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DIRECTOR'S PROGRESS REPORT
Food Protein Research and Development Center
Texas A&M University
College Station, Texas 77843

1979 - 1980

E. W. Lusas
Director

A Facility of

The Natural Fibers and Food Protein Commission of Texas

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The Natural Fibers and Food Protein Commission of Texas is dedicated to improving and expanding the state's natural fibers and oilseeds agribusinesses. The Food Protein Research and Development Center, part of the Texas Engineering Experiment Station on the campus of Texas A&M University, is the oilseeds processing and utilization research arm of the Commission. The Center focuses on expanding markets for current and potential Texas crops through development of new ingredients , on new and more profitable engineering processes, and on solving current problems of local industry. The Center conducts basic and applied chemical and engineering research on converting cottonseed, peanuts, soybeans and sunflower into high quality food, feed and industrial ingredients, and on demonstrating their use in commercial products. The Center is also concerned with problems of energy conservation, federal regulations of environmental quality, employee occupational hazards and modernization of operations, which threaten survival of existing Texas oilseeds industries. As part of the Texas A&M University System, the Center's staff participates in educating engineers and scientists. We are pleased to report on the state of the Center, and to summarize progress in research projects for the year 1979 - 1980.

STATE OF THE CENTER

1979 - 1980 was a year of relocation and consolidation at the Food Protein Research and Development Center.

- All personnel and laboratory instruments, and most of the pilot plant equipment, was moved to either the new Main Building on the Texas A&M West Campus, or to the new Research Oil Mill at the Texas A&M Extension Research Center, West Highway 21, Bryan, Texas.

- Operations at the old Oilseed Products Building, Teague Building, and Protein Chemistry Laboratory were closed . And, for the first time, all scientists and engineers were consolidated under one roof at the new Main Building.

Despite the best of planning, the transition did not always proceed smoothy.

- The Research Oil Mill buildings were delivered 4 months late in the previous year, and reinstallation of considerable equipment was delayed into this year. The new Main Building was also delivered 4 months late and moving of laboratory and pilot plant equipment (originally planned to require 5 months) had to be compressed into 5 weeks.

- Delays also occurred in reinstallation of equipment - often for reasons beyond the control of the subcontractors. For example, new North Sea refineries exhausted domestic supplies of certain parts, and delivery of explosion-proof switches and motor starters for wiring the new Solvent Extraction Plant was delayed by 3 months.

Although more Industry Services research could have been procurred, and certain vacancies in the professional staff filled, first priority had to be placed on relocating the Center into new buildings. Many operations were disrupted for 6 weeks to 4 months during the move; and all staff had to share moving and reinstallation responsibilities.

At the time this report is written, approximately 75% of the Center's equipment is again operational. All laboratories and the Protein Isolate Pilot Plant at the Main Building are operational. The Benchtop Seed Fractionation Laboratory, Grinding Room, and Solvent Extraction Pilot Plant are operational at the Research Oil Mill. Only the Seed Processing Line is not operating. This is a complex installation which requires reconfiguring the previous 3-story processing line into 1½ stories, rebuilding of several old machines which operate on flat belts, and incorporation of 8 donated machines (worth about $190,000) into a new facility which is a definite improvement over the old. It is expected that the new seed processing line will be operational in mid-spring of 1981. Only three of the nearly 30 projects are currently delayed while awaiting reinstallation of moved equipment.

DESCRIPTION OF NEW FACILITIES

The new Food Protein Research and Development Center (Main Building) is shown in Photo 1. The building is located in the West Campus section next to the Southern Pacific Railroad tracks. It is near the Soil and Crops and Animal and Food Sciences Buildings, and the site of the new Texas A&M Medical School. The rear of the building backs up to the Agricultural Engineering Shops which house projects such as construction of harvesting and module-building equipment, the Experimental Cotton Gin, Fluidized bed Gin and Trash Burner, and the new Alcohol Fermentation Plant.

Photo 1. New Food Protein Research and Development Center Building, Texas A&M University, College Station, TX.

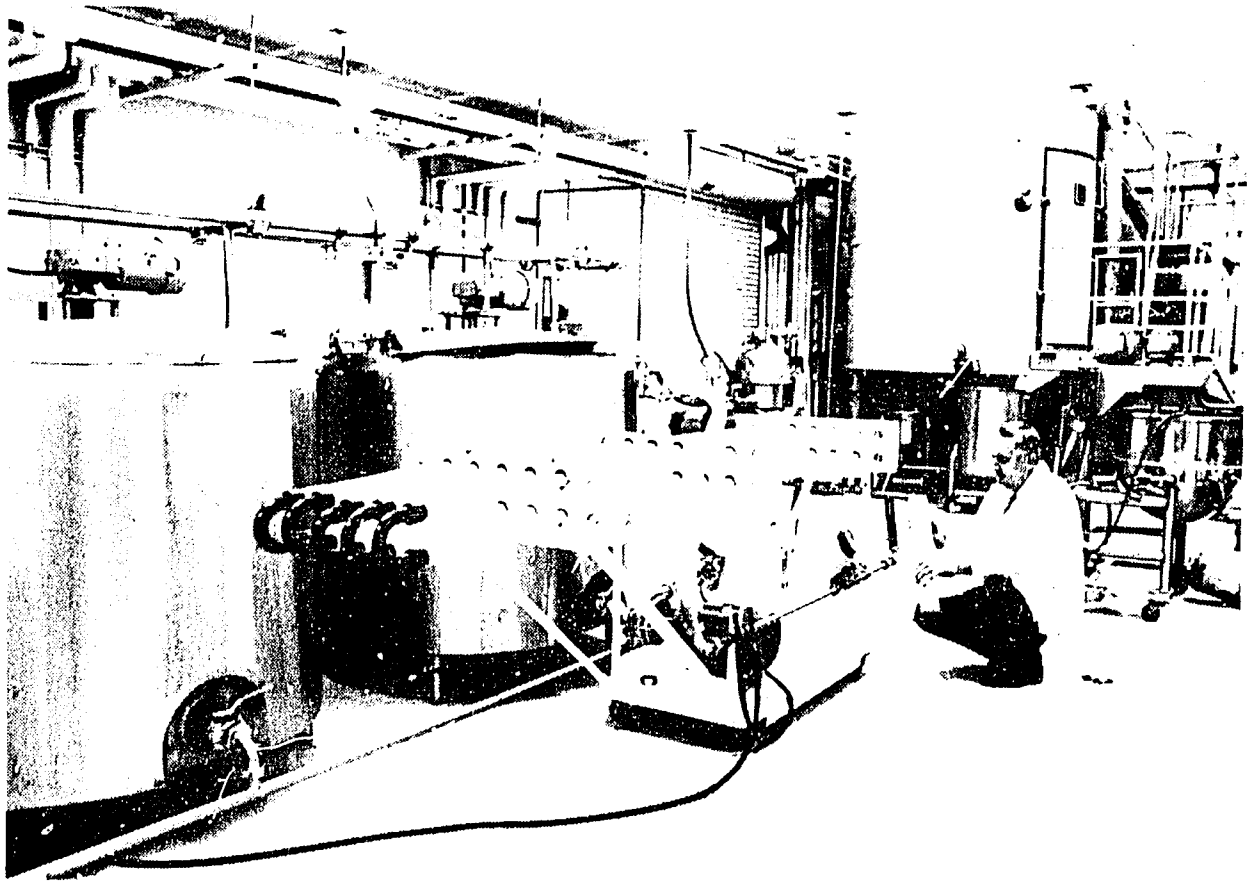

Photo 2. Protein Isolate Pilot Plant, Food Protein Research and Development Center Building

The Main Building contains 28,000 sq. ft. of space. Floor plans of the first and second stories are shown in Figures 1 and 2. The first story contains departmental offices, library, conference room,research kitchens and product evaluation rooms, engineering offices, machine shop, solvent storage room, boiler and utility rooms, locker rooms, and shipping-receiving room. The second floor contains 8 laboratories designated for Product Applications, Biochemistry, Physical Chemistry, and Industrial Microbiology research; Analytical Services; Process Engineering research; and supporting offices and dark room. The Protein Isolate Pilot Plant and the new Food Extrusion Laboratory have ceilings 2 stories high. Some of the facilities in the new Main Building are shown in Photos 2 through 6.

The new Research Oil Mill is located at the Texas A&M Research Extension Annex, and is adjacent to the Earth Machinery Training School. An outside view of the two buildings is shown in Photo 7. The Seed Processing Building contains 9,172 sq. ft. of space, and houses the seed cleaning, dehulling, conditioning, flaking, and screw-pressing equipment; flour grinding room; various heating and small seed processing equipment, machine shop boiler and utilities rooms; and a Benchtop Seed Fraction Laboratory and Engineering Support Laboratory on a mezzanine. The Solvent Extraction Building is located in a chain-link fenced weed-free area behind the Seed Processing Building. It contains 1,533 sq. ft., and houses a continuous extractor and solvent recovery system, extraction bed simulator, and batch extraction equipment. Some equipment in the Research Oil Mill is shown in Photos 8 through 11.

Other Changes and Accomplishments

In addition to relocation and resulting reorganization of operations at the Center, other organization changes also occurred at Texas A&M last year. A new full-time position of Director of the Engineering Experiment Station was created; and Dr. W.A. Porter was appointed Director. Changes occurred in accounting procedures as the new Engineering Experiment Station Business Office continued to develop. Supervision of various agencies, including the Texas Engineering Experiment Station, was reassigned to the office of the Chancellor of the Texas A&M University System. Fred J. Benson, long time Dean of the College of Engineering, and more recently Duputy Chancellor for Engineering retired after 45 years of service to Texas A&M. Dr. John C. Calhoun was appointed the new Vice Chancellor for Engineering. These changes in organization have resulted from needs for Texas A&M to expand and modernize its administrative functions to support rapid growth of student body, staff and research programs on its four campuses. It

