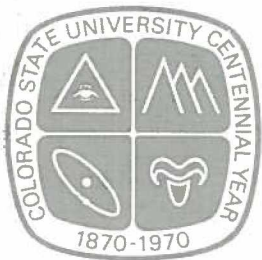


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**eighty-second annual report
colorado state university
1968-69**

eighty-second annual report
colorado state university
1968-69

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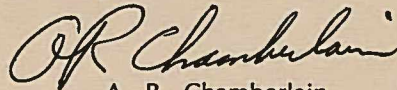
annual report 1968-69

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.

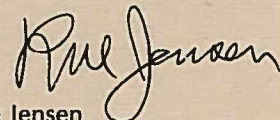


A. R. Chamberlain
President
Colorado State University

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.



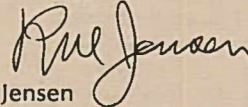
Rue Jensen
Vice President for Research
Colorado State University

Honorable John A. Love
Governor of Colorado
Denver, Colorado

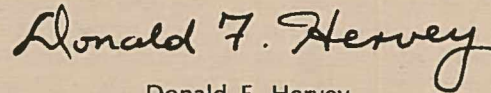
Dear Sir:

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-Second 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 1968-69.

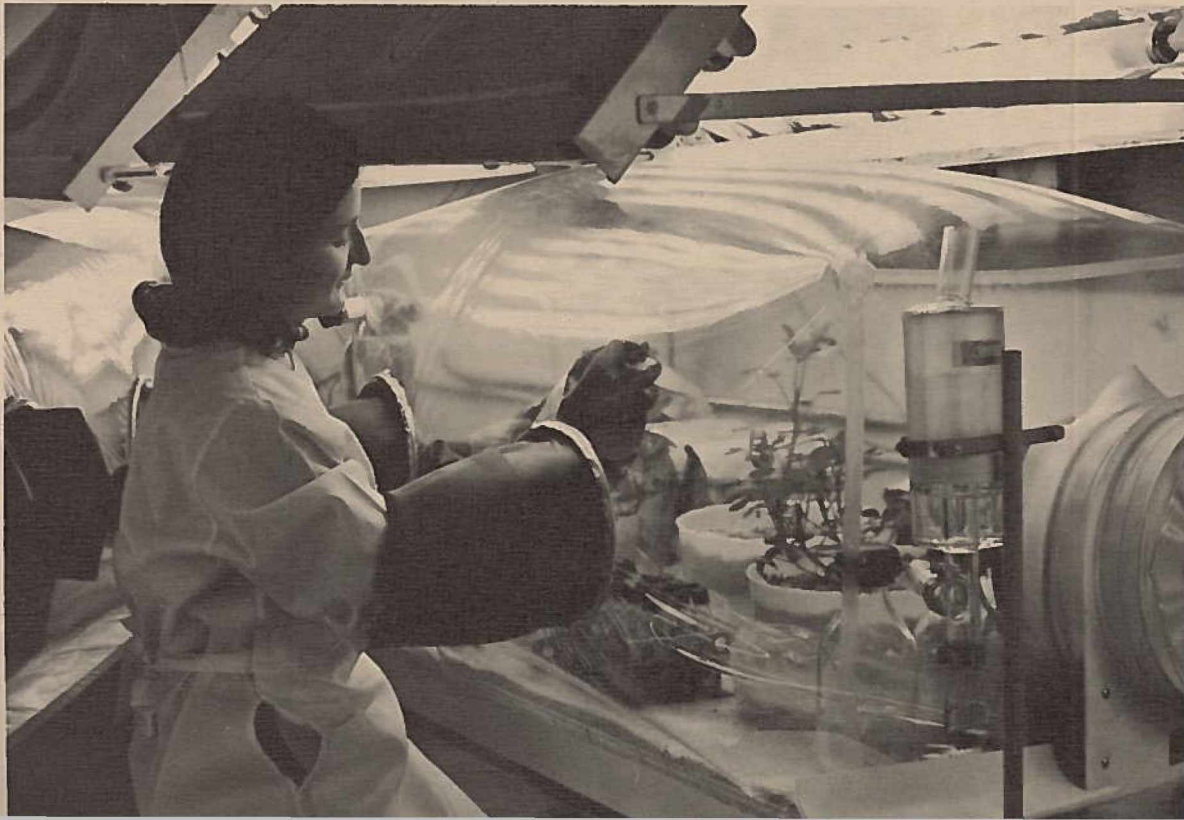
Respectfully,



Rue Jensen
Vice President for Research
Colorado State University



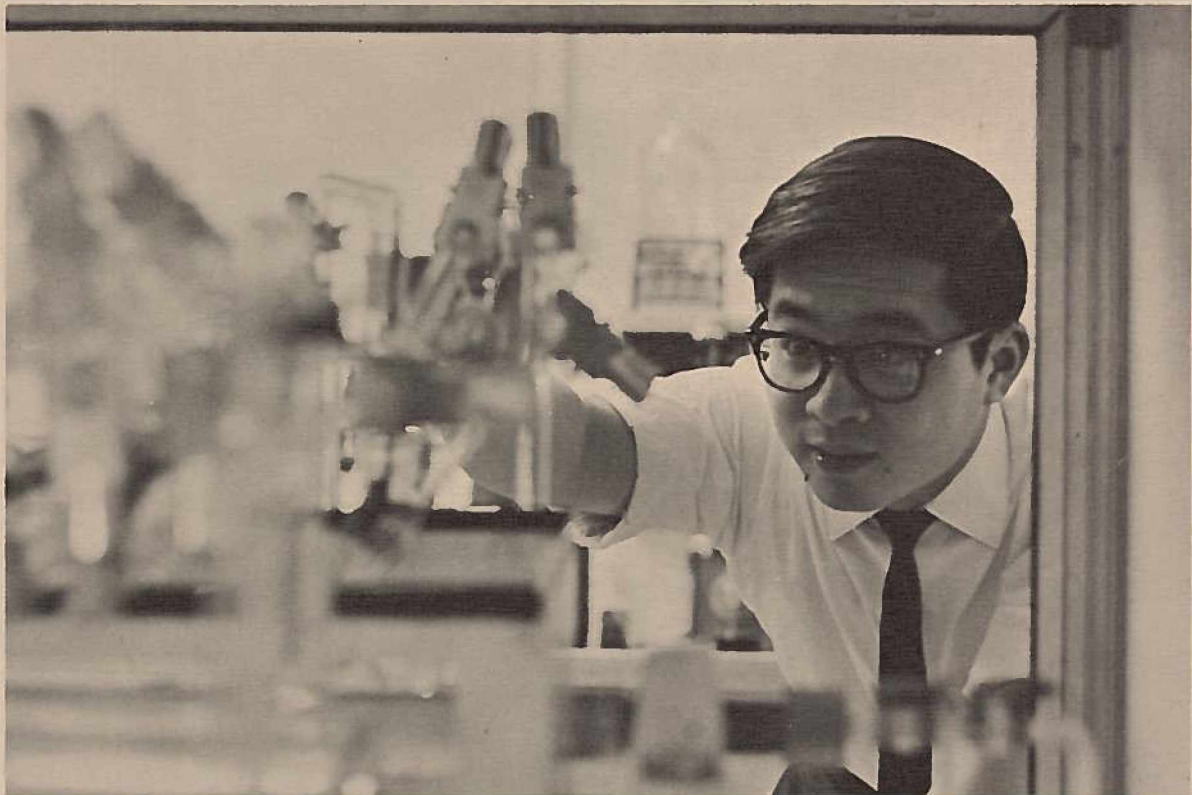
Donald F. Hervey
Director, Colorado State
University Experiment Station



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 & 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.

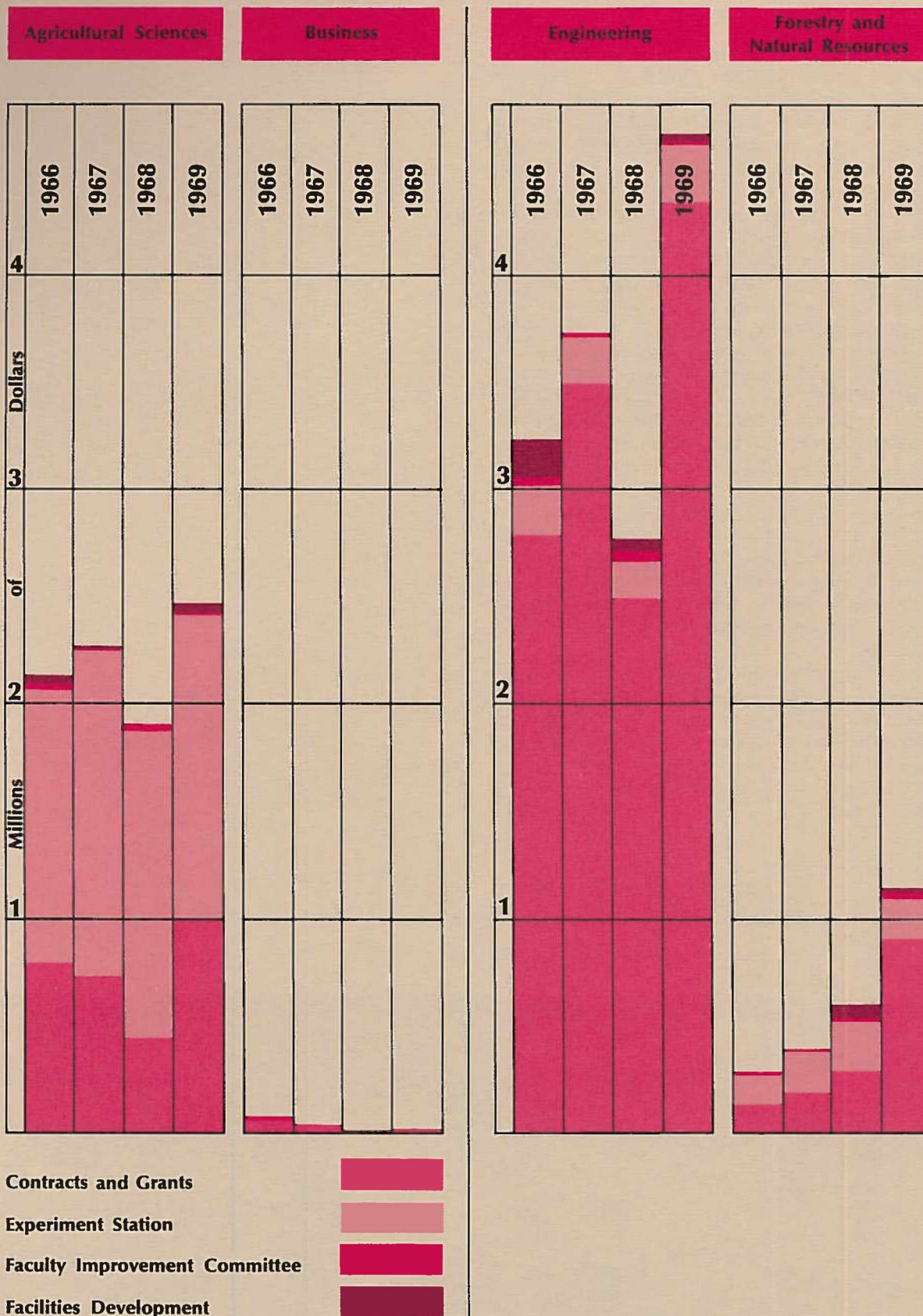
The Proposal Section supports the faculty by providing information concerning potential sponsors. Facilities for preparation of proposals are also available including pricing, typing, reproduction and distribution. Solicited and unsolicited proposals are sent to a number of organizations that would possibly support a proposed research project. Should a proposal submission result in interest by a sponsor, the Office of Contracts & 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.

During the 1968-69 fiscal year, 410 proposals were submitted requesting support for over \$41,000,000. During the same time, 359 research projects were awarded to the University with a value in excess of \$13,000,000, an increase of 19 percent above the amount of the previous fiscal year.



