturbations of the orbit of Jupiter V, the moon closest to the planet, are being used to determine the asymmetry in the mass distribution within Jupiter itself. This information is crucial to the determination of a proper trajectory to be used in the "Grand Tour of the Planets" being planned within the next decade. Additionally, this information is vital to an analysis of the actual internal constituency of the planet. Data is being gathered and assessed with respect to Jupiter's other moons, and it is hoped that it will be possible to improve the accuracy with which the orbital parameters are known. This type of analysis should also be extendable to the orbits of the moons of Mars and Saturn, for instance.

It is curious that the application of two physical theories, one barely a decade in development, the other having its roots in the classical theories of the 1700's, should contribute to the success and understanding of our space-age ventures.

Apollo IX Photos. Photographs taken from space stations orbiting 100 to 125 miles above the earth may provide meteorologists with better data about weather development and the general structure of the atmosphere than those taken from weather satellites.

Researchers in the Atmospheric Science Department are presently collecting data from photos taken by the crew of Apollo IX and are developing meteorological applications for photos to be obtained by crews of future manned spacecraft. The pictures of the earth's cloud cover were taken while the spacecraft was over the Rocky Mountain region.

The study is being done for the National Aeronautics and Space Administration (NASA). Officials of NASA want to know: "What can photos taken from an orbiting space platform provide in the way of data that cannot be obtained from weather satellite photos?"

CSU scientists believe there is much to be gained from photos taken at lower altitudes. They say the Apollo IX photos have greater resolution than those taken by television cameras in weather satellites orbiting 600 to 800 miles above the earth.

The Apollo photos captured very distinct wave patterns in the upper atmosphere. These waves were created by the mountainous terrain and have a direct relationship to the generation and maintenance of the jet stream. Such pictures from weather satellites are not possible.

Potential meteorological uses of photos taken from space stations include better weather forecasting, detection and forecasting of clear air turbulence, and detection of wind direction and change in direction at various altitudes.

Determination of Airflow and Diffusion Parameters for Atmospheric Water Resources Program. Several field programs are now in progress to augment water resources in the western states by artificially seeding wintertime orographic cloud systems. Artificial ice nuclei, in the form of silver iodide smoke from ground-based and airborne generators, are released in the natural airstream where turbulence and convection currents are expected to carry the material into supercooled water clouds, and thus to initiate precipitation by the Gergeron ice

crystal process. Studies have indicated that orographic cloud systems in which systematic condensation is caused by geographical obstacles are most suitable for seeding. However, the realization of delivering the optimal distribution of seeding material to orographic cloud systems presents a complex theoretical and operational problem.

In order to help solve this complex prolem several questions need to be answered in a quantitative manner: Under given storm conditions will artificial freezing nuclei reach the target area? How much of the target volume will be covered (i.e., what are the horizontal and vertical dimensions of the seeding plume) and in what concentrations? Is the seeding material getting into the clouds and at what concentrations? What role do atmospheric stability, wind shear, orographic features, and other natural factors play in distributing the seeding material?

The overall purpose of this research is to help provide some answers for these questions by utilizing special meteorological wind tunnels as a tool to model the atmospheric planetary layer over mountainous terrain. The passive tracer material (Krypton-85) is released to simulate the silver iodide seeding material.

The wind tunnel or laboratory method consists of making measurements of a dispersing tracer material over a scale model of selected terrain placed in a simulated atmospheric flow. Field measurements are used to confirm and/or correct the laboratory results.

At the present time, three topographic regions where operational cloud seeding is in progress have been selected for the laboratory studies. These regions are the Eagle River Valley-Climax region in the central Colorado Rockies, the Elk Mountain region in southern Wyoming, and the Wolf Creek Pass-Pagosa Springs region in the San Juan Mountains.

Scaled topographic models of each region have been made and placed in wind tunnels located in the Colorado State University Fluid Dynamics and Diffusion Laboratory. Three wind tunnels have been used for this research: the 6′ x 6′ meterological wind tunnel capable of producing thermal and momentum boundary layers similar to the atmosphere, the 6′ x 6′ CSU wind tunnel, and the 12′ x 7′ environmental wind tunnel capable of accommodating large topographic and building models.

The laboratory results to date are encouraging. Measurements of model vertical and horizontal dispersion patterns compare favorably with field results. Topographic effects on the transport of the seeding material have been verified by model and field results. Vertical concentration distributions for model and field have shown reasonable agreement.