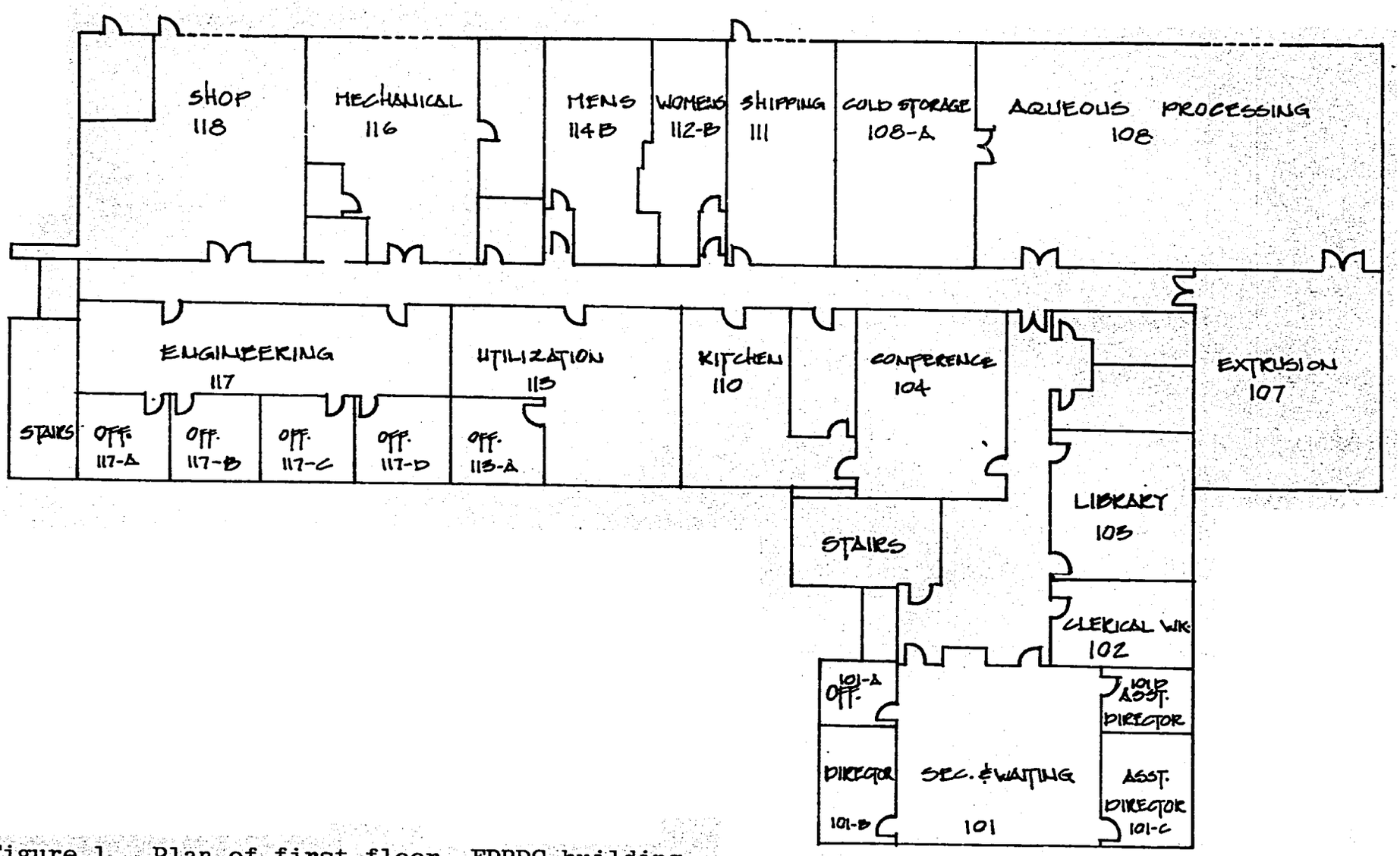

Figure 1. Plan of first floor, FPRDC building.

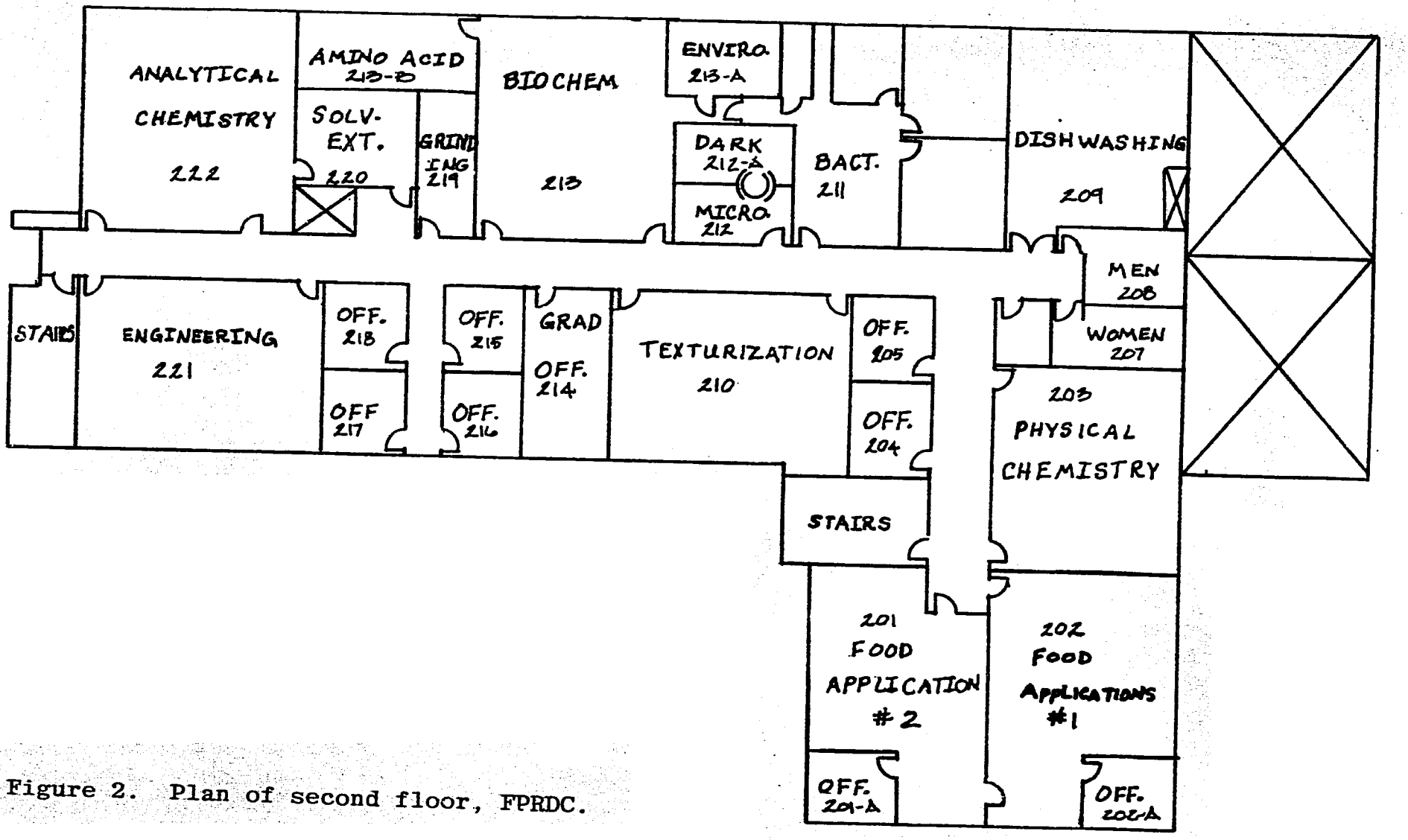

Figure 2. Plan of second floor, FPRDC.

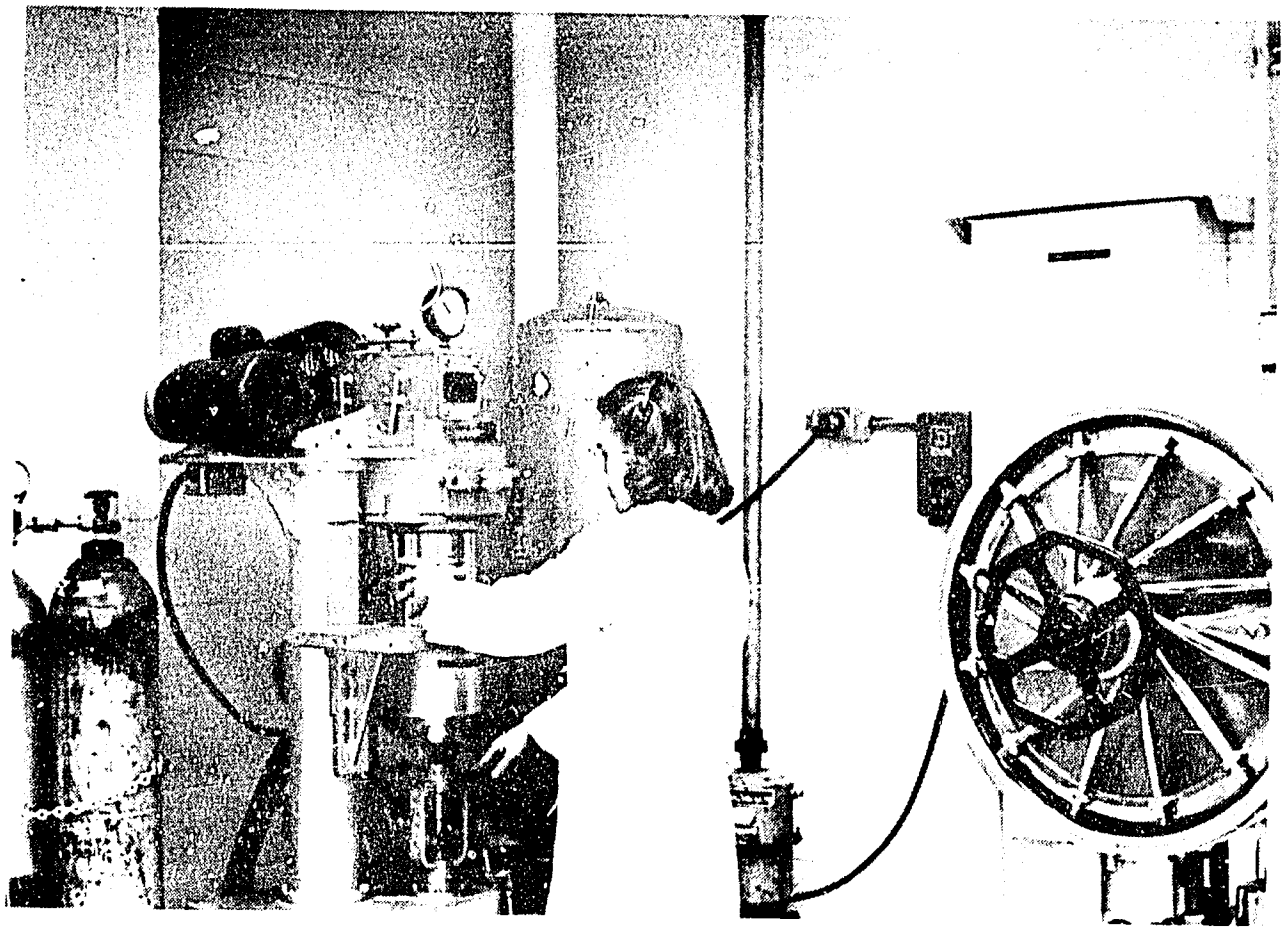

Photo 3. Canning Retorting Area, Food Protein Research and Development Center Building