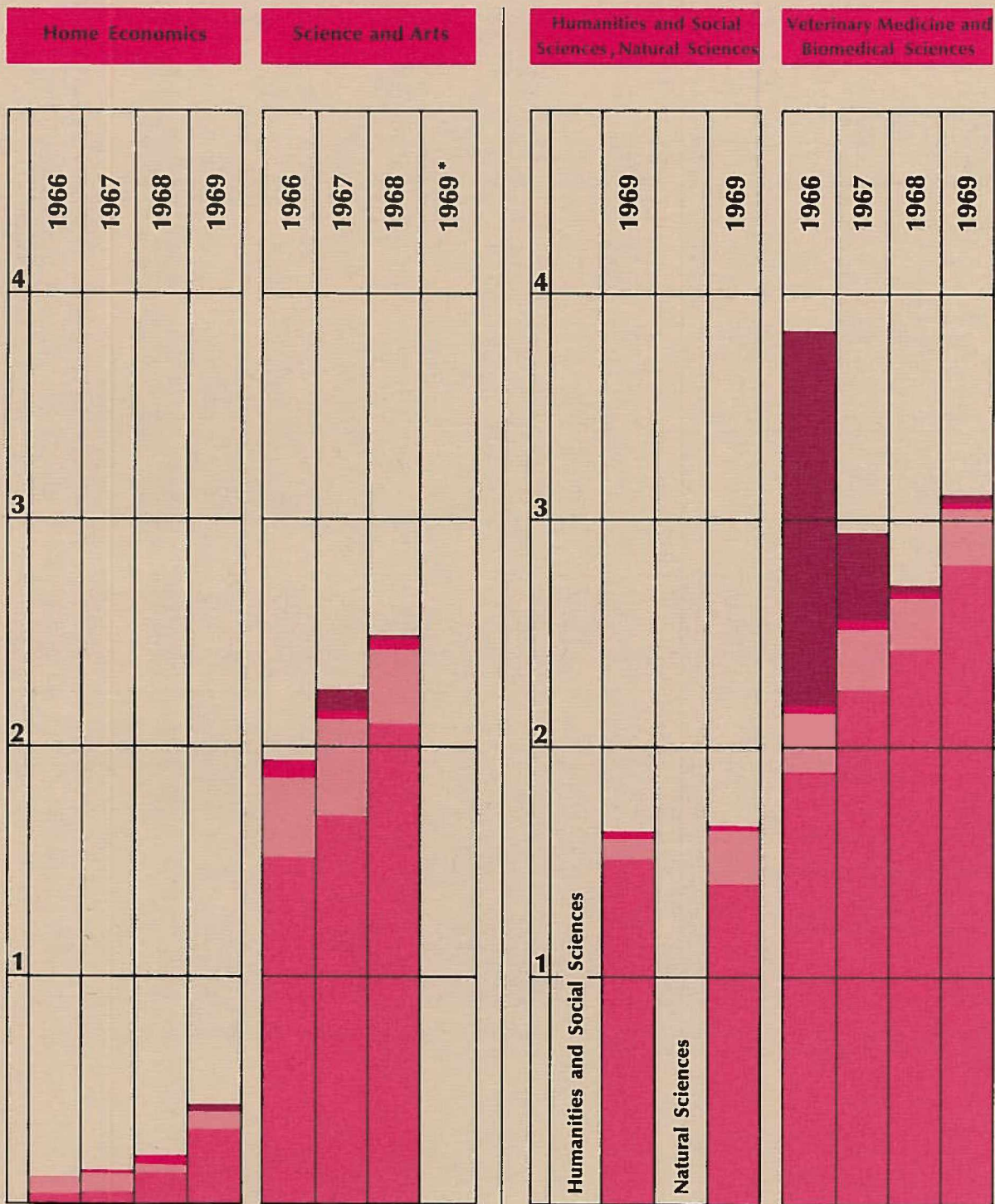
research funds expended by college, 1966-1969

growth of research



growth of research

research funds expended by college, 1966-1969



*Divided into the College of Humanities and Social Sciences and the College of Natural Sciences.

Financial Statement

COLORADO STATE UNIVERSITY EXPERIMENT STATION — FISCAL YEAR 1968-69

	Hatch	RRF	McIntire-Stennis	Specific Research	State Approp.	Research Sales	Total
Carry-over—7/1/68			14917.14	497.78	5.82	27,478.19	42,898.93
Receipts 1968-69	504,665.00	283,186.00	62,361.00	29,500.00	2,160,422.00	304,010.81	3,344,144.81
Total Revenue Available	504,665.00	283,186.00	77,278.14	29,997.78	2,160,427.82	331,489.00	3,387,043.74
Expenditure of Revenue:							
Personal Services	412,333.01	232,525.00	47,597.46	19,184.36	1,350,181.54	74,659.31	2,136,480.68
Travel	10,663.74	12,102.26	1,306.50	.....	43,149.63	5,591.64	72,813.77
Equipment	6,967.89	1,608.33	2,916.35	2,914.17	71,461.95	29,923.34	115,792.03
Land & Structures	.....	.....	.....	.....	.....	.....	.....
Personal Benefits	.....	.....	.....	.....	95,689.97	3,169.95	98,859.92
Supplies & Materials	33,855.63	29,488.35	3,825.19	590.16	138,308.15	84,571.33	290,638.81
All Other	40,844.73	7,462.06	3,990.09	191.29	93,885.58	133,573.43	279,947.18
Plant M&O	.....	.....	.....	.....	367,751.00	.....	367,751.00
Total Expenditures	504,665.00	283,186.00	59,635.59	22,879.98	2,160,427.82	331,489.00	3,362,283.39
Balance 6/30/69	.....	.....	17,642.55	7,117.80	.....	.....	24,760.35
Total Expenditures & Balance	504,665.00	283,186.00	77,278.14	29,997.78	2,160,427.82	331,489.00	3,387,043.74

Colorado State University

STATEMENT OF EXPENDITURES FOR RESEARCH — FISCAL YEAR 1968-69

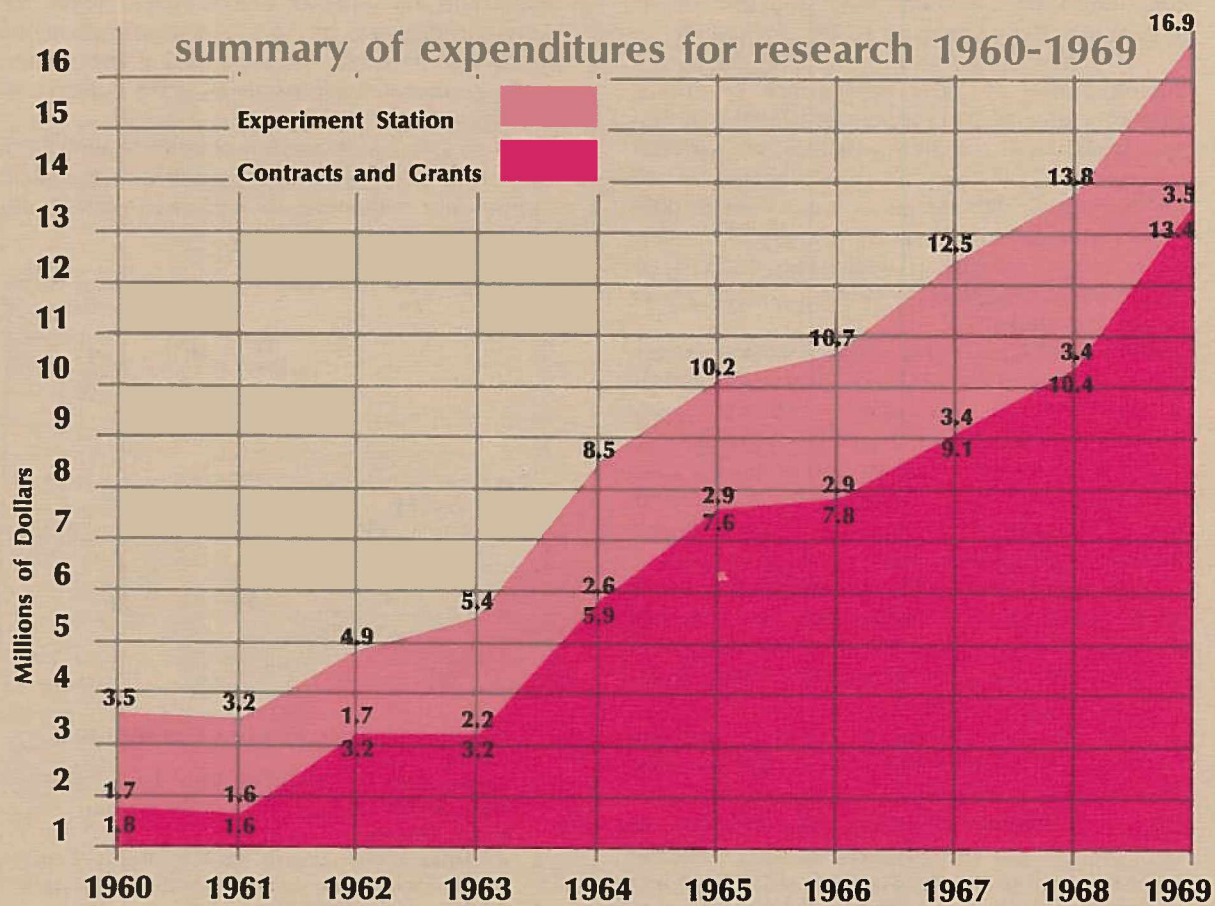
College	Total	Contracts and Grants	Experiment Station	Faculty Improvement Committee	Facilities Development
Agricultural Sciences	2,477,841	1,003,167	1,463,743	800	10,131
Business	17,038	17,038	.....	.....	.....
Engineering	4,651,228	4,345,534	276,373	700	28,621
Forestry and Natural Resources	1,156,791	914,679	233,998	2,205	5,909
Home Economics	433,704	325,884	86,997	.....	20,823
Humanities and Social Sciences	1,635,143	1,512,219	112,719	10,205	.....
Natural Sciences	1,646,427	1,407,671	230,916	7,840	.....
Veterinary Medicine and Biomedical Sciences	3,093,056	2,800,630	267,566	3,000	21,860
Other*	1,768,473	1,059,471	689,971	250	18,781
Totals	16,879,701	13,386,293	3,362,283	25,000	106,125

*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.

Advanced Degrees Awarded 1968-69*

College	Masters	Doctors
Agricultural Sciences	38	10
Business	14	
Engineering	96	25
Forestry and Natural Resources	45	10
Home Economics	25	
Humanities and Social Sciences	280	10
Natural Sciences	85	38
Veterinary Medicine and Biomedical Sciences	37	21
Totals	620	114

*Includes August 1969



Natural Resources Center. The Natural Resources Center coordinates education and research programs dealing with man's use and development of land, water, and atmosphere. These programs cut across departmental, college, and institutional boundaries. In addition, the Center administers a Federal program of water resources research funded through the Office of Water Resources Research (OWRR), U. S. Department of the Interior. The missions of the Center are to stimulate more and better research on natural resources problems of the state and nation, train scientists and engineers for the task of natural resources development, and improve the flow of communication between those engaged in research and those engaged in its application.

Five water research projects have been conducted during the past year under an annual allotment of \$100,000 funded by OWRR. Thirty-two professional research scientists or engineers representing 14 disciplines participated in 17 sub-projects. Five technical papers were published with an additional ten papers in process for future publication. Twenty-five students received advanced graduate training, four of whom completed theses.

An OWRR matching research grant program supported 12 major research projects. A total of \$151,000 was provided in Federal funds, matched by an equal amount from State sources. Thirty-five research scientists and engineers from 13 disciplines were engaged in these projects. Training of 25 students was provided through participation in the research.

During the year four new matching research grant projects were authorized for Colorado through OWRR with \$175,000 of Federal funds to be matched by an equal amount of State funds, over a three-year period.

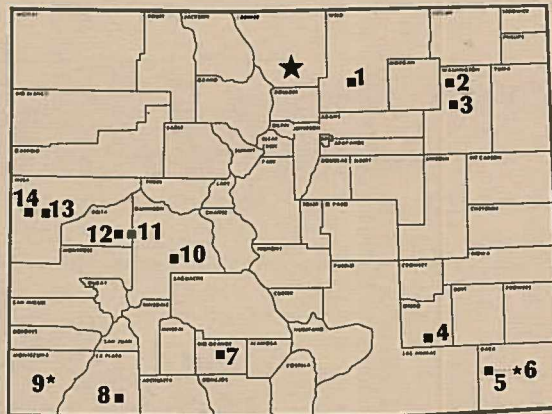
The Center, through the activities of nine standing committees and several special committees, has participated in academic activities related to natural resources, regional planning for new research or educational programs, coordination of research programs with State and Federal agencies, and general public affairs concerning natural resources.

Experiment Station. The Colorado State University Experiment Station is a complex of faculty, graduate students, technicians, laboratories, and field stations near the campus at Fort Collins and at 11 other locations scattered through-

out the state. Most of the scientists involved are both researchers and teachers.

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 through contracts and grants 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, Gunnison, and Grand Junction.



- 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. 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 (\$25,000) 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. Forty-seven grants from FIC funds were made to 22 departments for fiscal year 1968-69, with the following distribution:

College	No. of Grants	Amount Granted
Agricultural Sciences	1	\$ 800
Engineering	1	700
Forestry and Natural Resources	4	2,205
Home Economics	—	—
Humanities and Social Sciences	21	10,205
Natural Sciences	15	7,840
Veterinary Medicine and Biomedical Sciences	4	3,000
Miscellaneous—Libraries	1	250
TOTALS	47	\$25,000

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.