Model of Eagle River Valley-Climax region in low-speed wind tunnel (1:9600 scale).

Additional work is planned and needed to check further on the laboratory techniques. The present results reveal that this technique can help cloud seeding operational groups in testing proposed seeding generator sites and can assist in providing information on targeting the seeding material where it will be the most effective.

This Bureau of Reclamation-sponsored research is a cooperative effort between the Fluid Mechanics Program, the Civil Engineering Department, and the Atmospheric Science Department under the direction of Dr. J. E. Cermak and Professor L. O. Grant.

Hail Research. Every summer farmers in northeastern Colorado stand the chance of having their crops chopped and beaten beyond recognition by hail. The incidence of hailstorms in this section of the state's breadbasket is higher than that of any other part of the nation. Within

the span of a few minutes, a single hailstorm can cause crop damage in the millions of dollars.

Atmospheric scientists at CSU have been studying hailstorms for the past decade. In the past three years, the university has joined with the National Center for Atmospheric Research and the Environmental Science Services Administration in Boulder in a joint hail suppression project.

CSU's portion of the project in northeastern Colorado is the development, testing, and use of an airborne rocket to be used to inject seeding materials into hailstorms. The technique is similar to the Russian system, which uses artillery shells fired from land-based units. Soviet scientists have reported a reduction of 60 to 70 percent or more in the incidence of hail by using the artillery-shell method of seeding storms.

Plans call for the rocket to be fired into a hailstorm from a T33 jet aircraft. The university has been using the aircraft for the past three years to gather data on the internal structure of the hailstorm and in the design and testing of the rocket seeding system. The development of cloud models will lead to better hailstorm forecasting methods and procedures.

The rocket will be fired at a point three miles from the target zone in the storm. Ground-based radar will be used to detect the hail-producing portion of the storm and to guide the aircraft into firing position.

A time-delay fuse will explode the rocket as it reaches the hail genesis area of the cloud, releasing the silver iodide or lead oxide seeding material. Depending on the storm's stage of development, the seeding is expected to eliminate the hailstorms or effectively reduce their size and ground damage potential. Since the CSU scientists are anticipating a dramatic change in the cloud's structure, they probably will know within a few minutes whether the seeding was successful.

Final testing of the rocket and its delivery system has been completed. All that remains is to acquire from the Federal Aviation Administration a restricted zone over northeastern Colorado where the rocket can be shot into hailstorms. Actual seeding of storms is not anticipated before the summer of 1971.

Should the rocket technique prove successful, it will have a profound beneficial economic impact on agriculture in northeastern Colorado and other areas plagued by hailstorms. One of the most immediate effects could be the reduction of crop insurance rates. Besides the apparent benefits to agriculture in the state, all that is learned about hail suppression in northeastern Colorado should have application in many other regions of the world.

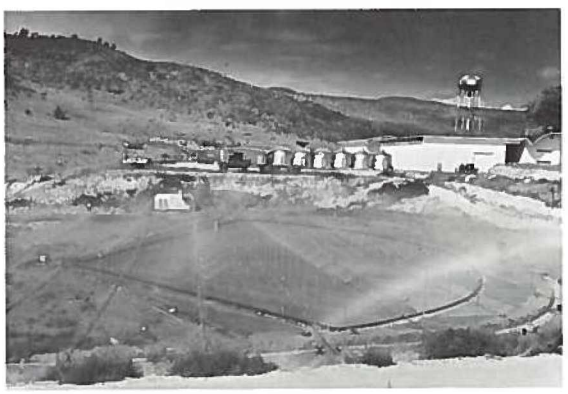
Large Continental Droughts. In September 1969 the National Science Foundation awarded a new grant to Professor V. Yevjevich for the study of large continental droughts.

It is a known fact that large droughts occur from time to time over extensive areas with significant economic damages and social consequences. Understanding, computation, explanation, and eventual prediction of droughts, measures of combating them, or eventual insurance against drought consequences are important topics of general water resources planning, design, and operation. Any meaningful research contribution in any of these areas will have significant practical consequences, since large continental droughts have eluded an appropriate investigation for a long time. Pertinent answers on the recurrence interval, areal coverage, predictability, and physical causes of large droughts are still lacking in the knowledge of water resources engineering and economics.