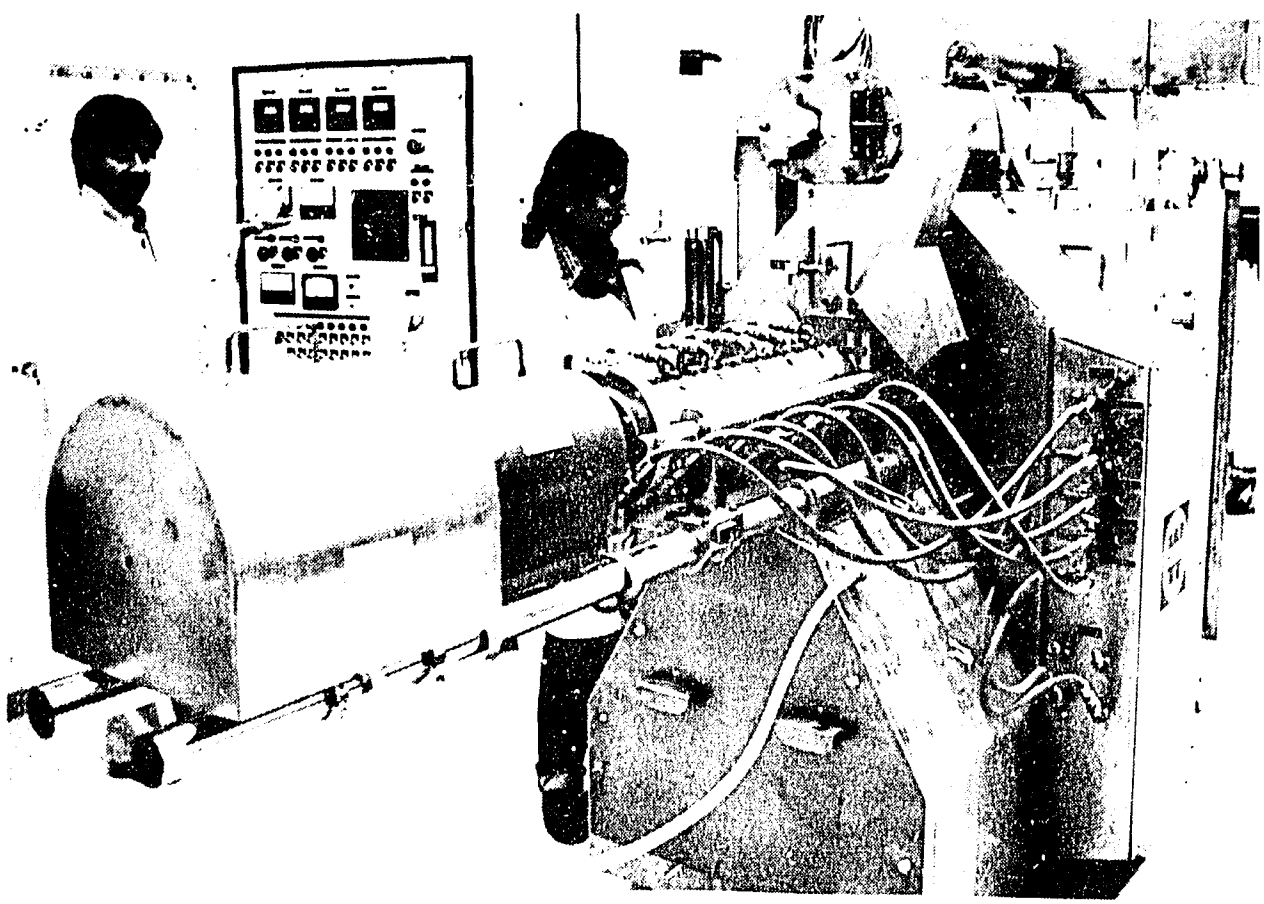

Photo 4. Wenger X-20 Food Extruder, Food Protein Research and Development Center Building

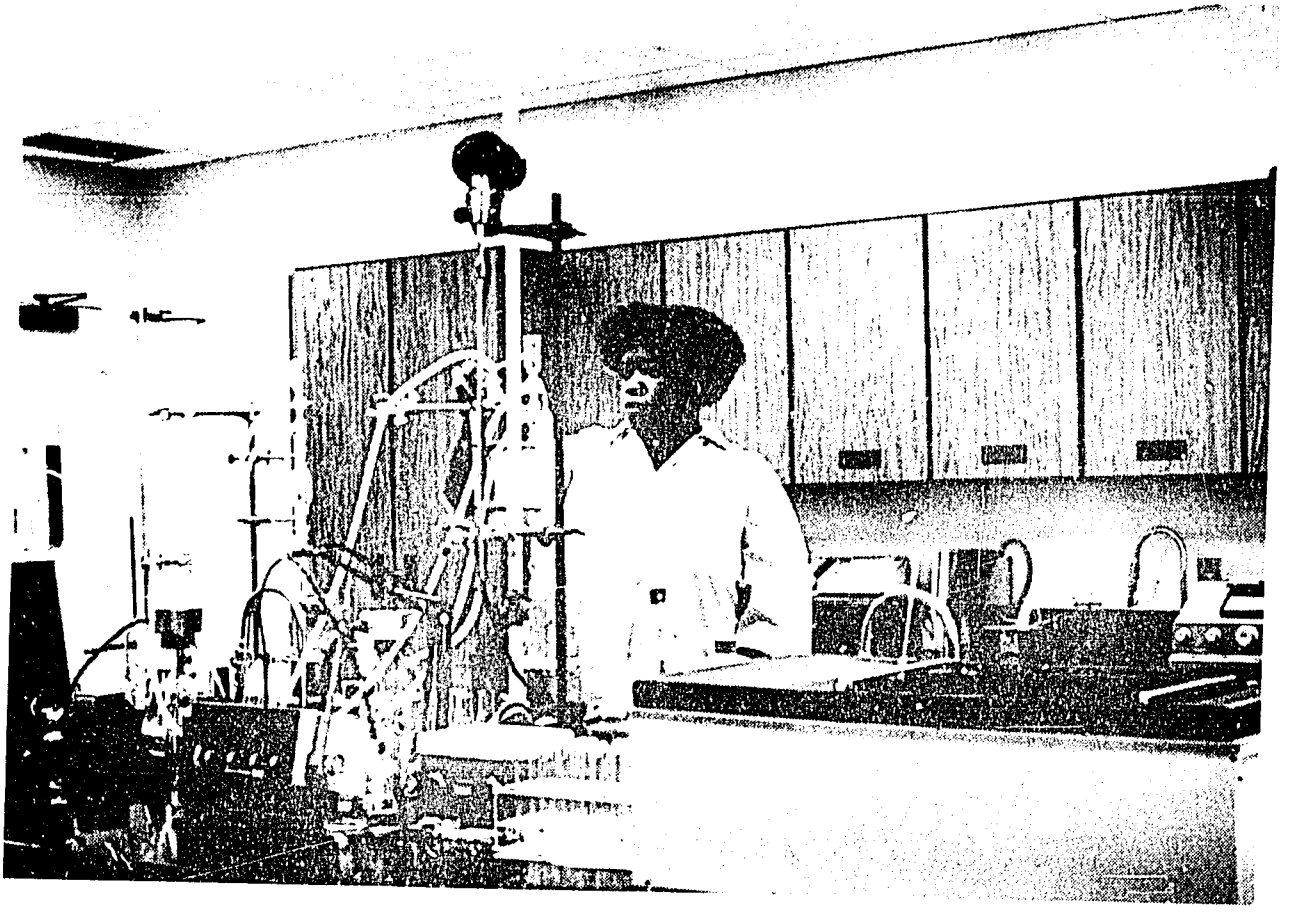

Photo 5. Engineering Process Laboratory, Food Protein Research and Development Center Building