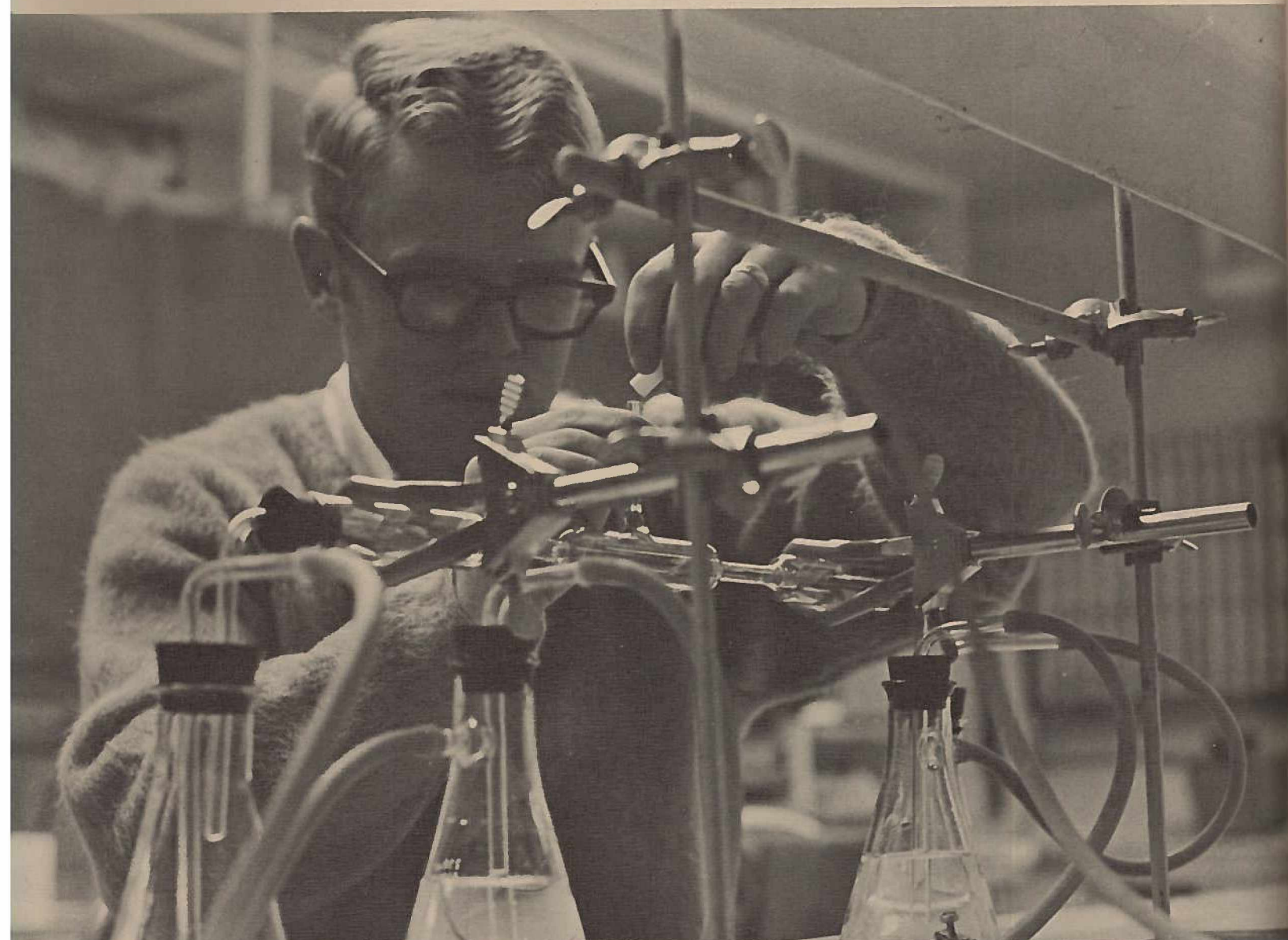
University Planning Office. The Planning Office is responsible for the funding, programming, design, construction, space assignment, and space utilization of the total facilities program. During the last year the following facilities concerned primarily with development of research and graduate training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

Facility	Sponsor	Amount
Biophysical Science— Completed	State of Colorado	\$ 50,000
Microbiology— Completed	HEW ¹	335,000
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	State of Colorado	90,000
Grassland Biome Research Lab	State of Colorado	225,000

¹Health, Education and Welfare
²National Institute of Health

In addition to the construction program responsibilities the Planning Office works with departmental and administrative committees in developing 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.



Artery Disease in Swine. In man, one of the foremost causes of death is due to fat infiltration into specific areas in the blood vessels (atherosclerosis) and subsequent deposition of calcium salts. This eventually leads to hardening of the arteries (arteriosclerosis). Man is more susceptible than woman and high blood pressure is related to the susceptibility to atherosclerosis. Since 1962 a research group consisting of Drs. D. H. Will, M. L. Hopwood, and N. H. Booth has been studying the primary causes for the onset of atherosclerosis in swine, concentrating on the sex differences and hypertension in the blood vessels. A miniature swine colony of approximately 150 animals has been established at CSU to serve this research. It is recognized that swine develop atherosclerosis and that they can serve as a model for the human disease since they can eat similar diets, are sedentary in nature, suffer cerebral damage, and have similarities in the heart and coronary vessels. Measurements on blood vessels of male and female swine conducted at the Department of Physiology and Biophysics show that under induced high blood pressure female swine differ from males. One apparent difference is that when the main arterial trunk, the aorta, is constricted to render both males and females hypertensive, the latter do not suffer enlargement of coronary vessels, whereas males are affected significantly. Differences between blood vessels in oxygen consumption, production of mucopolysaccharides (elastic components) and concentration of glucose indicate that the female has protection against vascular damage. These studies will be continued.

Automated Psychotherapy. Dr. Richard M. Suinn, professor of psychology and a trained clinical psychologist, has been actively engaged in research which may lead to the replacement of therapists such as himself. Within the past ten years a major revolution—behavior therapy—has developed in the techniques for treating emotional problems which challenges previous procedures such as psychoanalysis, insight therapy, and other psychodynamic therapies based on the Freudian view of man and his problems. Unlike Freud, the behavior therapists believe that symptoms of maladjustment are a result of defective learning rather than of deep, symbolic emotional

conflict. Fear of flying, for example, is seen as a learned response to the stimuli of airplanes and not because flying has sexual connotations representative of unresolved emotions.

On this basis the behavior therapist can draw from the vast pool of laboratory evidence on human learning of normal behavior and apply the same principles to pathological behavior. Rather than discussing the childhood significance of the symptom, the behavior therapist prefers to establish a learning condition which will promote adaptive, healthy behavior or extinguish pathological responses. Desensitization is one type of behavior therapy found especially valuable in the treatment of phobias, in which the client is trained in relaxation responses and then systematically and gradually exposed to visual scenes which currently arouse varying degrees of fear responses. The client soon exhibits relaxed responses instead of fear when presented with the visual stimuli. Dr. Suinn is credited with being one of the first to modify this standard desensitization procedure so as to make it possible to treat clients in groups instead of individually. Others have attempted to use closed-circuit television so that greater numbers of groups could be treated at the same time. Dr. Suinn's current research takes the next logical step of removing the therapists completely from contact with any clients; tape recordings are prepared for instructing the clients in relaxation and visualization. "This is not a unique notion," Dr. Suinn comments. "After all, we have developed in the area of academic education such devices as programmed textbooks and teaching machines which do away with the teacher."

Professor Suinn has been interested in exploring ways of perfecting the therapeutic procedures and developing more effective methods of treatment. One innovation that has appeared promising is the "massing" of desensitization meetings. Instead of the traditional once-a-week sessions, he sees clients daily for an hour, for a period of one week. This massed learning proved successful in removing a phobia of spiders of a group of clients. While prior to treatment none of the 20 clients were able to put their hands near a spider, following therapy 16 could do so. In comparison with traditional Freudian therapeutic approaches in which treat-

ment stretches over weeks, months, and years, this one week desensitization period is remarkable.

In a project started this spring, Dr. Suinn is examining a new approach to phobias. This approach views fears as highly aversive attitudes; in the case of phobias, the attitudes are so powerful that they force the person to avoid or withdraw from the topic or object. The research evidence indicates that attitudes, opinions, and even self-related beliefs can be controlled by an experimenter using operant reinforcement learning; in this, he selectively rewards the subject whenever the desired attitude is expressed verbally. Graphs of the subject's attitude statements during these sessions show a systematic increase in the number of such statements as a result of reinforcement (reward).

This procedure has even been demonstrated to be effective when the examiner reinforces a stranger who has been called on a telephone and asked to express an opinion on a controversial issue. Professor Suinn is applying similar tactics by presenting paired statements to clients with animal fears and asking them to read the statement which would characterize the attitude of a veterinarian. One of each pair is a statement which expresses a positive attitude towards the feared animal. Each time the client selects this statement, he is reinforced by the therapist. In effect, the therapist is shaping the client's attitudes away from the previous aversive, fearful attitude and toward a more accepting, comfortable one. Results are expected to demonstrate a removal of the fearful attitude and the behaviors attached to these fears. Of significance is the fact that in all previous studies of attitude and opinion change, the subjects were unaware of either the use of rewards or their own change in attitudes. Similarly, Dr. Suinn anticipates that recovery will occur without insight, or even the client's being aware of his being in "therapy."

Black-Tailed Jackrabbits on Sandhill Rangeland.

The diet of the black-tailed jackrabbit (*Lepus californicus*) at the Eastern Colorado Range Station follows definite seasonal trends. The jackrabbits eat about 40 species of plants in significant amounts. Fifteen plants made up 86 percent of the yearly diet.

Western wheatgrass and alfalfa served as

staple foods although many other plants were eaten in small amounts. A preference was shown for the green regrowth of western wheatgrass and alfalfa.

After forbs in the sandhill pastures matured and became unpalatable, jackrabbits shifted their feeding activities. Most jackrabbits in late fall and winter feed in alfalfa fields and western wheatgrass pastures. Alfalfa fields were used most in February when snow covered the short vegetation. In the spring and summer rabbits fed on sweet clover and alfalfa in old fields and on other forbs and grasses in the native pastures.

About 60 percent of the yearly diet of the jackrabbit was made up of plants that were eaten in small amounts or were preferred only at a particular time of the year. Certain foods were preferred for short periods. Six-weeks fescue, while it was in a green vegetative stage, was the second most important item in the diet in late April. Utilization of this grass more than doubled after it flowered and it was the most important constituent of the diet in late May. Sand dropseed was eaten in large amounts only after it had flowered. Prickly pear and ground-cherry were relished only when their fruits were ripe in late summer and fall. Sand sagebrush was eaten only after its leaves began to fall in November. A similar trend on utilization of big sagebrush was reported in Utah. Blue grama and prairie sand reed were preferred only during the summer, although they were the most abundant plants and were available throughout the year.

Jackrabbits probably influence secondary succession on old fields and denuded ranges and decrease the longevity of reseeded forage stands on rangelands. Over a period of 6 months jackrabbits can deposit 12.75 lb/acre of sand dropseed in fecal pellets on an abandoned field. Furthermore, the digestive processes of the jackrabbit increase the viability of the seed from 4.2 percent to 31.3 percent. Sand dropseed invades reseeded pastures and increases as the amount of intermediate wheatgrass decreases at the Eastern Colorado Range Station. Some jackrabbits concentrate on areas seeded with a grass-alfalfa mixture and disseminate sand dropseed seed while feeding, thus contributing to the invasion of the species.

Black-tailed jackrabbits defecate about 545 pellets per day. From counting the numbers of pellets deposited on the rangeland in 1968, we estimated that the average density of jackrabbits was about 3.2 per acre. From 15 April to 30 May, the density of jackrabbits averaged 1.0 per acre. From 30 May to 10 July the density of jackrabbits averaged 2.5 per acre. From 10 July to 5 August the average density was 4.5 per acre. There were about 4.5 jackrabbits per acre in September 1968. The last previous peak in jackrabbit density was 11 years ago, in 1958.

The dry weight of forage consumed by jackrabbits on the rangelands from April to September was estimated to be about 50 lb/acre and averaged about 10 percent of the average dry weight of plants on the rangelands.

Clothing and Social Acceptability of Adolescents.

Social acceptability is a crucial prerequisite for the individual's self-image and mental health. This is especially true for the adolescent. Twelve states are participating in a large-scale project to determine to what extent clothing and general personal appearance influence society's acceptance of the individual.

Findings of this research are expected to be a valuable aid in any effort directed toward improving the status of the economically disadvantaged. Since results of a pilot study run during 1967-68 seemed to warrant further investigation, Colorado State University has conducted a large-scale study using a sample of 105 boys and 115 girls at a local high school. Data are being analyzed at this time, and results will be available for publication in summer 1970.

Color and Flavor Deterioration in Raw Meat. The first thing that catches the consumer's eye at the meat counter is the color of the meat. Fresh bright red meat is desirable and is selected; darkened meat is not. Wrapping meat in transport oxygen-permeable film allows pigment change after several hours. Researchers have found that flavor and odor deterioration take place in association with color change. This rapid loss of quality is not caused by microorganisms; the meat is not spoiled in the usual sense. Oxidation of both pigment and lipid is the culprit. If oxidation can be delayed or prevented, attractive, unspoiled meat can be displayed for longer periods. More and better meat at lower prices could result.