The main objectives and the present lines of this research project are to contribute knowledge in three basic areas of drought investigation: analysis of stochastic processes which underlie the drought occurrence, with methods developed and tested for computation of recurrences of droughts of various characteristics; attempts for physical explanation of drought occurrence, primarily by ocean-continent interrelationships in moisture supply and deposition, and the assessment of outlooks for the predictability of large continental droughts; and analysis of various engineering and economic aspects of droughts, particularly the assessment of drought damages, drought-combating measures, and eventual insurance against droughts.

At present four graduate students are working as research assistants with Professor Yevjevich on this project.

In addition Professor Yevjevich, with the collaboration of Professors M. Siddiqui and Petar Todorovic and with five graduate students as research assistants, is conducting an investigation



Hydrology research investigation of small watershed.

in stochastic structures of hydrologic series. Because of the need for a better understanding of river flow and precipitation patterns in time and space and river flow regulation problems and methods, the investigation of stochastic structures of hydrologic series is systematically undertaken with the continuous support of the National Science Foundation.

For better planning, design, and operations of river basin projects, especially of storage reservoirs and flood and drought controls, new investigative methods based on advanced scientific accomplishments became necessary for two purposes: for an increased safety of water yields with a prescribed quality, and for a more economical approach to the development of conservation of water resources. All planning, design, and operation of water resources projects must necessarily start from the basic characteristics of river flows and precipitation, for which the appropriate mathematical descriptions and analyses are still lacking.

The sequence in time and distribution in space of river flow and precipitation are processes affected by climatic seasonal variations and river basin factors. The complexity of these phenomena has induced the hydrologists, as well as the practicing engineers, to apply almost exclusively empirical methods in analyzing the properties of hydrologic variables obtained as observation records in the form of time series or areal distribution. The substantial progress in recent times in the theory of probability, mathematical statistics, and stochastic processes; the advent of digital computers; and the new methods of numerical analysis and new insights into river basin hydraulics and hydrology permit new approaches in the structural analyses of hydrologic series.

By using large samples of data on river flows and precipitation, many results have been produced which represent mathematical and mathematical-physical descriptions of river flow and precipitation. The information is condensed in the number of mathematical models with their parameters estimated from data. New insights have been produced into the character and estimation of various properties of hydrologic series. New contributions have been added to the river flow regulation. Several new results on various other topics involving the structure of hydrologic series have been published.

E. F. Schultz, in a project funded by the CSU Experiment Station, is developing a mathematical model of floods in small watersheds.

A hydrologic data bank has been established at Colorado State University. The purpose of this project is to assemble and store in easy-to-process form high quality flood hydrographs measured from small watershed floods. These data are being used in a continuing research program on floods from small watersheds. The data are stored on magnetic tape so that sorting can be rapidly accomplished by the computer and calculations can be efficiently completed.

At present time data have been assembled from about 700 different floods from watersheds smaller than 40 square miles in size located over the United States. Up to the present time, high quality data have been assembled only from small watersheds which have been undisturbed by man. Present plans call for adding data from watersheds in various stages of urban development so that the advantages of an efficient data bank can be brought to bear upon the critical problems of urban flood hydrology.

In another project sponsored jointly by OWRR and CSU Experiment Station, E. F. Schultz and V. Yevjevich are gathering data from the CSU Experimental Rainfall-Runoff Facility which has verified the validity of the Kinematic Wave Theory as a means for deriving a hydrograph from flood-producing rainfall. The 120° conic section of the experimental watershed was replaced by a five element kinematic cascade of watersheds of decreasing width. The computed hydrograph was found to agree favorably with the observed runoff hydrograph. Because the flow is converging, it increases rapidly in the downstream direction and becomes turbulent.

A study of the effects of surface roughness on the volume of detention storage on a given slope of the watershed is continuing.

In yet another project sponsored by the CSU Experiment Station, E. F. Schultz has built an experimental rainfall-runoff facility at Colorado State University to study various analytical models for predicting the response of the watershed to flood-producing rainfall. An outdoor watershed has been constructed in which rainfall is created by the overlapping patterns of rainfall from a large number of lawn type sprinkler heads mounted on risers which are ten feet above the surface of the watershed. Rainfall rates of approximately 0.5, 1.0, 2.0, and 4.0 inches per hour can be created over the watershed in a conic sector having an interior angle of 120°, a radius of 100 feet, and a uniform slope of 5%. The watershed surface has been carefully graded to the desired slope and covered by a butyl rubber sheet to protect the surface from erosion.