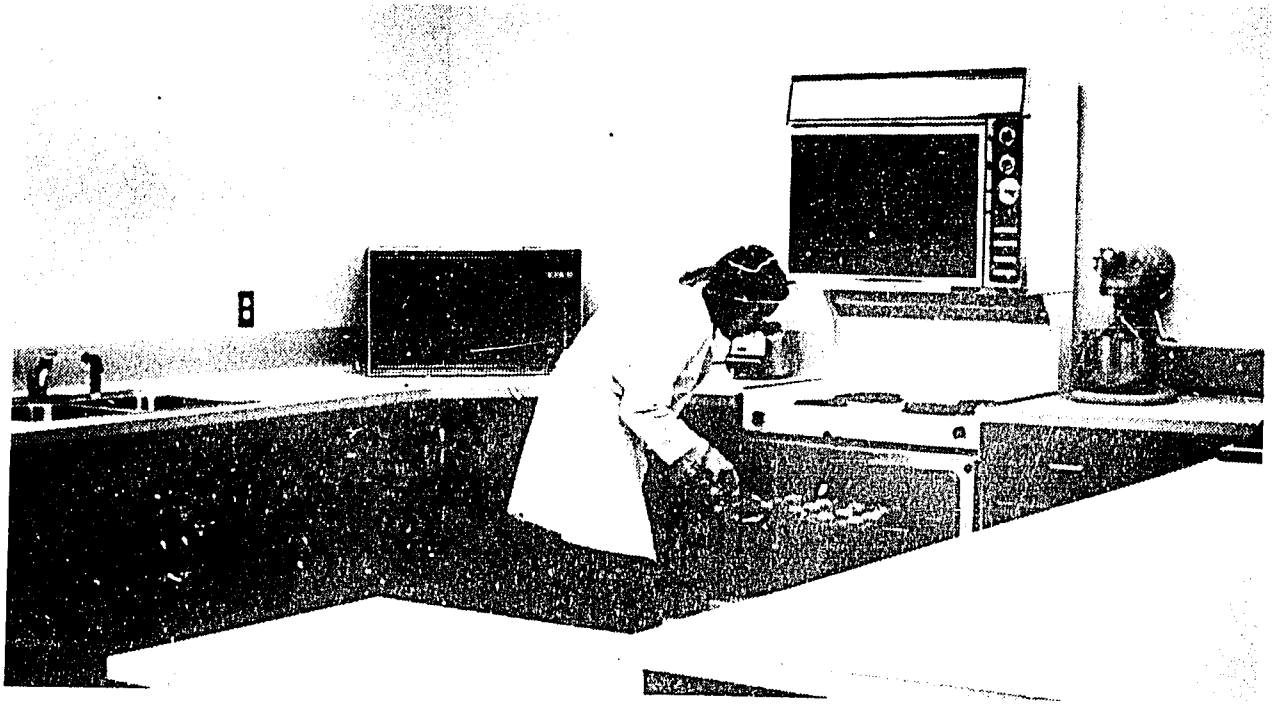

Photo 6. Research Kitchen, Food Protein Research and Development Center Building

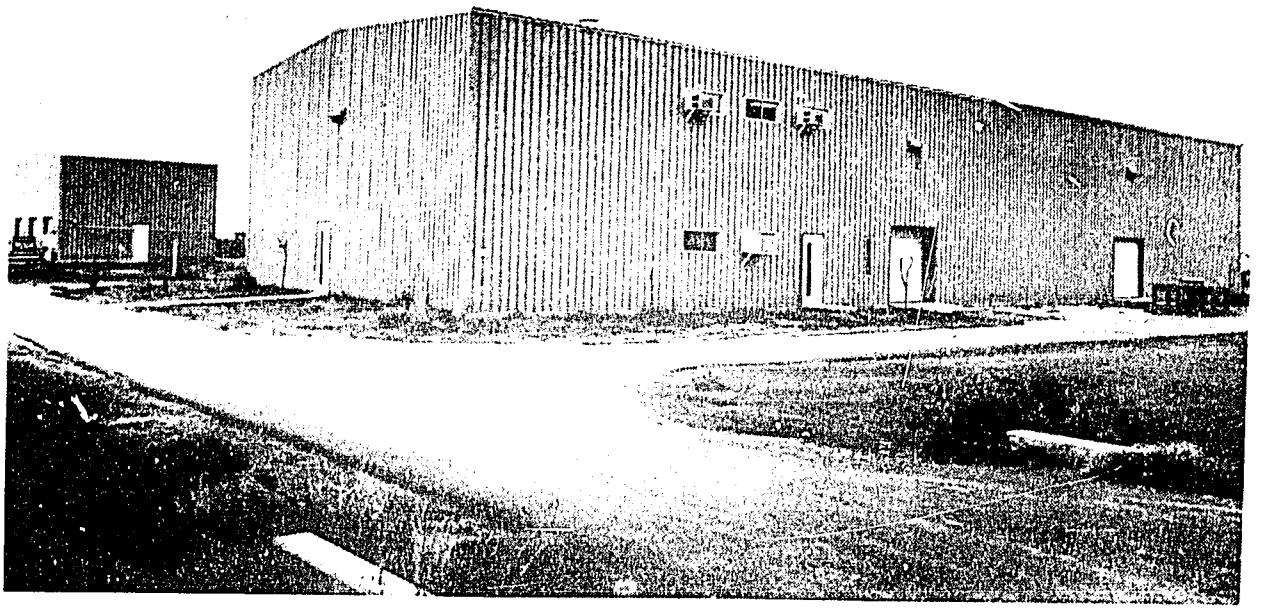

Photo 7. Research Oil Mill, Texas A&M Research Extension Center, Bryan, Texas (Seeds Processing Building in foreground, Solvent Extraction Plant in background)