Researchers' efforts have been directed toward determining the relationship between color and flavor deterioration—a "chicken and egg" riddle. When common lipid antioxidants, such as propyl gallate and BHA, are added to ground beef round, quality is retained longer. Lipid oxidation and flavor changes are halted and pigment deterioration is somewhat reduced. Addition of ascorbic acid (vitamin C) in conjunction with antioxidants results in a superior product because color is well preserved. Groups of students asked to select meat for purchase invariably chose these samples. Research is proceeding to determine exactly how these compounds act on meat. In order to do no disservice to the consumer, it must be determined if these additives mask spoilage.

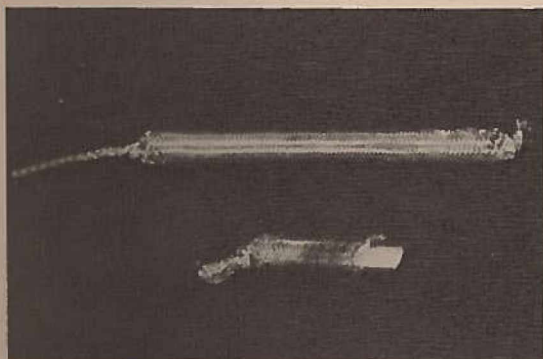
Competitive Bid Price Determination. While operations research techniques have been applied to the determination of competitive bidding strategies in empirical studies, the recently developed field of Bayesian statistical analysis has not. Academic writers have cited the potential benefits of utilizing Bayesian statistical analysis in the determination of competitive bidding strategies, but no empirical research in this area has been undertaken as yet. Dr. Stephen Paranka of the College of Business has been conducting a two-phase study of firms engaged in competitive bid operations. In phase one, a small questionnaire survey has been conducted of the Fortune magazine directory of the 500 largest corporations in the United States; responses to this mail survey are being analyzed for significant relationships. In phase two, questionnaires were mailed to representatives of 16 firms which had complied with invitations to bid on a selected federal government contract. A case study is being developed to provide a constructive basis for studying the determination process for competitive bids.

If the assumed hypothesis—that the application of Bayesian statistical analysis will improve the efficiency of competitive bidding—is valid, business executives will have the basis for a more sophisticated approach to determine competitive bidding strategies. More efficient answers can then be developed to answer such relevant questions as, what is the probable payoff at different bid levels, would a bid be feasible, at what price level should a bid be offered and what competition is likely?

Concepts of Authority. Authority is a fundamental concept of management operations. Effectiveness of management operations is highly dependent upon the manner in which authority is allotted and applied. Dr. Ronald L. Wiggins of the College of Business is conducting a study of concepts of authority. The work thus far has been concerned with definitions and meanings of authority within the classical framework, i.e., the "management process" school. A number of related terms occur and have been considered. How the classical concepts have been applied within the field of industrial relations is a particular focus of the study.

Another phase of the investigation concerns organizational relationships and practices in industrial relations as they relate to other schools of management theory.

Controlling Estrus and Ovulation in Cows. Short breeding periods in beef cattle have many advantages, chief of which is control. Control of the beef cow herd during critical periods such as calving and breeding would allow manipulation of the cow herd through nutrition, management, and labor to insure the greatest success.



The development of a simple, relatively cheap, and effective method which would insure that entire groups of animals would ovulate at the same time would give the rancher an effective tool for control.

Dr. J. N. Wiltbank of the Department of Animal Science has initiated a research project to introduce and test a new technique for synchronizing estrus and ovulation which would overcome the problems encountered with present methods of estrus synchronization. It synchronizes only cycling cows and low fertility has been observed at the synchronized estrus. His studies so far have shown that estrus can be synchronized successfully in beef cattle using a subcutaneous implant containing a progestational compound in the wall of the implant. Fertility appeared to be lowered in heifers receiving the implant for 16 days but not in heifers receiving an implant for nine days along with an injection of estrogen. His data further suggest that synchronization of ovulation can be accomplished within a 24- to 48-hour period by the injection of an estrogenic agent following a nine-day estrus synchronization treatment. Thus, it appears that this method is effective in synchronizing estrus and ovulation, but small numbers of heifers make it impossible to draw any conclusions concerning fertility at the synchronized estrus.

Additional investigations are to be initiated to further evaluate the optimum hormone levels needed to obtain maximum fertility following synchronization of ovulation.

Control of Thermal Stratification. Thermal stratification of lakes and reservoirs often limits fish yield and may interfere with other recreational uses of such water. Controlling thermal stratification for better fishery management has long been regarded as economically unsound for all but the smallest lakes. The Department of Fishery and Wildlife Biology and the Colorado Divi-

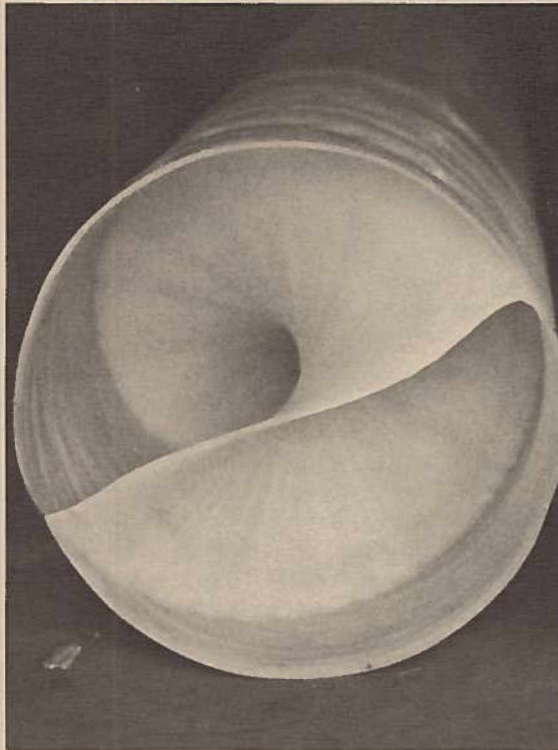
Progestational implant used to control estrus in the cow. The compound is encased in a nylon sack and is sewed beneath the skin of the cow. The compound is released slowly and can be removed from the animal as desired.

Implant sewed under skin of cow can be removed as desired without injury or danger of infection.

sion of Game, Fish and Parks are studying the feasibility and effects of eliminating or reducing thermal stratification. A recently developed aerator, originally designed for sewage treatment plants, has excellent potential for fishery problems caused by thermal stratification.

Parvin Lake, a 62-acre montane reservoir and one of the Division's experiment stations, is being used as a test site. Compressors, located on shore, are connected by plastic pipe to two aerators anchored on the lake bottom near the lake center. Aerators consist of a polyethylene cylinder with an internal, coiled separation. Air is forced into these aerators and is released in a spiral-like flow. Bubbling action creates water currents that break down thermal stratification. Aeration of the lake is a by-product that may have great significance. Compressors will go into continuous operation in late 1969.

An intensive year-long preaeration study of Parvin Lake is now underway. Important chemical nutrients, plankton, bottom life, and fish are being studied. Estimates of abundance, distribution, and species composition of the biological parameters are being obtained. Such information provides a base from which to evaluate the



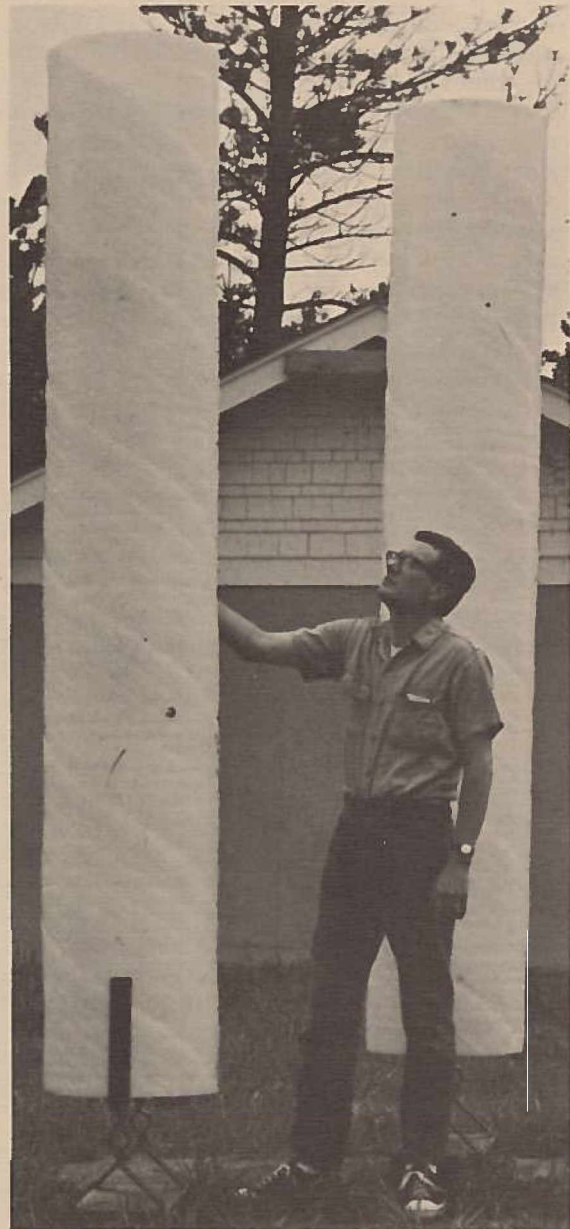
End view of aerator

Aerators used to eliminate thermal stratification in lakes and reservoirs.

overall effect of eliminating thermal stratification.

An identical sampling program will be carried out for a second year but with compressors operating continuously. In addition to determining changes in the ecology of Parvin Lake, the effectiveness of the system in eliminating thermal stratification will be ascertained. Cost analysis and efficiency are important criteria for consideration as a fishery management tool.

This project is funded by the Division of Game, Fish and Parks and is being conducted by Robert Lackey, Ph.D. candidate, Department of Fishery and Wildlife Biology, under the supervision of Dr. W. Harry Everhart.



Ecology of the Lark Bunting. Ecology is the attempt to understand the relationship of plants and animals to their environments—where they live, how they live, and, if possible, why they live as they do. Since the environment is our most essential possession, we must learn all we can about how and why its components do what they do.

Most of eastern Colorado is grassland, one of the major natural environments of the United States. This land does not become forested and its inhabitants develop to match their environment. Dr. P. H. Baldwin, Department of Zoology, has initiated a project financed by the National Science Foundation to determine the feeding ecology of the Lark Bunting as a primary and secondary consumer in the grasslands. The Lark Bunting—the state bird of Colorado—is a small black songbird with white patches. In ecological terms it is a small consumer of insects and seeds that is particularly adapted to the grasslands, where it is often the most numerous songbird in the summer.

A field study is being conducted in north-eastern Colorado which will measure bird and nest density through the nesting season and the characteristics of habitat vegetation. The factors involved in nest site selection will be identified and measured. The plants and insects used as food by the Lark Bunting will be identified and the amount of energy in them determined.

The knowledge gained of the Lark Bunting will define its role in the total ecosystem and help to preserve the bird as an inhabitant of the grassland. It is important that all natural members of the environment be protected and preserved in order to maintain stability in the grassland ecosystem.

Economical Grain Processing. For several years many research stations, including Colorado's, have offered studies that show that the flaking process, particularly of corn and milo, will improve the efficiency of cattle feed utilization anywhere from 5 to as much as 15 percent or more when compared to the conventional process of grinding or cracking grains. At CSU, Drs. J. K. Matsushima, R. J. McLaren, C. P. McCann and G. E. Kellogg of the Animal Science Department are pursuing studies along this line.

Although it has been fairly well established that the flaking process has certain merits, it

has not become a widely accepted commercial practice, particularly by small operators who have feedlot capacities of 2,000 head or less. The obvious reason for this is the large cost of the complete flaking unit, which includes a steaming system for rolled grain if it cannot be fed immediately.

A fairly large portion of the effectiveness of flaked grains appears to arise from the partial alteration of the starch and the physical nature of the flakes brought about by the steaming process. If a similar product could be produced without the use of steam, it should result in a cheaper process. An experimental machine developed for this method is referred to as the "extruder." Dry whole grain, without any moisture addition, gravitates into a hopper, then into a housing which contains the stator and rotor. The auger-like rotor crushes the grain and forces it through an orifice consisting of the external portions of the stator and rotor, producing flakes about one millimeter thick.

High moisture grains have been ensiled and dry grains have been reconstituted to about 30 percent moisture and ensiled. Limited research at CSU and data from various other experiment stations throughout the country indicate that the feeding of fermented high moisture grains does not promote feedlot cattle gains as well as feeding dry grains that are either cracked or flaked. This lack of gain appears to be promulgated by the lower dry matter consumption.

Data from the Colorado station indicate that the substitution of some dry roughage, such as alfalfa hay, for the corn silage seems to alleviate the problem when high moisture ensiled grain is fed. Feeding of high moisture grains, however, has shown improvement in feed efficiency in nearly all comparisons in spite of the decreased gains. This indicates that fermented high moisture grains or reconstituted grains are digested more effectively than dry-cracked or ground grains.