Work on the project is continuing. Two intersecting plane surfaces are being added to the watershed.

M. E. Holland and E. F. Schultz, in a project sponsored by OWRR, are applying the principles of multivariate analysis to seek the important physiographic and geomorphic characteristics of natural catchments that influence the flood hydrographs which result when the watershed is subjected to heavy rainfall.

A thesis which has been completed indicated that the flood peaks can be related to a term called "radiality," which is a measure of the plane-view shape of the basin.

Predictability of Winds in the Lower Atmosphere. A major study to improve the predictability of winds in the lower atmosphere is being undertaken by staff members of the Fluid Mechanics Program, Department of Civil Engineering. Support is provided through Project THEMIS and administered by the Fluid Dynamics Branch, Office of Naval Research.

The research effort is concentrated on experimental studies in flow facilities of the Fluid Dynamics and Diffusion Laboratory. Answers to several questions are being sought: How do nonuniform roughness and temperature of the earth's surface affect winds in the lower 600 ft of the atmosphere? How do mountain and valley systems control atmospheric flow near the earth's surface? What kind of flow interactions are produced by jets flying into a boundary layer? How can flow characteristics measured in the laboratory be extrapolated to full-scale atmospheric conditions? Application of the new knowledge being generated may be made to the study of air pollution problems, agricultural problems of water utilization by transpiration and spreading of insecticides from airborne sources, aircraft flight problems during takeoff and landing, problems of electromagnetic energy propagation near the earth's surface, wind forces on structures, etc.

Staff members participating in this program include Drs. Cermak, Meroney, Nickerson, Sadeh, and Sandborn from the Civil Engineering Department and Dr. Marlatt from the College of Forestry and Natural Resources.

Wind Loading on Structures. Tremendous forces can be produced by the wind, and the effect of these forces on structures can be disastrous. As early as the 17th century, Galileo and Newton discussed wind loading on buildings. The Tay Bridge diaster in 1879 and the more recent Tacoma Narrows Bridge collapse are classic examples of the dynamic effects of even moderate winds. The occassional strong leewinds along the eastern slope of the Rocky Mountains produce wind forces that cause much damage. Modern tall buildings are being made more and more flexible with great areas of glass and thin outer panelling, which make them extremely vulnerable to wind damage.

The flow pattern around a building or structure is so complex that to date a complete theoretical formulation has not been possible. Due to the wind velocity gradient and turbulence within the atmospheric surface layer, both average and fluctuating forces and moments are of importance in finding the overall structural response. In addition, instantaneous peak pressures on the outer skin (glass windows and stone or metal panels) must be considered. The latter pressures are determined by turbulence in the oncoming wind, local separation at sharp corners of the building, wake of buildings immediately upstream, and local vortex generation on the building. Because the wind-loading problem is so complex, actual loading on specific structures can be determined only through carefully designed model studies in special wind tunnels that are able to simulate the atmospheric flow.

The Fluid Mechanics Program of the Department of Civil Engineering, under the direction of Dr. J. E. Cermak, has pioneered in the development of wind loading and its effects on structures through laboratory studies. The Fluid Dynamics and Diffusion Laboratory has developed meteorological and environmental wind tunnels that are particularly suited for simulating the flow around structures. These facilities have been used to study wind loading on the 1400 ft high World Trade Center Towers in New York, the 800 ft high Bank of America Building in San Francisco, the 660 ft high Atlantic-Richfield Buildings in Los Angeles, and the 400 ft high Kaiser Building in Oakland.

A cooperative effort on a long-range fundamental study of wind loading on structures between the Fluid Mechanics Program and the Building Research Division, National Bureau of Standards, has been initiated. The initial study will include a program of pressure measurements on a full-scale structure and a model of the structure to confirm model-prototype relationships. Drs. Cermak, Sadeh, and Meroney are Colorado State University participants in this effort. Dr. R. D. Marshall, a graduate of Colorado State University who heads the Wind Loads Section, Building Research Division, directs the National Bureau of Standards research in this cooperative program.

Model of Fort Wayne, Indiana, prepared for wind and contaminant concentration measurements in the new environmental wind tunnel of the Fluid Dynamics and Diffusion Laboratory (1:4000 horizontal scale; 1:2000 vertical scale).

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Brownlee, George H. Centennial Show. Colorado State University. Fort Collins, Colorado.