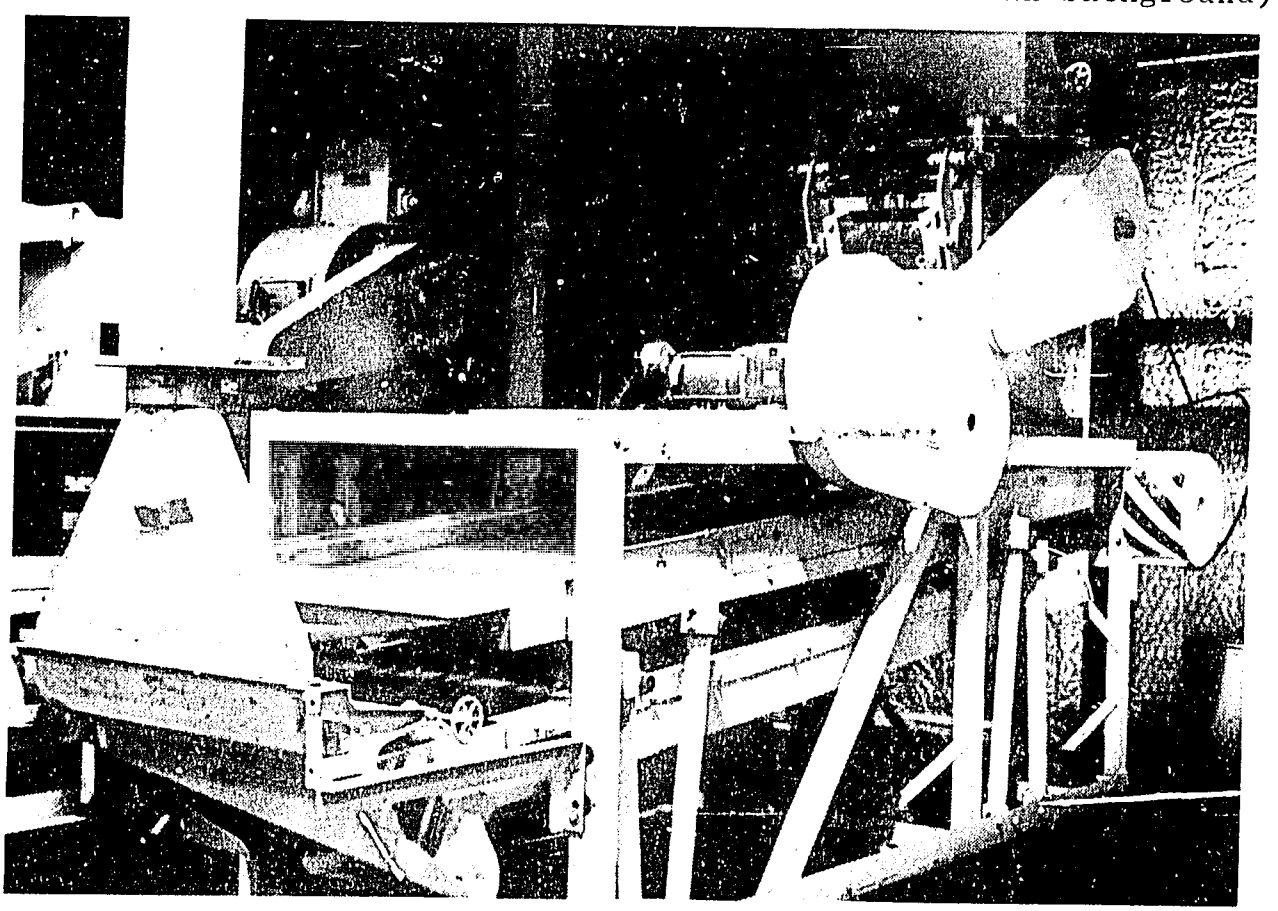

Photo 8. Murray-Carver cottonseed huller and shaker, Research Oil Mill

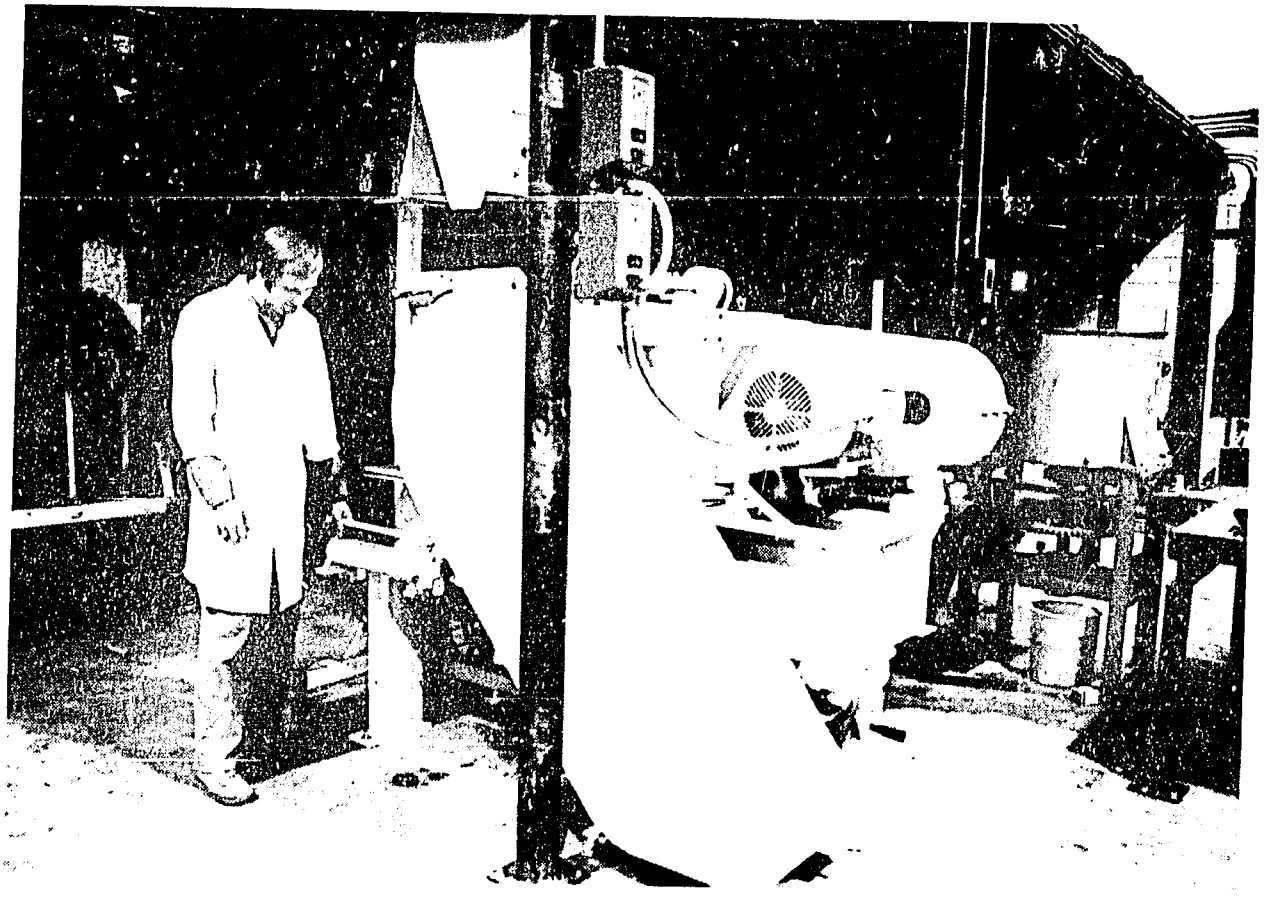

Photo 9. Ferrell-Ross flaking rolls, Research Oil Mill

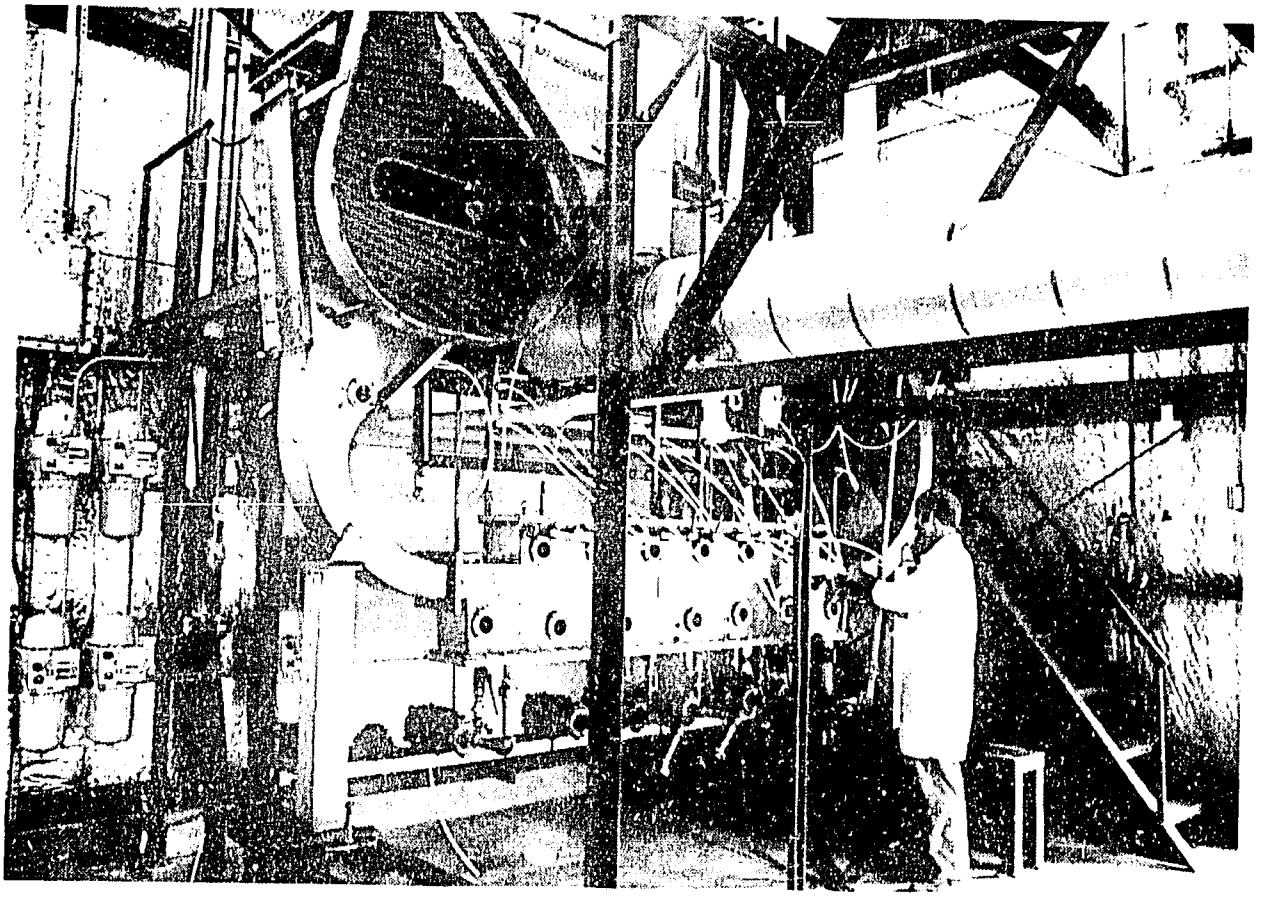

Photo 10. Crown continuous chain extractor, Research Oil Mill

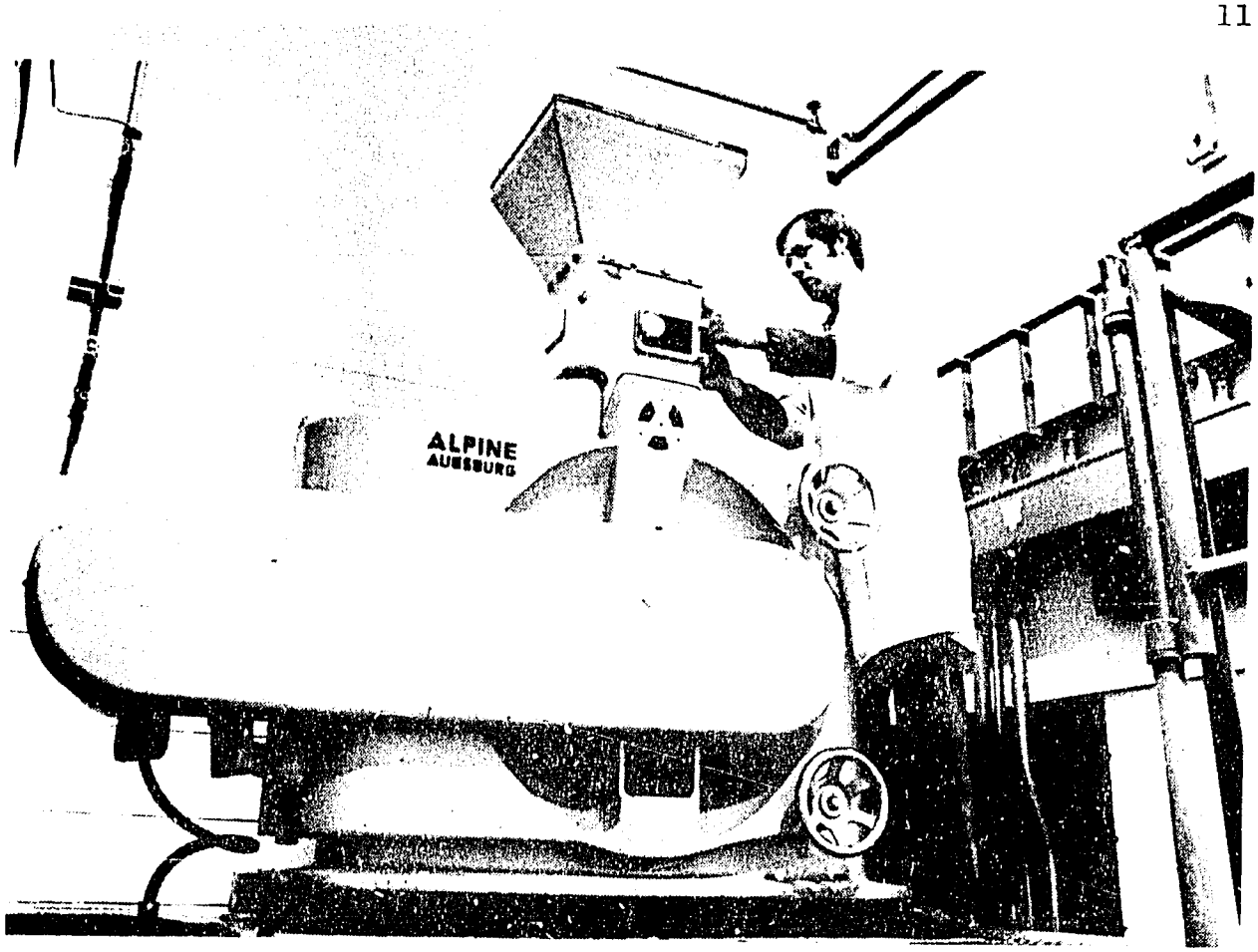

Photo 11. Alpine Contraplex Mill, Research Oil Mill

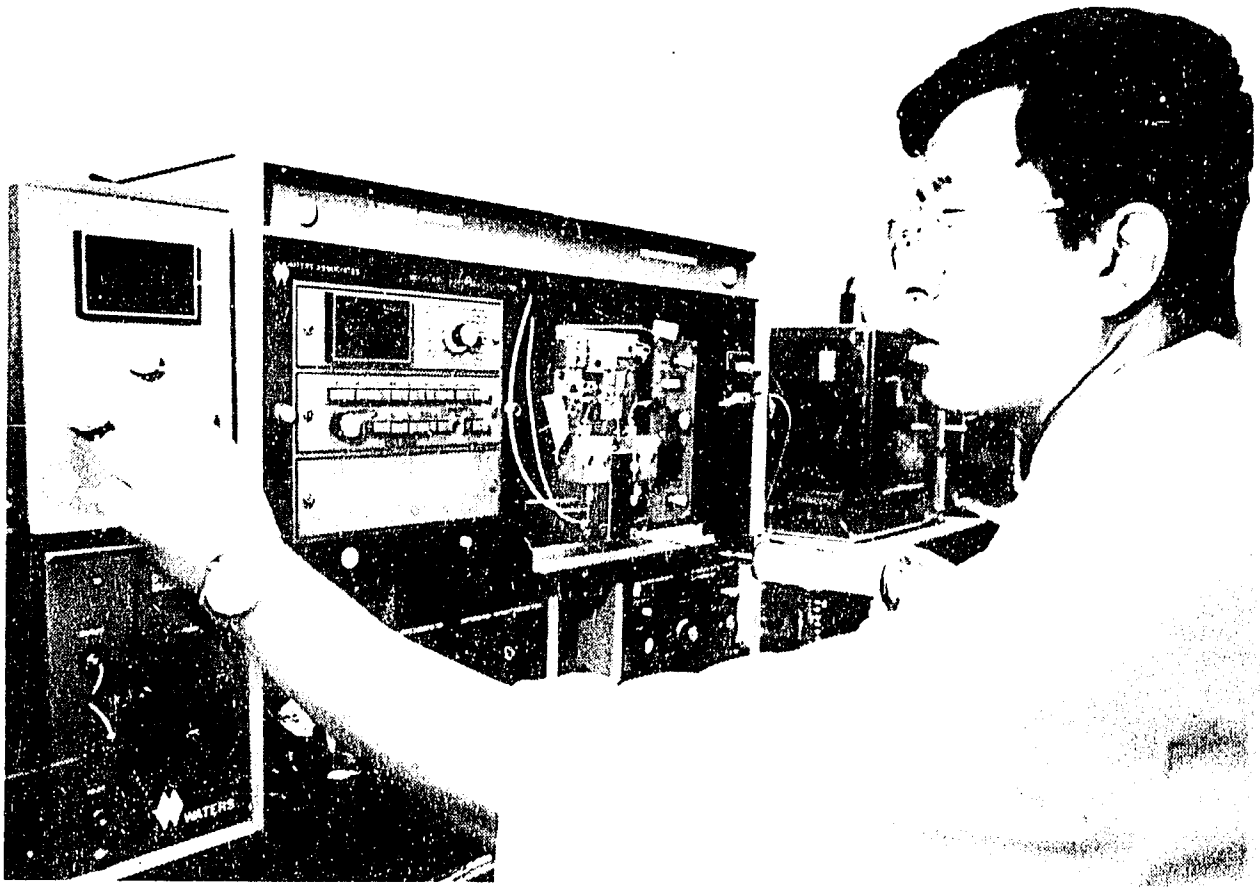

Photo 12. High Pressure Liquid Chromatograph - Food Protein Research and Development Center Building

is expected that these changes will bring more administrative skills into focus on operational problems and program development opportunities throughout the system and in individual departments.

Several new capabilities have been added to the Center's technological base. Development of the Food Extrusion Laboratory funded by the 1979 Texas State Legislature was initiated. A new extruder was ordered and delivered, and is being installed in the Main Building; additional equipment will be ordered and installed in 1980 - 1981 as the second half of the appropriation becomes available. A new vacuum-nitrogen can closing machine was acquired which enables vacuum packing of TAMUnuts and dry ingredients; and also sealing of cans for retorting. A sterilizer has been modified to operate as a retort, and the Center now has capabilities of undertaking research projects in canned food products. Additional seed dehulling, separation, conditioning, and screw pressing equipment was donated or loaned by industry to greatly expand the Center's seed processing capabilities. Also, a new-type of ceramic bead solid-to-solids heat exchanger, which heats or roasts seed in a fluidized bed, has been loaned for a new processing project.