Additional research trials from the Colorado State University Experiment Station have revealed that dry corn can be extruded with resultant feedlot gains, as well as feed efficiency, nearly comparable to flaked corn. Ensiled high moisture corn does not appear to be as good a feed for feedlot cattle as flaked corn or extruded corn because of the decreased feed consumption.

Economics of Water Transfer. In 1968 and 1969, Dr. Donald D. Rohdy of the Department of Economics studied the economic feasibility of irrigation system consolidation in Northern Colorado Water Conservancy District Number Three. After examining three alternative consolidation plans, he concluded that the existing irrigation system results in the optimum benefits for the entire system and recommended its retention.

Ditches involved in the study were the Pleasant Valley and Lake Canal, the New Mercer Canal, the Larimer County #2 Canal, and the Arthur Canal. Two interrelated irrigation systems also were considered with each alternative consolidation plan.

Of the three plans examined, the first would consolidate all four of the ditches, the second excluded only the Arthur Canal and the third would consolidate only the Larimer County #2 Canal and the New Mercer Canal.

Since none of the consolidation plans physically exists and the physical operation of the existing system has never been studied in detail, it was necessary to simulate their operations in order to make comparisons between the alternative schemes.

The alternative plans were ranked according to preference, both with respect to the upper system and to the lower system, by deriving indifference maps for both of the systems. From these preference orderings, it was possible to derive a preference ordering for the entire system (upper and lower combined). Simultaneous confidence intervals were used to perform the ranking. The simultaneous confidence intervals were then computed in terms of future benefits and costs.

The major contribution of this study was the development of a method for analyzing the economics of irrigation system consolidation or of any system where welfare theory is applicable. The irrigation system which was analyzed served primarily as a case study for a demonstration of this analytical method.

Effect of Kind and Level of Shortening on High Altitude Baked Products. During recent years researchers in the High Altitude Laboratory of the Food Science and Nutrition Department have been engaged in studying the effects of kind and level of fat upon quality of products baked at altitudes typical of Colorado. Many newer kinds

of fats in retail markets, representing both animal and vegetable sources and varying degrees of unsaturation, were substituted for shortenings specified in household recipes. Bread, cake, cookie and pastry recipes were modified as needed to produce good results using each fat at differing levels at altitudes of 5,000, 7,500 and 10,000 feet. While actual level of fat which yielded best results varied with kind of fat or oil and type of baked product, from 11 to 58 percent above and/or below the amount specified in recipes could be used successfully. Statistical analysis of scores by taste panels for chocolate, yellow and white cakes revealed that kind of fat affected aroma, flavor, tenderness and texture of cakes more than did level of fat. The low level of fat used in these cakes was from 35 to 40 percent below the amount of shortening recommended in household recipes. These findings should be of benefit to individuals who need to restrict calories or fat in their diets. Doctors often recommend that cardiac subjects and patients susceptible to atherosclerosis by heredity, obesity, or increased cholesterol levels in their blood, restrict fat intake or type of fat included in the diet.

Environmental Pollution. Dr. Jack Altman of the Department of Botany and Plant Pathology and Dr. John Staley of the U. S. Department of Agriculture Forest Service have initiated a project to determine the effect of air pollution on plants in the Denver area. An unexplainable needle tip burn was noticed on Ponderosa pine trees in the Denver area with a pattern of occurrence related to the air drainage pattern over the city; the symptoms appeared similar to those caused by sulfur dioxide, ozone, or photo oxidants. However, it was also found that the symptoms could be reproduced by varying salt concentration in the soil. Currently studies are being conducted to determine if a predisposing salt concentration in the soil makes the pine trees more susceptible to damage from air pollutants.

Dr. Charles Wilber, Chairman of the Zoology Department, is attempting to ascertain the effects of environmental variables such as pollution, temperature, and mechanical stress on the pathology which may develop in the circulatory system of vertebrates, especially fish. This work is funded by the Air Force Office of Scientific Research and was begun with a study of the

incidence of arteriosclerosis in fish in the polluted and unpolluted portions of the Delaware River and Bay. Research has continued on trout, examining the effect of many potential stresses. Initially the pollutants that cause stresses will be identified and the stress and resultant pathology characterized; this work will eventually be expanded to include higher primates. Dr. Wilber has recently completed a monograph which analyzes and evaluates the literature dealing with the biological aspects of water pollution, which will be a very valuable and authoritative contribution to the study.

The U. S. Department of the Interior has funded a project to evaluate the water pollution potential at mountain dwelling sites. Many of these sites do not have water or waste disposal facilities, so a first step in site development is to drill a well and put in a septic tank. Because of the geologic nature of mountain terrain and the soil conditions, waste is often mishandled and serious yet totally unknown pollution can occur between properties or at one site. Dr. James P. Waltz will study the conditions that lead to pollution and ways to eliminate the problem in the future. The goals of the study are to increase public awareness of the problem and develop a classification system to evaluate pollution potential on mountain dwelling sites.

Erosion Processes on Alpine Rangelands. Alpine tundra represents a major land type in the Rocky Mountain states. An estimated 5 million acres are classified as alpine tundra within the central Rocky Mountain region, of which 2¼ million acres occur in Colorado. These lands have been widely used as summer range for sheep throughout the region. In addition, necessary use for recreation has caused widespread concern among conservationists and land managers.

Alpine lands occur at the higher elevations, generally about 11,000 feet, in the Rocky Mountains. Because of the harsh environment at these elevations and the limited grazing season, vegetation is limited to various grasses, sedges, forbs, and shrubs which form a mat-like vegetative cover.

Because of the increasing use of these lands, and the general lack of knowledge of the erosion processes at high elevations, a study was begun in 1965 to determine rates of erosion as related to various site factors including slope, aspect,

slope position, soils, and vegetation. Results of this study show that the normal erosion rate in undisturbed alpine rangelands is very low. Maximum soil particle displacement from steep, essentially undisturbed slopes averaged less than 3 feet over a two-year period. Maximum particle movement occurred on areas of natural snow accumulation while windswept slopes had less. Low rates of particle movement may be attributed to several factors. First, the coarse textured soils are relatively stable and highly permeable; as long as water can enter the soil freely it will not move soil particles. Second, normal rainfall intensities are relatively low during the summer and seldom cause surface runoff or erosion.

Grazing by sheep under the condition of this study does not greatly increase soil particle movement. Although measurable changes in vegetation density and compaction occur, and surface soil disturbances were observed, the temporary nature of the grazing impact as well as limiting the grazing to the late summer when soils are dry and relatively stable combine to minimize the disturbance and permit a rapid recovery. In spite of this, alpine soils and vegetation are known to be extremely sensitive to repeated disturbances such as vehicle traffic. Once the alpine turf is broken and the soil beneath disturbed, recovery is very slow and, if disturbances are repeated, severe erosion problems may develop.

Mouine El Zoghet, a Syrian graduate student in the Department of Recreation and Watershed Resources, carried out the field and laboratory portion of the study on two mountains in the northern Colorado Front Range. The project, financed by the Office of Water Resources Research, is under the direction of Dr. W. D. Striffler.

Establishment of Pine Seedlings. Researchers of the Department of Forest and Wood Sciences have been studying problems of pine seedling

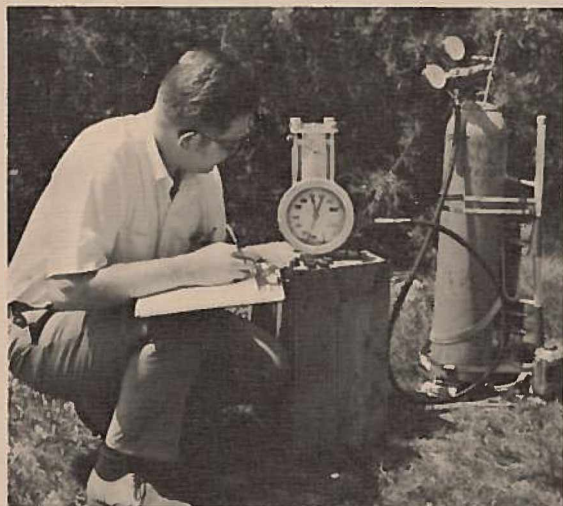
Typical alpine rangeland found in the Rocky Mountain area.



establishment using a miniature pressure chamber, popularly known as a "pressure bomb." A simplified, portable instrument to facilitate field use was made by modifying recently published specifications. With this device water stress within woody plants can be quickly and accurately measured. To determine the internal water stress, a single twig (or bundle of needles) is removed from the tree and sealed in the "bomb" with its cut end protruding through a small hole in the top of the chamber. Nitrogen from a high pressure cylinder is slowly admitted to the chamber until just enough pressure is built up to force a small bead of sap out of the cut end of the twig. The pressure in the chamber is read the moment sap appears. This pressure equals the water stress, or tension, within the sap stream of the twig at the time it was cut. High water stress values indicate the tree's roots are unable to absorb water as rapidly as it is lost by potential transpiration; consequently, a tension is created in the sap stream.

Water stress in over 800 planted and natural pine seedlings was measured on two experimental sites near Pennock Pass. These measurements revealed that immediately after a rain, naturally established seedlings normally had an internal water stress of only 45 to 50 pounds per square inch (psi), but when drought became severe the sap tension often exceeded 600 psi. The maximum tension observed was just over 900 psi.

Planted seedlings were found to have a high water stress until new root growth replaced the absorbing roots lost during planting. Usually two or three growing seasons were required before water stress in planted stock and natural seedlings appeared to be equal. Planting method and root condition are key factors in hastening establishment, but seed source also appears to be important. Planting stock grown from seed obtained in Idaho had consistently lower internal water stress than comparable planting stock produced from Colorado seed.



Extraction of Insecticides. Soil is recognized as a principal reservoir of environmental pesticides, particularly for the chlorinated hydrocarbon insecticides such as DDT. The persistence of these insecticides in the soil has created problems in recent years.

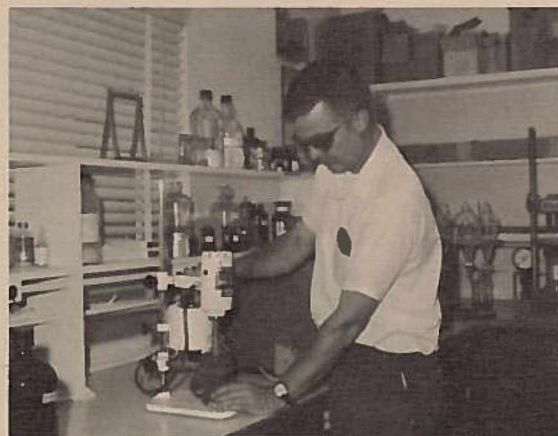
Pesticide analysts are seeking continuously to improve procedures for the determination of pesticide residues. The chief objectives are to reduce the time of analysis and to increase the accuracy and sensitivity of the methods. The extraction of residues from soils is very important since residues not extracted are not measured. Soil's highly complex and variable nature complicates the extraction of residues. These chemicals are often trapped by soil flora and fauna or by binding to soil particles.

Ultrasonic energy has been used in extraction of various materials from plants, animals and microorganisms. Dr. R. E. Johnsen, Department of Entomology, has developed a method of using ultrasound to extract pesticide residues from soil.

An organic solvent is added to the soil sample and the high intensity ultrasonic generator immersed in the soil-solvent solution. The generator is turned on maximum power for 30 seconds. This process reduces the soil to a fine powder and transfers the insecticide into the solvent solution. By this method extraction may be accomplished in 30 seconds instead of the standard 8 hours. Various soil types containing residues were extracted with this new ultrasonic method and compared with other methods. Various experimental conditions were tested for their effect on extraction efficiency such as length of extraction, concentration of insecticide, soil moisture, type of insecticide, length of soil aging, soil wetting and drying cycles and extraction solvents.

Extraction of soil sample using high-intensity ultrasonic generator (right).

The portable pressure bomb was designed for field measurement of internal water stress in seedling trees (left).



Without exception, the high intensity ultrasonic extraction method was superior to the other methods compared relative to extraction efficiency and ease of extraction. This method holds promise as a common soil extraction method for quantitative recovery of residues and great savings in time when analyzing a large number of soil samples.

Financial Management Study. With his current study of financial management of flower gardens, Dr. John McKeever of the College of Business has discovered some very interesting facts relevant to financial management planning and control of operations. First, most managers do not accumulate, record and report sufficient financial data to provide them with the necessary information to measure and improve performance. Second, the flower growers do not utilize uniform and consistent policies and procedures in classifying, recording, reporting and analyzing their financial data. Third, very little cost analysis, which is so necessary to the decision-making process, is being performed by management.

Thus, Dr. McKeever will extend the original research project, which was concerned with a financial management study of 20 firms in the Flower Growers Association, to include several new objectives: to determine a uniform system of accounting and cost control that would be applicable to the operations of all flower growing firms; to develop a procedural manual to provide management guidance in classifying, recording, reporting and analyzing financial transactions; and to investigate the need for a training program to assist the manager in better understanding, and integration of, the accounting and cost system into his operations.