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Yust, David. One-Man Exhibition, Maude I. Kerns Art Center. Eugene, Oregon.

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Foster, John Edward. 1970. The United States, Texas, and the Indian Problem. M.A. Adviser: Charles J. Bayard.

MUSIC DEPARTMENT

Anderson, Edward D. Tenor soloist - Beethoven Ninth Symphony, Fort Collins Civic Symphony and Community Art Symphony. Denver, Colo.

Cavarra, Robert N. Centennial organ recital; featuring works by American composers for organ. Colo. State Univ., Fort Collins.

Cavarra, Robert N. Lecture: A contemporary church organ—its design and construction. American Guild of Organists (Fort Collins-Loveland Chapter). Fort Collins.

Cavarra, Robert N. Lecture recital; the design of the classical French organ, American Musicological Society (Rocky Mountain Chapter). Colo. State Univ. Fort Collins.

Cavarra, Robert N. Organ recital; Brahms, Chorale Preludes for Organ, works by J. S. Bach, Muffat, and Vierne. Colo. State Univ. Fort Collins.

Cavarra, Robert N. Organ recital; works by Clerambault, Brahms, Bach, and Franck, Broadmoor Community Church. Colo. Springs, Colo.

Cavarra, Robert N. Program for organ and choir with chamber singers; works by Handel, Purcell, Samuel Barber, and Cecil Effinger. Colo. State Univ. Fort Collins.

Cavarra, Robert N. Research paper. Comparison of mechanical action with other types of organ actions and their relation to pipe speech. 1969 Regional Convention of American Guild of Organists. Fort Collins.

DeBroder, Gordon W. The relationship of improvement in training of musical perception to dimensions of the personality. Ph.D. dissertation, University of Denver.

Diebel, Wendel H. Harp Trio: Harp, Flute and Cello. Society of Colo. Composers, International House. Denver.

Diebel, Wendel H. Les danses gothiques (Symphony Orchestra). World Premier, Fort Collins Symphony Orchestra. Fort Collins.

Diebel, Wendel H. Ten bagetelles for brass quintet and harp. Denver Brass Ensemble, assisted by Suzann Davids, Harp, World Premiere, International House. Denver.

Diebel, Wendel H. Ten Bagatelles for brass quintet and harp. New England Music Camp. Oakland, Maine.

Diebel, Wendel H. Ten bagatelles for brass quintet and harp. Symphonic Brass Choir, Calif. State College. Los Angeles, Calif.

Diebel, Wendel H. Theme and variations for woodwind quintet. World Premiere, Faculty Woodwind Quintet, Metro State College. Denver.

Garrett, Lee R. 1969. The organ works of Olivier Messiaen from 1928 to 1939. M.M. Ind. Univ.

Garrett, Lee R. Lecture on church music delivered to St. Luke's Episcopal Church. Fort Collins.

Garrett, Lee R. Organ recital. Colo. State Univ. Fort Collins.

Nisbett, Robert F. Piano Recital: Two Sonatas (L. 461, L. 25, D. Scarlatti; Sonata in C. Op. 2, No. 3, Beethoven; Two Etudes (Op. 10, No. 1; Op. 25, No. 1), Chopin; Variations and Fugue on a Theme by Handel, Op. 24, Brahms; Jeux d'eau, Ravel; Danse, Debussy. Music Department, Colo. State Univ. Fort Collins.

Parsons, John N. The Franco-Belgian violin school and its three chief teachers-artists: de-Beriot, Vieuxtemps, and Ysaye: a paper read before the 1969 Annual Meeting of the Rocky Mountain Chapter of the American Musicological Society, Univ. of Colo. Boulder, Colo.

Parsons, John N. and Wendel H. Diebel. Recital: Sonata in G by G. B. Summartini; Sonata #4 in C, Op. 102, No. 1 for Violoncello and Piano by Beethoven; Sonata, Op. 4 by Kodaly. Colo. State Univ. Fort Collins.

Rhoads, Mary R. Christmas recital; Brahms Intermezzi, Christmas carol improvisation. Colo. State Univ. Newcomers Club. Fort Collins.

Rhoads, Mary R. Influences of Japanese Hogaku manifest in selected compositions by Peter Menin and Benjamin Britten. Ph.D. dissertation, Michigan State Univ. East Lansing, Mich.

Rhoads, Mary R. Knight Before Classes (musical play for children). Poudre High School. Fort Collins.