Industrial and technical interest continued strong in the Center, although some projects had to be postponed because of moving. A total of 386 professional and business visitors (46% over the previous year) came to the Center. Foreign visitors included two delegations from People's Republic of China, and persons from Canada, Mexico, Guatemala, Dominican Republic, Columbia, Venezuela, Brazil, Argentina, Chile, Peru, Japan, India, Poland, Italy, France, Israel, Egypt, and England. The number of publications and reprints distributed for the year was 3,580.

In response to requests for equipment donations, often endorsed by members of the FPRDC Industry Advisory Committee and the Research Oil Mill Advisory Committee, numerous equipment, components and services were donated to the Center. Also, considerable equipment has been loaned on a long-term basis, often with promises by suppliers to update or replace machines as they become obsolete. Value of donated equipment received this year was approximately $56,895, and value of loaned equipment was $108,000. Donations and loans of other equipment have been promised by manufacturers in 1980-81.

While new buildings and equipment facilitate research, the real strength of any organization is in its programs and people. The pioneering spirit of the Center's staff was well-demonstrated by their determination to conduct research between moving and reinstallation of equipment. Extreme flexibility was shown in using time effectively on research planning, development of funding proposals, and writing papers and reports while waiting for utili-

ties to be connected in new quarters. Approximately $285,735 funding for new projects was obtained during the year, and negotiations are in progress for additional grants. Equally, important, personal contacts were made with potential funding sources which have resulted in suggestions for proposals from the sponsors.

Accomplishments and development of the Center's staff continue to be recognized by increased invitations to review technical articles and peer research proposals, and to participate as leaders in various professional societies.

Dr. Cady R. Engler joined the staff in January, 1980, on a half-time basis. Dr. Engler has a PhD. in Chemical Engineering and teaches basic courses in thermodynamics and heat trasfer in the TAMU Biochemical Engineering Program. His background strengthens the basic engineering resources at the Center. Dr. Engler is interested in processing research of industrial crops, and is developing several funding proposals in this area.

Dr. Larry Johnson reorganized the graduate-level course FST-635, "Oil and Food Products" taught through an academic appointment in the Soil and Crop Sciences Department. Dr. Johnson also became Chairman-elect of the Protein Division of the American Association of Cereal Chemists, and chaired a session on Food Proteins at the association's annual meeting in Chicago.

Dr. Jose Aguilera organized and presented the first course in Food Packaging taught at Texas A&M University, through an academic appointment in the Agricultural Engineering Department. It is expected the Center's expertise and facilities will continue to grow in this essential food science field. Dr. Aguilera was invited to lecture at the Second International Course on Extrusion organized by CIEPE (Venezuelan National Institute of Technical Research) at San Felipe, Venezuela. Under a National Science Founation sponsored travel grant to develop institutional linkages, he visited national research institutes in Guatemala, Chile, Brazil, Argentina and Columbia. Contacts developed have resulted in preliminary agreement for funding of a cooperative project, between the Center and institutions in Brazil and Argentina, on extrusion of sorghum and oilseed protein foods. Under a travel grant sponsored by the AID Title XII Strengthening Grant Program, Dr. Aguilera travelled to Dominican Republic and Jamaica to develop new institutional contacts and has since submitted project proposals. Dr. Aguilera was also awarded a travel grant by the American Institute of Nutrition to attend the Western Hemisphere Nutrition Conference in Los Angeles.

Dr. Khee Choon Rhee, Associate Director, was a member of the Organizing Committee and Session Chairman at the 7th Biennial Conference of Korean Scientists' and Engineers' Association in Seoul, Korea in July. Also, he was an organizing member and session chairman at the First American - Korean Food Scientists and Technologist Conference in Seoul, Korea.

Dr. Ed Lusas, Director, served on a National Research Council - sponsored task force to evaluate the Tech Base at the Department of Defense Food Program, U.S. Army Natick Research and Development Laboratories, Natick, MA. Dr. Lusas serves as Chairman of the Food Protein Sessions of the American Oil Chemists Society Annual Meetings, and organized and chaired two sessions at the ISF/AOCS World Congress in New York City in April. He has also been a member of the Organizing Committee and Co-chairman of the Food Protein and Regulatory Sessions for the World Conference on Soya Processing and Utilization held at Acapulco, Mexico November 9-14, 1980. During the year, he became a member of the Soybean Utilization Research Advisory Panel of the American Soybean Association, St. Louis, MO. In addition, Dr. Lusas made two trips to Washington and New York to introduce the Center's programs to various potential funding sources.

RESEARCH PROGRESS

Progress on projects supported by the Natural Fibers and Food Protein Commission, and by other trade association and private funding made possible by the Commission's sponsorship, is summarized in this section. Detailed project reports are presented in the Annual Report which follows. Projects, have been arranged under the general headings of Basic Engineering, Applied Engineering, Basic Sciences and Applied Sciences to organize a practical interpretation of the results.

The need to devote considerable resources to moving this year resulted in postponement or interruption of some projects. For example, the project "Dust Control and Energy Reduction in Cottonseed Oil Mills" was not started, since all available engineering talent had to be applied to relocation of and reinprocessing equipment. However, equipment is being reinstalled in the Research Oil Mill in a manner that it can be used for studies on dust control and monitoring energy use. These activities could not have been undertaken with the previous processing line.

In like manner, projects on Biochemical Processing of Oilseeds and Protein and Removal or Control of Phytates were postponed, as it became apparent that new hired personnel would not have a place to work during relocation of the Center; and in effect, their salaries would be wasted.

Basic Engineering

The basic engineering study "Recovery of Protein from Soy, Glandless Cottonseed and Peanut Flours Using Industrial Membrane Systems" was originally seeded with the Commission's funds and has received $493,000 from the National Science Foundation and other sources during the last 4 years. It will be completed by April 30, 1981. This has been a very successful project and has shown that membranes can be used effectively to produce protein concentrates and isolates, with advantages of: recovery of 25 to nearly 50% more saleable protein; improved nutritional value of resulting food protein ingredients; improvement in functional properties of ingredients for certain uses; elimination of plant waste discharges, since 75% of the processing water is recovered for reuse; and reduction of processing energy requirements, since only about one-tenth as much energy is required to operate pumps in industrial membrane processing, as compared to drying protein processing solubles.

Another valuable aspect of the project was the new vistas opened for the Center. In the course of the work, 9 ultrafiltration and 5 reverse osmosis industrial membrane systems were evaluated. Industry contacts made have been continued in proposing new membrane applications and research. Also, new product spin-offs have resulted. For example, it is indicated that industrial membrane systems can be used to selectively process or extract various undesireable constituents of oilseed proteins.

This year's work concentrated on evaluation of economic feasibility of processes developed. It was determined that a 15 million lb/yr plant would cost approximately $18 - $21 million. Prices of membrane - processed cottonseed and peanut protein isolates would have to sell at $1.28/lb. and $1.73/lb. respectively, to yield a 10% after tax discounted cash flow rate of return on investment. While these prices are significantly higher than for isolates prepared from lower cost soy flours, the resulting ingredients may have unique properties which will attract users.

A major food processor, Kraftco of Glenview, Illinois, sponsored a project on "Combining Aqueous Extraction and Membrane Isolation Techniques to Recover Protein and Oil From Soybeans", and has since authorized release of the data. The objective of this project was to combine both of these processes, pioneered at the Center, to produce oil and protein concentrates or isolates from full-fat soybeans. In addition to the advantages described previously for membrane processing, the Aqueous Extraction Process contributes the following advantages: 1) all problems associated with use of oil extraction solvents (scarcity, cost, explosive and worker health hazards, atmospheric discharges,

and concerns about solvent residues in the food supply) are eliminated; 2) during the aqueous phase, additional destruction of unwanted components, or modification of protein can be conducted; and 3) the process is adaptable to running in milk drying plants,with minimum modification, during shortages of processing milk.

In the work completed, it was found that, indeed, full-fat, intermediate-fat, or low-fat soy protein concentrates and isolates can be produced. It is estimated that construction of a plant to produce 15 million lb. intermediate-fat product/yr. would cost $18 - $19 million.

While the soybean industry already has its own facilities for producing protein concentrates and isolates, neither the peanut or cottonseed processing industries have progressed as far. The prospect of using modified dairy plants during periods of milk scarcity, as a rapid, low-capital investment means of producing oilseed ingredients,is attractive. A project on "Preparation of Oil and Food Grade Proteins from Raw Peanuts Using Combinations of Aqueous Extraction and Industrial Membrane Procedures" was initiated to evaluate effectiveness of the combined processes peanuts were chosen because; it is the next largest domestic source of oilseeds, after soybeans, available for processing into food protein ingredients, because peanut protein shows special promise for use in the growing artificial cheese industry; and because of interest in peanut protein products as infant weaning foods in developing countries.

It was found that the combined Membrane Isolation and Aqueous Extraction Processes are adaptable to processing blanched whole peanuts. Potential applications of resulting ingredients are now being evaluated.

The major oilseed proteins typically contain 3 to 5 fractions which differ in molecular size, functionality and nutritional value. Since industrial membranes are essentially "molecular sieves", potential exists for using a series of selected membranes to commercially produce large quantities of relatively pure protein fractions for selected markets. Marketing advantages of being able to separate natural products into pure fractions, have been demonstrated in other industries - such as fractionation of fatty acids by molecular distillation in the oils processing industry. A project on "Commercial Separation of Soybean Proteins into Major Fractions Using Ultrafiltration Membranes" has been initiated to develop preliminary data for seeking outside funds. Separation of proteins by ultrafiltration membranes is not a simple matter of conceptually "stacking" a series of progressively larger sieves, since many proteins exist as polymers. For example, two small molecules may associate and become the same size as a naturally-occurring large molecule. Salt and pH conditions have to be

selectively manipulated to obtain pure protein fractions Funding proposals will be developed as the exploratory work progresses.

APPLIED ENGINEERING

Sunflower growing has expanded rapidly in the U.S. and the world in the last 10 years. Sunflower is now the world's second major source of edible oil and the 4th largest source of feed protein. The U.S., with a crop of 5-6 million acres, is the world's second largest producer of sunflowers. Because of its short season and deep root system, sunflower may become an increasingly important crop as the ground water levels drop in Western Texas and energy costs of irrigation increase. Two major problems exist in processing sunflower seed: 1) difficulties in dehulling the black-seed high oil yielding varieties; and 2) development of an irreversible dark green color in sunflower protein when isolates are prepared by conventional alkali extraction processes.

Development of green color in protein isolates results from oxidation of a tannin-like compound called "chlorogenic acid". Not only is off-color a serious problem in production of protein isolates, but green discolorations can occur when less concentrated protein ingredients (like sunflower flour) are used in foods. Current programs to reduce chlorogenic acid content of sunflower seed by selective breeding are likely to be of long duration - if they are successful at all. The immediate means of making sunflower protein available to the human food supply is by development of processes to extract or deactivate chlorogenic acid so it will not turn green in subsequent processing. In the project "Preparation of Low-Phenolic Acid Sunflower Seed Protein Using Industrial Membranes", the Center developed a low-cost procedure for preventing greening of chlorogenic acid at the laboratory bench. Funds are now being sought from sunflower association and industry sources to further optimize and demonstrate this process in pilot plant scale.