Measuring Texture of Fruits and Vegetables. Texture is an attribute of food that affects its fitness for handling, processing, and storage as well as its acceptance to the consumer. Research findings showed that Colorado homemakers placed high value on texture of a food. For certain foods, texture was more important to these consumers than was color or flavor. Whether an apple variety remains crisp, firm and juicy or becomes mealy, soft and dry affects its fate in marketing channels.

Sensory, chemical and physical methods were employed to measure textural qualities of

size 100 Golden Delicious, Red Delicious, and Winesap apples purchased from the same source in Washington and of Golden Delicious and Red Delicious apples produced at a Branch Experiment Station in Colorado. All the apple varieties were stored under controlled conditions until the day they were to be tested. An eight-member taste panel scored crispness, tenderness and juiciness of coded samples of the five lots of apples on 14 dates during the 1968-69 year. Scores of the panel and data obtained from each of the chemical and physical tests chosen for measuring textural characteristics were treated statistically. Analyses of variance and covariance were used to find which, if any, objective measurements were related to panel evaluations of crispness, tenderness and juiciness. Moisture content and force required to shear apples correlated closely with panel evaluations for crispness and tenderness.

Shear force is a quick and easy method of testing texture which can be adapted for use under field conditions. This procedure may prove to be of practical value to growers, processors and buyers.

Medicinals from Poppies. Prickly poppy is a spiny, noxious weed 1 to 3 feet tall with large, white, poppy-like flowers. The several western species occur in an elevational range of 3,500 to 7,000 feet in Colorado and Wyoming. Dr. F. R. Stermitz of the Department of Chemistry, in his search for new medicinals, turned to these poppies because of their known content of alkaloids and the suspected activity of these compounds. The isolation, purification, and proof of molecular structure of these complex natural compounds has produced significant chemical knowledge and new products of possible medicinal value. This research has revealed, for the first time, a compound having both analgesic and quinidine-like activity within the same substance. (Quinidine is a drug used to regulate heart rhythm.) To date, testing of the compound has been restricted to animals. It is significant that no mammalian toxicity has been detected. Since toxic effects are one of the main barriers to the use of new drugs in human medicine, this characteristic certainly favors the possibility of eventual testing of the material on human subjects.

Chemotaxonomic studies have revealed two additional Argemone species which should con-

tain alkaloids with the active structure. Thus, this study also has shown a unique relationship between alkaloid content and botanical classification. Possible additional valuable poppy species among the many occurring in Mexico have been pinpointed and await chemical analysis.

The long-term goals of these studies are to use the basic techniques of chemistry to provide new medicinals, clarify the relation of chemical structure to physiological action, and understand alkaloid biosynthesis and metabolism in the plant.

Model for Determining Consumer Policies. Marketers traditionally have relied upon standard scaling techniques when determining what policies consumers hold concerning a given product. Only very recently has attention been devoted to gauging consumer response via techniques that force multidimensional considerations.

Such techniques as the semantic differential fail to give this quality to the research. Investigators Dr. Ronald W. Hasty and Dr. R. Ted Will of the College of Business are working with a technique to describe and measure the policies held by consumers and to label those that are important to consumers in their purchases by recognizing the multidimensional aspects of the purchase decision.

The investigation required the development of an instrument adaptable to attitude research which would systematically measure the quasi-rational thought processes upon which attitudes are formed. Attitudes are proven to be formed neither entirely through rational processes nor entirely through intuitive processes; properties of both enter the formation. Thus, they are called quasi-rational thought processes. This means that a way to measure these processes is basic to any valid understanding of the attitude and ultimately the determination of policies held by the consumer. The technique employed to describe and measure these attitudes was an adaptation of the multiple regression model.

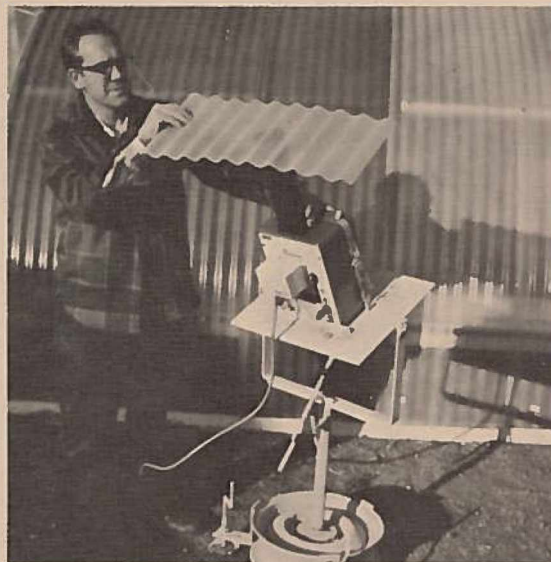
The study is a continuation of one funded by the University.

Modifying Solar Energy to Aid Plant Growth. The growth habits of many plant species are controlled by the quality of light energy they received. For many years researchers in light have known that solar energy transmitted through blue

filters yields shorter plants with increased vegetative breaks. Red light contributes to cell elongation resulting in taller plants but delayed flowering. Under the direction of Dr. Kenneth L. Goldsberry, the Horticulture Department is investigating the feasibility of tinting fiberglass reinforced plastic panels, commonly used for greenhouse coverings, with hues of blue, pink, or violet. Cooperating in the study are three panel manufacturers, Filon Corporation, Lasco Industries, and Structoglas, Inc. Financial assistance includes grants from F. C. Gloeckner Foundation, Inc., and Colorado Flower Growers Association, Inc.

Plant growth data obtained during the shortest days of the year in chambers covered with tinted fiberglass reinforced plastic panels indicated that various plant species respond differently to light quality. Tomatoes grown in high blue and low red light were short and slow in development. French marigolds grown in the same compartment were taller than those grown under the other covers. Panels transmitting the complete spectrum or those providing only slight decreases in the green portion of the spectrum provided the best overall plant growth.

An expansion of research efforts is planned to correlate light quality and quantity with all other plant growth factors including plant temperatures. Better control of the complete plant environment should enable the genetic potential of more plants to be realized.



Transmission characteristics of fiberglass reinforced plastic sample are being determined with a recording spectroradiometer.

Spectral Transmission Laboratory designed to evaluate transmission characteristics of coverings used for plant protection.



National Speech and Hearing Survey. The data collection phase of the National Speech and Hearing Survey conducted in the Department of Hearing and Speech Science in cooperation with the U. S. Office of Education was completed in June 1969. The primary purpose of the survey is to estimate the prevalence of speech and hearing disorders in the public school population.

The data collection procedures were divided into two phases, a pilot study involving a sample of over 6,000 subjects in the Rocky Mountain Census District and a national sample of approximately 40,000 school-age subjects located in 100 randomly selected school districts in the United States.

The pilot study, which was conducted in the Rocky Mountain Census District in 1967-68, was designed to evaluate methodology and specific procedures over an extended period of time as well as to collect data on a relatively large sample of subjects. Data from the pilot study were subjected to a preliminary analysis and the results were used as guidelines to modify procedures for use in collecting data on the national sample.

During the past year (October 1, 1968 - June 1, 1969), six field survey teams used mobile units which were equipped with testing equipment to collect data on the national sample of 40,000 subjects. The six survey teams departed from the Colorado State University campus on October 1, 1968, and tested subjects continuously during the eight-month period.

In the procedure a battery of tests which was designed to evaluate pure-tone hearing ability and numerous aspects of speech performance was administered to each of the 40,000 subjects individually. Hearing was evaluated by measuring the bilateral hearing acuity level for five pure tones. For speech, a subjective evaluation was made of articulation and voice proficiency and a standard test to determine phonemic accuracy was administered. The presence or absence of stuttering behavior during connected speech activities was also recorded. The total testing time required for each subject was 15 minutes. With three evaluators testing simultaneously, an average of 50 subjects was processed each day by each of the six survey teams.

A preliminary analysis of the data on the 40,000 subjects has been initiated and it is expected that at least a year will be required to complete an analysis that will yield meaningful

information regarding the prevalence of speech and hearing disorders.

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

Performance of Permanent Press Garments. Colorado has completed the wear study phase of an investigation of men's permanent press white dress shirts. Ten volunteers were supplied with two 100% cotton and two 65% polyester/35% cotton shirts to be worn during normal work days at their offices. After each wearing, shirts were washed and tumble-dried in the textile laboratory, and returned without ironing to the wearers. At the end of 12 weeks, half of the shirts of each fiber content were withdrawn for evaluations by a panel of judges. The remaining half were retained for a second 12-week period of similar treatment. Following the final judging, shirts were sampled for physical testing in textile laboratories. Precise measurements were taken for comparisons of whiteness, smoothness, and strength of the new and worn shirts. Concurrent with the wear study, records were kept on temperature, humidity and water analyses.

Identical studies are being conducted at five other experiment stations to assess variations in appearance and durability possibly associated with differences in climate and water used for laundering.

Permanent School Trusts. A study has just been completed to determine the current condition of the permanent school trusts in the United States. The study was directed by Dr. Stanley M. Cole of the Department of Education and was supported by the Ford Foundation.

The major finding of this research was the identification of a "sales" versus "retention under lease" controversy apparent in nearly every state. Relevant to the sales versus retention discussion is an unhealthy evolution that has developed during the history of our country and was identified in this study. The evolution has in too many instances dissipated a land asset of substantial value and/or abolished a productive permanent school fund.

The typical evolutionary chronology is:

1. A state was awarded a grant of land from the federal government upon entrance into the Union.
2. A portion of the land was sold creating

a Permanent School Trust Fund to be held in perpetuity.

3. The state would then have a land asset and a permanent fund.
4. Over time, all the land was sold creating a larger permanent fund.
5. At some given time, the money would be borrowed by the state from the permanent school fund to be used for other purposes.
6. A permanent debt was created, acknowledged by the state as an obligation that must be paid to the schools.
7. The permanent debt would then be written out of existence by statute or a constitutional change. If the permanent debt remained as a perpetual obligation, the fund became essentially hidden taxation with "interest" being paid on a fund that no longer exists.

The unfortunate evolution described is apparent in nearly all the states of our nation which retain trust lands. This evolution is a gradual one and must be a major consideration when land disposal practices are reviewed. The facts indicate that when the land asset is liquidated, somewhere through time, the total fund is also liquidated.

A second relevant contribution made by the research is found in the fact that much legislation is written in terms of obtaining "maximum revenue return" from public school lands. This unfortunate phrasing has led to certain land abuses and has also promoted unwise selling practices in many states. Perhaps it is time to turn attention to a focus on the principle of **optimum** revenue return from school lands as opposed to **maximum** revenue return. "Maximum return" tends to denote the greatest possible immediate revenue from the lands and is thus interpreted by most land administrators. "Optimum return" on the other hand suggests a compromise of conflicting forces and an application of a long-range philosophy of efficient management. Optimum revenue may not be the most one can get out of the state land in revenue in any one year, but it is the most satisfactory revenue that can be obtained on a sustained yield basis, while being equitable to both the beneficiary and the land users.

The question of maximum immediate revenue return is nearly always tied to some type

of "prudent sale" which would purport to take advantage of inflated land values and invest the money in government securities. Land would then be placed on the tax rolls and income from investments would be greater than is currently being realized. This position is refuted by the argument that the holding of public school land is an excellent hedge against inflation. Land, perhaps better than any other asset, is the ideal hedge against the well-documented and historic inflationary spiral. Over time, land has shown a constant appreciation in value whereas fixed income securities have been constantly eroded by inflationary pressures. This fact above all others justifies continuing research into the problems of disposing of public school lands.

Political Factors of Colorado Water Development.

Members of the Political Science Department of Colorado State University are currently conducting research in an area of crucial importance to Colorado—water resources. The underlying assumption of these research projects is that the development of water resources is more than a problem of engineering and economics. Political factors, long ignored, may spell defeat or success for the attempt to provide an adequate water supply for Colorado's citizens. A recent report by the National Research Council Committee states: "Communication to the public and its representatives of knowledge of alternative opportunities for water management and use will result in more rational decisions."

Charles L. Garrison, Duane W. Hill, and Roy L. Meek have isolated the factors which influence and restrict the range of options available to policymakers in local water agencies of north-eastern Colorado. The three-year study, completed in August 1969, examines the relationships between the water agencies and general community publics, relevant special publics, and other factors such as the legal framework and economic systems. Five communities were studied in depth and were categorized in terms of levels of administrative development and community political participation.

A second aspect of water resource development—planning in local water distribution systems—is the focus of a research project under the direction of Professors Hill and Garrison and Phillip O. Foss, Chairman of the Department. The boundaries of a water planning system will

be determined empirically from the responses of those involved in planning. Three aspects of the political process will receive special attention: patterns of communication and methods used to promote communication among planners and between planners and the public; methods used to promote comprehensive, long-range planning and the factors which impede that goal; and the degree of involvement of public and private organizations in the planning process. Extensive interview schedules are being used to obtain the relevant data.