Rhoads, Mary R. The Mudlark (full-length musical comedy). Helen Mary Greene Theatre. Fort Collins.

Rhoads, Mary R. Piano Recital. Beethoven Piano Concerto #1. Unitarian Church. Fort Collins.

Thompson, Sidney. Piano Soloist with Colo. State Univ. Symphony. Saint-Saens, Africa, Student Center Theatre, Colo. State Univ. Fort Collins.

Waddell, Josephine. Lecture: liturgical renewal, Eastern Wyoming Ministerial Alliance. Torrington, Wyoming; Church Music Workshop. Lingle, Wyoming.

Waddell, Josephine. Lecture-recital: an experiment in relevance; chorales and chorale preludes 18th to 20th centuries. First Presbyterian Church. Lincoln, Neb.

PHILOSOPHY DEPARTMENT

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DEPARTMENT OF PHYSICAL EDUCATION

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Phllips, Sally Jo. 1970. Physical Education and AAHPER Fitness Test. M.Ed. Adviser: Alvin M. Pettine.

Ross, Renee Wade. 1969. A Measure of Teacher-Pupil Rapport. M.Ed. Adviser: Alvin M. Pettine.

POLITICAL SCIENCE DEPARTMENT

Foss, Phillip O. (ed.). 1970. Public land policy. Proceedings of Western Resources Conference. Colorado Assoc. Univ. Press, Boulder.

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Brady, Roger Alan. 1970. Complaints as Political Acts. M.A. Adviser: Charles L. Garrison.

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Nelson, Michael Boyd. 1969. An Exercise in Political Logic. M.A. Adviser: Duane W. Hill.

Schmidt, Robert Frederick. 1970. West Pakistan Water Management Agencies. M.A. Adviser: John A. Straayer.

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Larson, Gary Lee. 1970. Theory of Underground Structure. M.S. Adviser: T. R. Young.

Madson, Patricia Ann Olson. 1969. The Residence Hall Community. M.S. Adviser: Evan C. Vlachos.

Palmer, Dwight Eldon. 1970. A Study of Trust in Organized Groups. Ph.D. Adviser: Glenn C. Dildine.

Salazar, John Hay. 1970. Spanish American Social Participation. Ph.D. Adviser: William W. Winnie.

Schnell, David Robert. 1970. Sources of Self and a Neo-gemeinshaft Community. M.S. Adviser: T. R. Young.

Tiller, Beverly J. 1969. Adjustment of Foreign Students. M.S. Adviser: William W. Winnie.

DEPARTMENT OF SPEECH AND THEATRE ARTS

Braddy, Robert E. 1969-70. Scene design and lighting for: Importance of Being Earnest, Adventures of Scapin, Thurber Carnival, Troilus and Cressida, all at CSU.

Braddy, Robert E. 1970. Director: The Visit, at CSU.

Gardiner, James C. 1969. The effects of perceived audience response on speaker attitudes. Ph.D. dissertation, Michigan State Univ., June.

Hopkins, Richard. 1969-70. Director: Readers' Theatre presentations, "Oral Literature: Rhetoric" and "Poetry, Mostly Modern," at CSU.

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Hladky, Valerie Ann. 1969. Personality Change of Students in High School Drama. M.A. Adviser: Ronald A. Willis.

Kugler, Thomas William. 1969. Hubert H. Humphrey's Acceptance Speech at Chicago. M.A. Adviser: Gordon F. Hostettler.

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DEPARTMENT OF TECHNICAL JOURNALISM

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DEPARTMENT OF VOCATIONAL EDUCATION

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Huffman, Harry. 1970. Business and educators compare notes on the office procedures course. J. of Data Education pp. 10-15. Feb.

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Huffman, Harry and Dale D. Gust. 1970. Business education for the emrgent office. The center for Voc. and Tech. Edu., Ohio State U. p. 200. June.

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Breese, Edward Lloyd. 1969. Factors of Testing in Three Trades. M.Ed. Adviser: Duane L. Blake.

Fritzler, Connie June Miller. 1969. Study of Selected Vocational Programs. M.Ed. Adviser: Albert C. Masterson.

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Neal, Charles Robert. 1969. Interdisciplinary Vocational Education. M.Ed. Adviser: Duane L. Blake.

Needham, Raymond John. 1969. Development of Technical Occupations. Ph.D. Adviser: Harry Huffman.

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DEPARTMENT OF BIOCHEMISTRY

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