Mechanical dehulling of sunflower seed became extremely difficult with introduction of the high-oil content hybrid varieties. This new type of seed has thinner and more flexible hulls, and lacks the air space between seed and hull which enabled easy impact hulling of the older grey-stipped "confectionary" varieties. The presence of unremoved hulls has several major implications for the sunflower processing industry - 1) without removal of hulls, the resulting meal contains too much fiber for feeding non-ruminant animals, and the 41% protein level typically sought in oilseed feed proteins cannot be achieved; 2) during solvent extraction of seed with hulls, hexane also extracts waxes, which must be removed in subsequent refining; and 3) dark pigments from hulls cause undesireable grey colors in flours or protein isolates produced from the meal.

The Center conducted a USDA-sponsored study on sunflower dehulling several years ago, and is now assembling machinery for a more intensified study. Two new types of hullers; a new air aspiration system for separating seed, hulls and kernels; and a new heating device for expanding the air space between seed and hull, are now available. An additional dehuller and separation system, of the type used in European and Russian processing plants has been promised by an equipment supplier. Pilot plant trials for the project will be initiated in 1980 - 81 after installation of new equipment.

A new USDA sponsored project, in cooperation with the Food Science Department at Michigan State University: "Process Development, Characterization and Utilization of Dry-Heated Navy Bean Products" is in progress. In this program, the Center is developing processes for preparing precooked whole bean flour; high-protein flour, hull flour, and a high-starch ingredient. Michigan State University personnel are evaluating the functional and nutritional characteristics of resulting ingredients, and are preparing prototype food products.

The Center is particularly interested in this project for several reasons: 1) experience developed with navy beans may be applicable to pinto and black beans and other legumes grown in developing countries, as part of an international research program; and 2) this project enables experience to be gained with a new type of solids-to-solids heat exchanger, which is also available for evaluation in other oilseeds processing applications. This new roasting machine operates on a "sand bath" or fludized solids principle. Ceramic beads are heated by direct gas flame to 465 to 520°F and are then mixed with the product to be dry roasted. After a roasting period, beads are separated from the product, are reheated, and are used to process additional fresh product. Since, in effect, the beads become a continuously flowing "solid liquid", opportunities result for increasing efficiency in heating and use of heat regenerators to minimize fuel requirements.

By combining the new dry roasting process, pin-milling and air classification, the Center has already produced samples of precooked whole bean flour, hull flour, a high-protein fraction (containing 44% protein instead of the 23% found in dry beans), and a high-starch ingredient containing only 12% protein.

The 1979 Texas State Legislature approved a special $200,000 appropriation to establish a Food Texturization Laboratory at the Center, with half of the funds becoming available in each of the two years of this biennium. In the project "Start-up of Texturization Laboratory", 10 potential suppliers of extruders and supporting equipment were visited to inspect their machines; and to assess the type of field service, and special machining and spare parts support, they might provide if their equipment was purchased. A model X-20 Extruder was ordered from the Wenger Manufacturing

Company of Sabetha, Kansas with funds available the first year. This is a single screw machine, purchased from the leading manufacturer in the country. (Approximately 80% of the world's extruded food products are made on Wenger equipment). The machine is sufficiently large for collection of useable engineering scale-up data, and comes with a variety of barrel and screw sections and provisions for process control and monitoring. Building of the extruder required 9 months, and the machine was delivered in mid-September. It will be installed in the new Texturization Laboratory as soon as possible, and supplementary drying and processing equipment will be purchased and installed in 1980-81.

The Iranian crisis, again, brought to attention this nation's heavy dependence on imported oil. Although considerable potential exists for development of new energy sources (including coal, nuclear, solar, and liquid hydrogen), most of these applications seem best suited to stationary power plant uses. The U.S. transportation and agricultural production industries are dependent on mobile power units which need liquid fuels. The federal government's alcohol fuels program is geared to produce gasahol - an extended fuel for spark ignition (gasoline burning) engines. However, the nation's heavy trucks and agricultural tractors primarily run on diesel (compression ignition) engines. In addition to not meeting diesel engine fuel needs, the economic viability of the gasahol program is dependent on continuation of preferential fuel tax allowances which can be changed by the government at any time.

It has been shown at numerous times that diesel engines can burn vegetable oils, either alone or mixed with diesel fuel. The caloric density of plant oils and animal fats is approximately 90% that of diesel fuel. During the past year, animal fats sold for nearly as much per pound as diesel fuels. Thus, demonstrated use as fuels could strengthen market price for products of oilseeds and rendering industries. Even without a tax incentive, potential use of certain oils and fats appears to be more economically realistic than gasahol. Uses of plant oils (especially sunflower oil) as fuels in tractors and buses have already been demonstrated by several U.S. universities. Also, feasibility of growing sunflower specifically as a fuel crop to power farm engines has been demonstrated at remote ranches in South Africa.

Many factors are yet unknown about using plant oils and animal fats as substitute diesel fuels. The long term effects of burning plant oils on engine wear and maintenance are not known; fouling of lubricating oil in less than 100 hrs. engine time has been reported several times; little is known about requirements for refining plant oils for fuel uses. Also, development of an oilseed fuel crop industry includes providing for processing, stabilization, deactivation and utilization of the large quantities of feed meals which would result. (For

example, for each pound of fuel oil, one to nine pounds of oilseed meal would also be produced.) Of special interest to the NFFPC is that, of plant oils which might be used in the U.S. as emergency diesel fuels, cottonseed oil is reported to have the poorest combustion characteristics.

The federal government is planning to fund programs to study uses of plant oils as diesel fuels in early 1981. An interdisciplinary task force, comprised of personnel from the Center, and Agricultural Engineering and Agricultural Economics Departments, has been organized at Texas A&M to study practicality of using plant oils and animal fats as diesel fuels in Texas and the U.S. A copy of the position paper reviewing various pertinent factors, and plans for research, is included with the Center's Annual Report.

A project entitled "Oil Mill Industry Support" has been established to facilitate the Center's contacts with the oilseeds processing industry. As soon as reinstallation of equipment in new buildings has been completed, specific programs will be developed to visit local oilmills, to organize practical short courses, and to assist the industry in solving common operating problems. Although six oil mills were visited this year, most of the efforts in this project were directed to organizing the 48th Annual Short Course for Oil Mill Operators. A record 139 persons attended the course this year. Dates of April 13 - 14, 1981, have been set for the 49th Annual Short Course.

Basic Sciences

Development of a low-gossypol content cottonseed products industry requires analytical methods which can detect levels of free and bound gossypol as low several parts per million (ppm). Current AOCS procedures are only sensitive to 30 to 50 ppm, and often give false readings when totally inert inorganic materials are analyzed. Although the Center, as well as federal laboratories, have worked on development of highly sensitive gossypol analysis methods for several years, these techniques are not easy to devise. A major problem is that the current official test actually measures a mixture of several gossypol-like compounds. In the project "Development of Improved Analytical Methods for Cottonseed Products", a new extraction step, which showed promise of increasing sensitivity of the gossypol analysis by a factor of 10, was studied. However, further development of this technique had to be abandoned when it became shown that other substances normally present in cottonseed also affected gossypol determination. A second extraction method was also developed, but only doubled sensitivity of the current official method, and was not sufficient improvement to warrant its replacement.

The Center's project: "Physico-Chemical Properties of Texturized Proteins" is one of several key programs in Food and Biochemical Engineering sponsored by the National Science Foundation at U.S. universities. Although seeded and partially supported by NFFPC funds. This project has received Natural Science Foundation funding for 2½ years. Confirmation was received this fall that the project has been refunded for another 2½ years, thus bringing total outside funding up to $160,000. The major objective of this project is to determine effects of various treatments and components of natural ingredients, and food additives, on texture of extruded proteins. Considerable basic data is being collected in this project, including effects of nitrogen solubility of soy flour, pH, enzyme modification, and various added salts, emulsifiers and, reducing and oxidizing agents.

Functional effectiveness of protein ingredients in producing desired physical characteristics in food products, is the single most important factor determining their market value. The fractionality properties most sought after in protein isolates today are the high solubility and smooth thromoplasticity of sodium caseinate which is derived from milk. In the basic project: "Molecular Structure and Functionality of Natural and Enzyme-Modified Oilseed Proteins", effects of various molecule modifying treatments on protein functionality are being studied. It has been shown that significant improvements in potential commercial value of glandless cottonseed protein can be achieved by succinylation- a process which treats protein with a compound common in normal metabolism of man and animals. If warranted by further studies, sponsors will be sought to support further development and documentation research to obtain FDA approval for commercial use of this process.

Applied Sciences

Many of the applied science projects are concerned with studying the problems of incorporating ingredients developed at the Center in specific food products. The project "Use of Cottonseed and Peanut Proteins in Extended and Analog Dairy Products" is concerned with development of immitation (or "analog") milks. The main problem is that although nutritious, vegetable food protein isolate ingredients are unlike caseinate, and have problems of dispersibility. FDA regulations require that immitation milks contain as much calcium as cow's milk. However, addition of supplementary calcium causes precipitation of many vegetable proteins. Also, even though a modified protein may be initially dispersible in preparing a milk analog, it may separate rapidly, with the solids raising into the cream layer and formation of a clear "whey" layer at the bottom of the container. This year, it was found that modification of cottonseed protein by succinylation procedures (developed in another project)

vastly improves its useability in milk analogs. Use of this new ingredient was further enhanced by selected emulsifiers and stabilizers.

Although peanut protein isolates do not perform well in calcium-fortified immitation milks, they are the protein source of choice in preparation of analog cheeses. In the project: "Development of Cheese-like Products from Oilseed Proteins", use of peanut protein isolates was demonstrated in several types of cheese. Modification of peanut protein by enzyme treatment enhanced its suitability for use in analog cheeses, more than the previously-described chemical succinylation process.

Use of synthetic cheeses for pizza toppings and institutional feeding is increasing rapidly. These are products made from sodium caseinate (isolated from milk) and vegetable oils. In fact, the market is growing so rapidly that it has nearly committed all of the world's useable sodium caseinate that can be imported into the U.S. The Center's work in using vegetable proteins in immitation cheeses is being monitored very closely by industry, and representatives of all the larger synthetic cheese manufacturers have visited the laboratory and requested samples of ingredients. Close working relations have been established with technical staff of these companies. An acceptable sample of synthetic cheese, made by replacing half of the sodium caseinate by peanut protein isolate, was shown to the Texas Peanut Producer's Board meeting in College Station in February 1980.

"Modification of Vegetable Proteins for Uses as Coffee Whiteners and Microencapsulation Ingredients" is a highly interesting applications project. In addition to offering a potential market for vegetable food proteins in a rapidly growing sector of the food industry, expertise and equipment developed in this area are directly applicable to many other projects. In previous studies, it was found that vegetable proteins are potential ingredients for replacing scarce sodium caseinate in production of coffee whiteners and powdered shortenings. This year, it was found that the newly-developed protein succinylation process, in addition to improving solubility and encapsulation performance of vegetable proteins, also improves dispersibility of vegetable protein whiteners in coffee and, surprisingly, their whitening effectiveness as well.