Roy Meek represents the Political Science Department in an interdisciplinary and inter-university project to examine the economic, political, and legal aspects of Colorado water law. The Departments of Economics at Colorado State University and at the University of Colorado and the Civil Engineering Department at the University of Colorado also are involved. Emphasis will be placed on the effects of changes in water law on major water user groups and on Colorado's economy; the social and political changes resulting from new laws, court decisions, and public goals; and the impact of water law on the development of outdoor recreation. By-products of the research will include compiling and updating information on Colorado water law, court decisions, and changes in administrative policies.

The knowledge acquired by these three projects should help decision-makers in the vital area of water resources by alerting them to the political realities which condition their performance. Furthermore, wide distribution of information about alternative courses of action should promote public understanding of, and participation in, the policy-making process.

Radiation and Aging. Fundamental studies into the nature of life take many forms. Quite often, discoveries in one scientific field which are of considerable, even critical, importance in another are not recognized until a chance meeting of scientists occurs and until a chance remark leads to a happy marriage of ideas. In one important field, the Department of Radiology and Radiation Biology and the Department of Physiology and Biophysics have not left things to chance and a collaborative study has been initiated in an aspect of life which concerns all of us: aging.

It has been known for a number of years that cells have the ability to repair much of the damage inflicted upon them by radiation. The critical site of damage is the cellular deoxyribonucleic acid (DNA). The giant molecules of DNA are constructed from a very large number of units in the form of a code—the genetic code—which contains the information that a cell (and an organism) requires in order to exist, survive, and multiply. If the genetic code is disrupted and damaged by radiation, the cells will die unless they are able to repair and restore the damage. The DNA exists in the cell in conjunction with protein in structures called chromosomes which become visible under the microscope in dividing cells. Irradiation produces aberrations of various types in the chromosomes; cells of dividing tissues have the ability to repair or eliminate chromosome aberrations.

In mammals there are basically two types of tissues: (1) rapidly dividing tissue such as bone marrow in which cells are multiplying and replacing older cells throughout the lifetime of the organism; and (2) nondividing tissue such as the nervous system where the full cell complement is attained not long after birth and thereafter grows older as the organism grows older. With special scientific techniques, it is possible to induce cell division in tissue which is normally nondividing. When this was done with tissue from animals of different ages it was found that the number of chromosome aberrations increased with the age of the animal. Moreover, if the animals were given small, nonlethal doses of radiation during their lifetime, additional chromosome aberrations were produced together with a decrease in the average life span of the animals.

Two questions should now be asked. Is the repair of chromosome aberrations related to the repair of DNA? And is the increase in the number of chromosome aberrations which occurs with age due to the inability of the cells in nondividing tissue to repair chromosomes and, by implication, DNA? If this were the case, cells in nondividing tissue would be less and less competent to perform their biological functions as they age because of the damage which would accumulate in their genetic systems.

To answer the overall question, it would be necessary to do two things: first, bring together competent scientists in the fields of DNA dam-

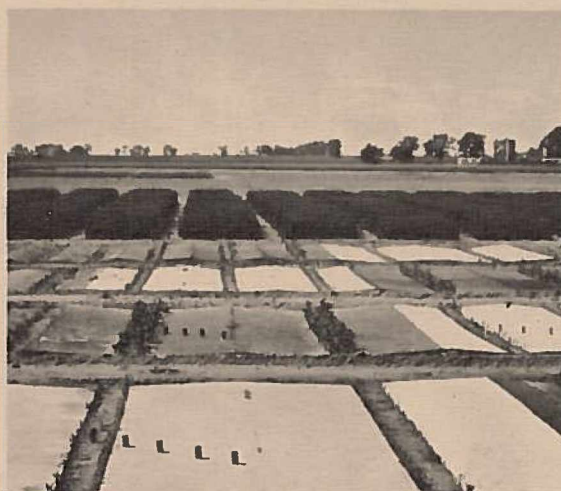
age and repair, and the long-term effects of irradiation; and second, provide a source of non-dividing tissue in aging animals. The Department of Radiology and Radiation Biology at Colorado State University has achieved the first objective with two of its staff members, Dr. J. T. Lett and Dr. R. J. Garner, both of whom are recognized authorities in their fields, and has achieved the second by the maintenance over a number of years of the beagle colony at the Foot-hills Campus now under the direction of Dr. Garner. Another group of aging dogs is maintained by Dr. W. J. Tietz, Chairman of the Physi-ology and Biophysics Department.

For the past ten years Dr. Lett has been one of the foremost researchers in the study of the formation and repair of radiation damage in cellular DNA. His basic approach to the problem has been to employ centrifugation and radio-active labelling techniques to measure molecular weight changes in the DNA isolated from irradiated cells of dividing tissues. Since DNA from nondividing cells cannot be radioactively labelled, standard biochemical assays which require large amounts of DNA are required. Dr. Lett has recently obtained an advanced experimental centri-fuge rotor of large capacity (on loan from Dr. N. G. Anderson of Oak Ridge) with which he is investigating the concept that DNA damage accumulates in the brain of the dog with age. Iso-lated brain cells also will be studied to see if the capacity of neurons to repair DNA damage also varies with age. This research, which at-tempts to relate aging, radiation, and DNA dam-age, is supported by a research grant from the National Institutes of Health.

Reducing Evaporation in Soil. The recurring de-ficiency of moisture for the growth of crops in Colorado continues to be a major agricultural problem. In dryland regions, the approach to this problem must concern conservation and more efficient use of available precipitation. On most irrigated farms it involves more efficient use of the supply of irrigation water as well. Much of the present research by soil scientists is directed toward the discovery of new prin-ciples and methods applicable to these problems.

The benefits that could be derived from reducing evaporation losses of water from soils are significant. In this regard, research by the Department of Agronomy has shown that layers

Microwatershed studies to evaluate precipitation amounts on corn growth. Agronomy Research Center.



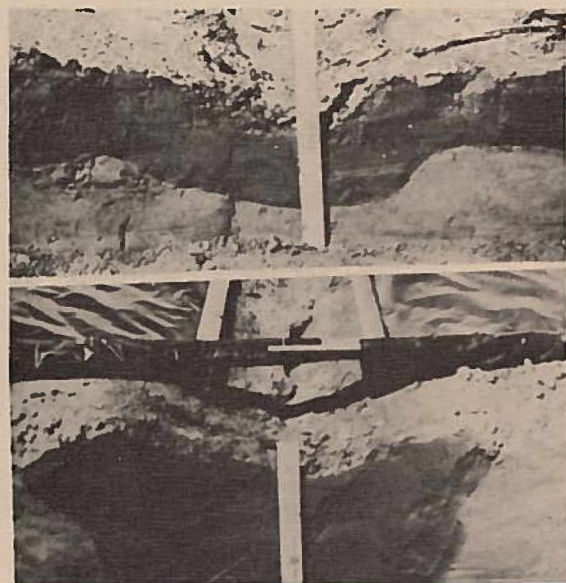
of coarse-textured materials such as sand or gravel can reduce the annual evaporation loss from soils as much as 80 percent. This finding can form the basis for increasing groundwater recharge in semi-arid regions or for conserving water for plant use.

It also has been shown that cultivated soils with good aggregate stability lose less water by evaporation than soils with poor soil structure and stability. The development of soil crusts has been found to affect both the infiltration rate of water into the soil and evaporation. Thin dense soil crusts were formed by the flooding action of water. Resistance to entrance of water was greater in these crusts than in any other layer of the soil. Resistance to flow during evaporation, however, was greatest in the layer with large pores below the crust. Formation of a surface crust caused by rainfall resulted in an earlier surface drying and decreased evaporational loss.

In studies concerned with the efficiency of water use by crops, a relatively simple technique has been developed to control water stress in plants and to evaluate growth responses as in-fluenced by stress under laboratory conditions. The system is being used to evaluate growth and transpiration rates at controlled levels of induced plant-water stress in order to understand both stomatal behavior in leaves and physiological re-sponses to stress at various stages of plant growth and development.

Under field conditions at the Agronomy Re-search Center, initial evaluation of the amount and time of irrigation on crop yields and on the efficiency of water use in relation to yield per unit of water consumptively used has been made on corn, beans, and sorghum. Appreciable in-creases in yield per unit of water used were dem-onstrated on all crops when moderate water stress was allowed to develop. At lower stress levels (adequate water for growth), water use ef-ficiency was increased by nitrogen fertilization. An economic evaluation of water and fertilizer use in corn production has been made using data obtained from the field studies. Statistical production functions have been fitted to the input-output data to predict the most profitable point of operation for alternative price relations of water and fertilizer.

Soil moisture infiltration studies. Agronomy Research Center.



Rural Poverty in Costilla County. A recently completed study of Costilla County, Colorado, indicates that two-thirds of its residents are living in rural poverty. The study is a follow-up of a report by the President's National Advisory Commission on Rural Poverty, issued in September 1967. Entitled "The People Left Behind," the report concerned the plight of some 14 million Americans who have not shared fully in the prosperity of our nation. Director of the Costilla County study was Dr. Rex D. Rehnberg of the Department of Economics.

Dr. Rehnberg found that Costilla County has been declining rapidly since 1940. From the first permanent settlement there about 1850, population increased steadily to 7,533 residents in 1940. Between 1940 and 1960, however, the population declined to 4,219 and the decline continues. During this period, Costilla County has had the highest rate of out-migration of Colorado's 63 counties.

Out-migration is heaviest among young adults. As a consequence, the percentage of the county's population in the age group 20-40 is much less than in the state of Colorado or the United States as a whole. Moreover, migrants between 20 and 29 years of age had, on the average, about two more years of education than did those of the same age who remained in the county. The educational differential was less for older persons leaving the county.

Migration has been primarily to urban areas where job opportunities are greater and more varied. More than half of the migrants are now living in cities with populations of 10,000 or more. Less than one-eighth of the migrants have gone to other rural areas. More migrants moved to the Denver metropolitan area than to any other city, although Pueblo and Colorado Springs have attracted many, also.

The out-migration of young adults has affected the productive capacity of the county as a whole. As a result, approximately two-thirds of the families which remain in the county had an income of less than \$3,000 in 1968. About one-fourth of the heads of households earned their living either as farmers, farm managers, farm laborers, or unpaid family workers. Nearly 40 percent of the heads of households were retired, disabled, unemployed, or were housewives.

Deprivation shows up in statistics on basic facilities to meet elementary human needs. Less

than half of the homes had piped water, a bath tub, or shower; less than half had a telephone.

To improve the incomes of county residents, the rate of population decline must be arrested and new opportunities for gainful employment must be developed.

Dr. Rehnberg found that recreation and tourism, one of the fastest growing industries in the United States, offers the greatest potential to the county. The natural beauty of the area and the places of historical interest present opportunities to develop such industry. Improved water and sewer facilities, now being installed in the larger towns, will facilitate construction of accommodations for tourists and visitors and also improve the quality of life for local residents.

The property and income tax base in the county is inadequate to generate the revenue needed to finance programs for recovery, so wherever possible, efforts should be made to secure state and federal financing for these programs. The improvement of economic and social conditions in the county is not exclusively a local issue. The citizens of Colorado and the United States have a vested interest in seeing that all citizens have an opportunity to participate in the growing affluence of our society.

Serum to Aid in Transplantation. Transplantation of human organs has gained worldwide attention. The surgical techniques now employed need very little improvement. However, the main obstacle to transplantation still remains: the body's immune mechanism which wages warfare against anything "foreign" such as bacteria, viruses, and tissue grafts. Thus an organ graft, unless from an identical twin, is rejected unless a damper can be placed on the immune system. Doctors can inhibit the activity of the immune system with irradiation and powerful drugs, but too much suppression leaves the body open to infection. This is believed to be why the first heart transplant patient, Louis Washansky, died.

One of the newer approaches to suppression of the immune response is with anti-lymphocyte antiserum (ALS). Dr. D. C. Lueker and a graduate student, Jack Tribble, in the Department of Microbiology are working on a serum that may prove to be superior to serums now being used to fight transplant rejection. This is an antiserum to the thymus (ATS).

Tribble and Lueker believe that ATS is bet-

ter than ALS because ATS suppresses a specific cell type which controls graft rejection. On the other hand, ALS suppresses many cell types some of which have nothing to do with rejection.

During their three years of research, the scientists found that ATS completely restructures the normal architecture of the thymus thereby reducing its ability to activate the body's rejection process.

ATS was injected into mice about seven times during the first month after birth. At the end of the period, the animals showed the classic signs of wasting (loss of weight, lethargy, ruffled fur and hunched posture). All of these are indications that normal functioning of the thymus had been suppressed. Armed with this data, ATS was used in mice which had received skin grafts from other mice. The result was a definite suppression of the rejection process.

The ATS produced at CSU is more potent than that being made at other universities testing the antiserum. This is a result of a new production method. Tribble and Lueker also discovered that by mixing ATS with spleen cells prior to injection, the serum's potency was greatly increased. Besides suppressing graft rejection, the CSU researchers found that ATS also effectively attacked on-set lymphoid leukemia in a strain of inbred mice. This disease is similar in many ways to the lymphoid leukemia found in man.

Sprinkler Irrigation Efficiency. Farmers are rapidly turning to labor-saving irrigation equipment. Center-pivot sprinkler systems are currently among the most popular of the new equipment. They consist of a sprinkler lateral supported by wheel-mounted towers at intervals of 90 to 124 feet. This system is in constant motion during irrigation, with one end of the lateral pivoting at the center of the field. Individual sprinklers are selected and spaced so that their capacity is proportional to the area which they irrigate. The common size for this equipment irrigates a circle of about 132 acres out of a square 160 acres.

Agricultural Engineer Dale F. Heermann developed a mathematical model of the center-pivot sprinkler system, which has been verified by field tests, making it possible to simulate and analyze the operating characteristics of the system. The effect of changes in sprinklers, pipe diameter, and speed of operation can be studied

on a computer using the model.

These systems apply water in such a manner that it cannot be absorbed uniformly. Application rates exceed infiltration rates over a large portion of the area, resulting in water running off high spots and slopes into depressions.

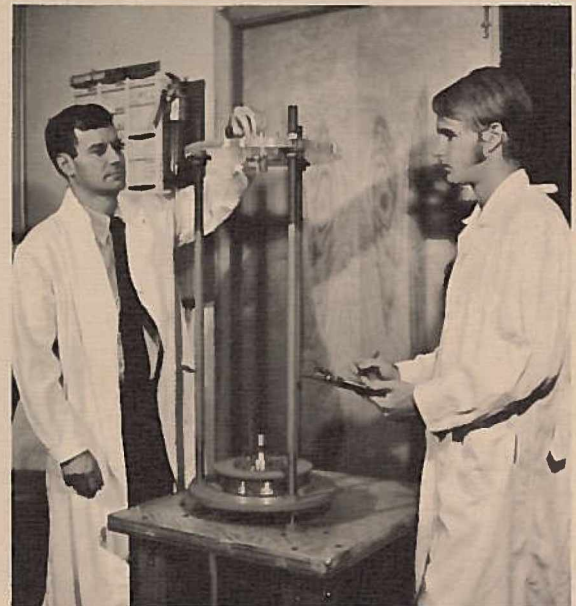
Although modification of these systems can improve their performance, it is not likely that they can be designed to avoid applying some of the water at rates exceeding the intake rates of most soils. Since intake rates vary greatly with cultural practices, modification of soil intake rates by use of special tillage and planting methods has been included in a study being conducted by Donald L. Miles. Tillage and planting procedures have been developed which can eliminate all surface water movement in fields of continuously cropped corn. Other special treatments will reduce the amount of water movement under crop rotation.

The sprinkler studies have been directed towards problems of immediate importance. As a result, recommendations made from these studies have been put into use with nozzle sizes, operating pressures and pipe diameters being changed on nearly all new systems. Many older systems also have been modified.

The more difficult problems have been only partially solved. Therefore, remaining problems are becoming more important as the popularity of this equipment increases. With the help of a new Office of Water Resources Research grant, detailed studies are being made of the infiltration behavior of various soils under these systems, and ways to apply this information to more nearly fit irrigation systems to the soils on which they operate.

Stability of Blood Flow. Research in the field of biomechanics has as its goal a better understanding of the physical processes of which life is comprised. One such process of great importance is the flow of blood in the human body. Despite an increasing amount of research directed to the study of the heart and circulatory system, some major physical characteristics of the system have yet to be examined. One of the most important

Biomechanics — Hardee viscosimeter for biological fluids.



of these is the stability of laminar blood flows and the possible transition from laminar to turbulent flow—a process which directly determines the amount of work imposed on the heart, for turbulent flow demands a more powerful pump than does laminar flow.

Research is being conducted to investigate the stability of the laminar flow of blood in glass pipes using an extremely sensitive electrokinetic technique to detect instabilities in the flow. Blood, however, is a very complex and variable fluid. Its physical properties, such as viscosity which is the governing property for the stability of flows, can vary considerably from sample to sample, even for samples from the same subject; therefore, one of the prime efforts has been the design and construction of a highly accurate viscosimeter, capable of determining the absolute viscosity of biological fluids in very small samples. The design of this new viscosimeter is based on the theory of flow between rotating cones at very low Reynolds numbers.

The research is partially supported by the Air Force Office of Scientific Research. The research staff includes Dr. Knox Millsaps, Dr. A. G. Hardee, J. E. Nydahl, with supporting staff and students.

Studies in Germ-Free Environments. A gnotobiotic environment is one in which all living components are known and can be controlled. No organism in nature lives in such an environment; the natural environment is so complex it is often impossible to determine the role of each component.

One of the initial tasks of the gnotobiotics laboratory of the Department of Botany and Plant Pathology, originally developed by Drs. D. L. Lindsey and R. R. Baker and currently under the direction of Dr. W. A. Kruetzer, was to learn how to grow germ-free plants and maintain a germ-free, controlled environment. Concomitant with the development of this laboratory there was a great deal of interest in mycotoxins as potential human health problems. In particular, alarm was expressed at the amount of carcinogen (a substance that produces cancer) that might be present in peanuts and other common protein sources in human and animal diets. Therefore, the peanut has been studied intensively under gnotobiotic conditions.

There is a considerable amount of informa-

tion on the number and identity of microorganisms in the microenvironment surrounding the roots and peanut fruits; there is a dearth of information on the effect these microorganisms have on the plant itself or its fruit, and their role in protecting against soil pathogens. The complexity of the microenvironment surrounding the peanut fruit in natural soil makes it very difficult to study the effect on the peanut fruit and the pathogen of individual microorganisms. For this reason gnotobiotic conditions where the total environment can be controlled are adapted for evaluations of microfloral environmental variables.

The gnotobiotic environment is also suited for evaluation of other variables such as nutrients or continued growth in a germ-free condition which, for example, might be essential in space flights. In future extended space explorations the entire food, water, and oxygen supply of humans might well be dependent on plants. It would be imperative that the initiation of these flights not be coincident with the introduction of pathogens. Because of the likelihood of man's dependence on plants, the gnotobiologist is examining ways to insure germ-free inhabitable environments and their effects on man and his animal and plant companions in space flight.

Study of Determinants of Stock Market Profits.

For most investors (and potential investors) the stock market is surrounded by an aura and mystery which seemingly defies comprehension. In part, this is understandable since the stock market deals with extremely complex economic and psychological factors. Much of the mystery can be stripped away, however, if the investor can grasp the fundamental factors which will influence the profits he will earn in the stock market. Dr. Philip A. Shade of the College of Business is preparing a study in which he is attempting to identify the key variables that will determine investor profits, and to measure the magnitude of the effects of these variables on profits. A mathematical model is being developed which shows the investor precisely what he can expect to earn from an investment, given reasonable economic psychological expectations (assumptions) about the stock. A side benefit of the study is that it should give the investor a rationale for determining the normal and maximum price-earnings multiples that he should pay for any

stock (and especially those stocks categorized as "growth stocks").

Thermohaline Convection. As man's exploration and exploitation of the ocean's depths penetrate ever deeper beneath the sea surface, it becomes increasingly important to recognize and hopefully to understand the underwater "climate." In fact the thermal and chemical properties of seawater vary widely from place to place and often from time to time. These variations are important in the contexts of geophysical effects and biological conditions and their influence on the economics of the sea.

One of the features of the oceanic climate is a stratified structure associated with density differences. A density-stratified fluid consists of two layers each of roughly constant density separated by an interface across which the fluid properties change sharply. Oil floating on water is an example of this sort of stratification. Stratifications of the atmosphere and ocean are well known and are important to many natural phenomena. In the ocean and other bodies of water, nonuniform heating or cooling of the water, as well as the intrusion of one mass of water at one temperature upon another mass of water at a different temperature, can often be found. In the atmosphere the stratification appears in the form of temperature inversions so well known to city dwellers. In the ocean, though, there is the further complication of the effect of dissolved salt, which may also influence density stratification; thus, the name "thermohaline" convection. The two combined effects can sometimes cause large and persistent density stratification.

An example of oceanic density stratification is the thermocline, which exists without need for intrusion or secondary ocean currents. The existence of the thermocline, or a region of sharp salinity and temperature gradients in the vertical direction, is caused primarily by surface effects: namely, heat radiation from the sun; heat losses by evaporation, convection and radiation; waves (both surface and internal); and surface water salinity changes through evaporation and rain. The thermocline can be either temporary or permanent and it can change its vertical position with time. An understanding of the existence, maintenance and properties of the thermocline will provide valuable information about ocean

circulation, climate distribution, and biological environment in the oceans. It is these layers which provide the interplay of the atmosphere with the deep ocean below. Of further practical significance is the fact that these density stratified layers create acoustical sound channels which can influence underwater communication.

There is another example, the so-called "overstable" situation, which is sometimes found under icebergs or ice islands in the ocean. There is a deficiency of salt just below the nearly salt-free ice, and the temperature is low in the vicinity of the iceberg. Thus, both heat and salt flow upward from the warmer, salt-rich ocean below. This situation also lends itself to the production of layers separated by interfaces of sharp temperature and salinity change. The prediction and observation of both types of ocean stratification are of interest to geophysicists, oceanographers and engineers.

The fundamental defining experiments of turbulent thermohaline convection have never been done. A new research program is being undertaken to provide both experimental and analytical modeling of thermohaline convection through a sharp density interface. The desired result of this work is the prediction of interfacial transport rates and vertical profiles of temperature and salinity, backed by a sizable body of experimental data. By these means it is hoped to provide a firmer understanding of the nature of turbulent transport processes through natural convection in the ocean. The work is being done by Dr. Robert D. Haberstroh and by William R. Lindberg of the Department of Mechanical Engineering.

Use and Management of Seeded Ranges. Research on the oakbrush ranges at the Hesperus Station in southwest Colorado indicates that introduced wheatgrass and Russian wild rye grass produce about twice as much as native grasses even when both are seeded on similar sites. Intermediate wheatgrass and Russian wild rye grass produced steer gains amounting to about 2.5 pounds per day during the spring and summer grazing seasons. These introduced grasses produced from 2400 to 3000 pounds of air-dry forage per acre when oakbrush areas were cleared and seeded to them. Generally, when alfalfa was seeded with these grasses the total yield was increased from 500 to 1000 pounds per acre.

Alfalfa in the mixture increases livestock gains especially during late summer from about July 1 to September 1. Bloat from alfalfa in the mixture has not been a problem on these dryland pastures. If intermediate wheatgrass-alfalfa or Russian wild rye-alfalfa mixtures are grazed heavily during spring, the alfalfa becomes dominant. If these pastures are grazed heavily in late summer the grasses become dominant.

Seeded pastures have produced more herbage and more nutritious forage which has resulted in increased gains per acre over native ranges. Gains per acre on seeded ranges averaged approximately five times those on native oakbrush ranges. Livestock gains as a result of seeding were increased about 120 pounds per acre. Assuming a value of \$.30 per pound this would yield a gross return of \$36 per acre per year.

Vaccination to Control Parasitism. Parasitic diseases caused by roundworms in both man and his domestic animals take a significant toll of health and life. Our present means of controlling these diseases is either by avoidance of contact with them using sanitation and education or by administration of drugs once the diseases have been contracted. Both of these methods are fraught with difficulties, disappointments, and failures. A new weapon to combat these parasitic diseases may be by protective vaccination. Vaccines against many bacterial and viral diseases have long protected both man and animals, but the development of vaccines against worm parasites has lagged far behind. Encouragingly, however, current studies throughout the world indicate worm vaccines are a distinct possibility in the foreseeable future.

A contribution toward the understanding of parasitic immunity and especially of the response to vaccination is being made by an interdisciplinary research team consisting of parasitologists Robert Rubin and Charles P. Hibler (Department

of Pathology) and immunologist David C. Leuker (Department of Microbiology). The investigation is being conducted using a laboratory model consisting of the mouse and one of its intestinal roundworm parasites, *Nematospiroides dubius*. Successful and long-lasting protection by vaccination can be accomplished in the mouse. The primary vaccine being studied consists of living third stage larvae of *N. dubius*, which are introduced under the skin of the mouse. They do not migrate from this site and are highly immunogenic as evidenced by the fact that the vaccine produces a 95 percent protection that persists for at least 16 weeks and probably much longer.

Current research is directed toward a clearer understanding of the immune response in the mouse. Whether the response is humoral or cellular or both must be clarified. The effect of age on response to vaccination is being studied. It must also be determined why a vaccine made with larval worms is successful when one made with adult worms is not. Also under study is the maximum duration of protection by the vaccine; hopefully, it can be extended for the lifetime of the mouse.

When the above questions are answered regarding this immune response, similar vaccines will be prepared from larvae of worms parasitic in sheep and cattle. The vaccines will then be tested to determine if they will protect these domestic animals from parasitism under natural conditions.

At present, this research is being supported by the Agricultural Research Service, United States Department of Agriculture, and by the Colorado State University Experiment Station as a contributing project to Western Regional Project W-102, "Biological Methods for Control of Parasites of Livestock." Additional research funds for expansion of this investigation are being sought from the Office of Naval Research and the National Institutes of Health.

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