The project "Utilization of Glandless Cottonseed Kernels and Protein Products" was highly successful in bringing information about the new processes and products developed at the Center to the attention of the industry and the public. Infor-

mation was provided to a large number of visitors, and through phone discussions, letters and oral presentations. Also, 6,590 samples of ingredients, and products demonstrating their use, were distributed. At least 22 newspapers, magazines and broadcast (Radio and TV) stations ran stories on the Center's accomplishments. A 48-page cookbook: "Cottonseed Cookery" was completed and is ready, in galley proof condition, for publication. A sponsor has been found to fund publication and distribution of the cookbook, but its distribution is being delayed until glandless cottonseed kernels become available to the general public through grocery and health food stores.

A can closing machine, with capabilities of packing dry ingredients and TAMU nuts, and sealing cans for retorting, has been acquired. Also, a microbiological sterilizer has been modified for use as a retort to enable the Center to initiate studies on uses of vegetable protein products in canned foods.

Distribution of food ingredient samples for evaluation by potential industrial users and other researchers is partially conducted under the "Food Protein Ingredients Sample Program" project. This project also receives funds from the National Cottonseed Products Association and the Texas Peanut Producer's Board to assist preparation and distribution of samples. Twenty-eight samples were distributed to qualified users under this program in 1979-80. Emphasis last year was on using up stocks of previously prepared protein isolates. In its new facilities, the Center (for the first time) has sufficient cold room space for storing food ingredients, and now also has equipment for sealing samples of products in vacuumized or nitrogen-pack cans to ensure long shelf life. Fresh stocks of cottonseed and peanut protein ingredients will be prepared in the pilot plant for this program this year.

The Center shares in funding a research baker at the Cereal Quality Laboratory at Texas A&M. Uses of new food protein ingredients in bakery products are evaluated as developed in the various research projects. Baking tests of glandless cottonseed protein isolates showed that succinylation of isolates actually detracted from protein performance at 7.5 and 10.0% wheat flour replacement levels, compared to isolates prepared by conventional procedures.

A new project: "Establishment of Oils Extraction Program for Cottonseed and Other Crops" has been organized to also emphasize oils extraction and processing technology in addition to the Center's on-going vegetable food protein work. Work in this project was interrupted by moving, and limited by lack of oils refining and processing pilot plant equipment. Emphasis will be placed on seeking funds for equipment from state, and private industry sources in 1980-1981. Availability of oil

refining and processing equipment would also enable the Center to engage in industrial and arid lands crops research which is being increasingly funded by the federal government and undertaken by private industry.

During 1979-80, additional seed preparation equipment, essential to improved oils extraction, was obtained (seed conditioner, flaking and cracking rolls, hulls aspirator, and a horizontal-bar cage screw-press). Research also showed, for the first time, that oil from glandless cottonseed (with up to 10% glanded seed contamination) does not undergo color reversion rapidly enough to warrant installation of miscella refining equipment in future oil mills processing glandless cottonseed. Instead, refining of crude glandless cottonseed oil can be delayed until the regular refinery without appreciable deterioration in its market value. Studies also found that glandless cottonseed oil can be a commercial source of light-colored cottonseed lecithin, which is at least equivalent to soybean lecithin in its functionality, but may offer additional advantages to the foods and chemicals industries.

The objective of the project "Processing Varieties of Oilseeds" is to monitor, and assist development of oil and protein crops for specific applications. For example, many oilseeds have been bred primarily for yield, with the protein entirely intended for use as animal feed. Preparation of "food grade" products from "feed grade" crops poses special problems of removal of off-flavor, and off-color compounds. However, it is genetically possible to develop crops specifically for the food industry (white-hulled lowchlorogenic acid sunflower, white-skinned peanuts, white-hulled and also black-hulled soybeans) if plant breeders can be convinced of sufficient market potential. Also, opportunities exist for introducing new types of food and industrial crops suitable for Texas agriculture.

Processing requirements of lupine and quinoa as human foods was evaluated this year. Lupine is a legume with flat round seeds about the size of a large soybean. Literature indicates that protein yields per acre can be as much as that of soybeans. Although lupine seeds typically contain about 8% oil, varieties with oil contents of up to 20% have been reported. The advantages of lupine are that it is a nitrogen-fixing crop, is frost free, has a short growing season, and grows well in heavily-leached soils. For example, Italy, whose hilly soils have been farmed for nearly 2,500 years, is studying lupine intensely as part of a national program to become self-sufficient in food protein. (Lupine is also a distant relative of the Texas Blue Bonnet - possibly indicating potential compatability with local climate and soils.) "Sweet" (alkaloid-free, non-toxic) varieties of lupine have been developed in recent years. They have been evaluated in Florida and Georgia by the Costal Plains Experiment Station, and are receiving considerable attention in Australia and England. Lupine is being used in human foods in

Chile. Trials at the Center in 1979 - 1980 showed that lupine handles easily in seed processing and protein isolate preparation equipment. Although nutritional qualities of lupine protein isolates are low, opportunities exist for enhancement by combination with other oilseeds.

Several years ago, the U.S. National Academy of Sciences became concerned that the world's food supply relies heavily on only a few plant species (wheat, rice, corn, soybeans, barley, rye and oats.) Because of the close botanical relationship of some of these crops, the world could suddenly become in dire need if one or several plant diseases, new insect species or climatic changes developed suddenly. As a precautionary measure, the National Academy of Sciences has identified and encouraged initial studies of 26 potential new food crop species. Plants which have been identified in this program include grain amaranth (a form of large-seeded "pigweed") which was the major cereal in various Latin-American indian cultures before the arrival of Columbus. Various U.S. agronomists are evaluating potential domestication of these newer crops.

One of these potential crops is quinoa, a weed-like crop which has been domesticated in western South America. For example, Bolivia requires that wheat flour sold for bread making also contain 5% quinoa meat. A member of the Texas A&M Biology Department has become interested in quinoa, and has traveled to South America to collect seeds of quinoa-like plants. In 1979-80, the Center processed and assessed limited samples of quinoa. It was found that quinoa protein is of extremely high nutritional quality (very similar to the FAO standard), and that seed starch is deposited in unusually small starch granules which might have potential commercial use.

In early 1980, the Center was approached by a private firm seeking collaboration on processing Chinese Tallow Tree seeds. This tree grows well in costal lands from South Carolina to Texas, and is frequently used as an ornamental tree. It looks somewhat like a poplar, and has red leaves and clusters of white hard berries in the fall. This tree may have agronomic potential in Texas, since it grows well in marshy (including salty-water) areas, and its fibers are suitable for making newsprint. Also, this crop could produce up to 4,000 lbs. of seeds per acre if a suitable mechanical harvesting system could be developed. The seeds are covered with a pithy white layer which contains a highly saturated hard fat that has been used for making candles and soap, and may have potential as a replacement for cocoa butter. After extraction, the seed hull can be cracked with a cottonseed bar-type huller to free a kernel which yields a light oil that may be used as a liquid fuel, or, possibly as a drying oil in the paint industry. In early 1980, the Center surveyed the processing characteristics of Chinese Tallow Tree Seed, and cooperated with the Agricultural Engineering and

Animal Sciences Departments and a private firm in submitting a research proposal to the National Science Foundation. Limited pilot plant batch extraction trials resulted in 22% of the weight of whole Chinese Tallow Tree Seed recovered as solid fat, and 14% of whole seed weight recovered as oil. The private contractor has since submitted samples of extracted fats to potental food company customers, and of oil for evaluation in as a diesel engine fuel.

If glandless cottonseed could be dehulled and suitably stabilized before shipping, approximately 50% of the weight and 82% of the volume could be saved, as compared to handling grey whole seed. In research on "Determination of Optimum Storage and Shipping Conditions for Dehulled Cottonseed", sponsored by Cotton, Inc., it was found that free fatty acid and moisture are the two critical quality factors affecting storage life of raw dehulled kernels. The preferred ways of ensuring maximum stability of glandless cottonseed currently are:

- Keep the whole seed intact as long as possible, as cool as possible, and under 8% moisture.

- Do not utilize raw seed with greater than 1.0% free fatty acid and 8% moisture. Roasted seed becomes organoleptically unacceptable at 2.25% free fatty acid content, but should be removed from the marketplace much earlier.

- Keep dehulled whole seed as dry and cool as possible Dehulled kernels with 8% moisture had a storage life of 4 months at 68°F, and 29 months at 47°F. Increasing the storage temperature from 68°F to 104°F doubled the rate of free fatty acid development; raising the moisture content from 7% to 9.8% increased the rate of fatty acid development by a factor of 4.

- Breakage of seed during hulling greatly accelerates rates of free fatty acid and peroxide development. Therefore,broken seed and fines fractions should be used in further processing or refrigerated as soon as possible.

- Little advantage was gained in drying raw whole kernels from 7.8% to 4.6% moisture content.

- Roasted kernels in cans at 68°F showed a storage life of about 6 months; longer shelf life of roasted kernels is expected with vacuum or nitrogen flushing.

A literature search and review of current industrial methods for destruction of aflatoxin in peanut and cottonseed, were completed for the project: "Continuous Detoxification of Peanut and Cottonseed Meals". Pilot plant trials on continuous detoxification of aflatoxin will begin in 1980-81 after installation of the new food extruder.

A new project on "Process Improvement and Development of Applications for Sesame" was initiated this year as a PhD thesis project. The objective is to increase recovery of food proteins extracted from sesame, while also avoiding problems of bitterness and reduced digestibility caused by high levels of naturally occurring oxalates and phytic acid. Use of sodium chloride, calcium chloride and sodium sulfite improved protein extraction. Use of sodium chloride and sodium sulfite also resulted in unexpected benefits of producing light-colored protein isolates.

The Center also has an Industry Services Program to assist process and product development of private companies and individuals. This program includes two major types of activities: 1) fractionation and processing of small amounts of oilseeds through its Benchtop Seed Fractionation Laboratory to assist seed breeders and producers of agricultural spray chemicals; and 2) making pilot plant equipment and trained operators available for process development trials. Although most of the laboratories, and all pilot plant equipment, were shut down at some time because of moving, approximately $145,000 of work was done for industry - an increase of 33% over last year. A total of 181 seed samples were processed, and 19 runs were made for 8 agricultural and food companies. Experimental ingredients were prepared from cottonseed, soybeans, peanuts, sunflower and other crops, and new processing ideas were evaluated. Costs of the Industry Services program are fully recovered from users, and pilot plant equipment is occasionally purchased from surpluses. This programs also helps keep the staff informed about industry's problems. Approximately $44,147 of additional research contracts were obtained in 1979-80 from contacts made through the Industry Services Program.

FUTURE OUTLOOK

While fiscal 1979-80 was very demanding on the staff and program because of numerous interruptions for moving of personnel and equipment, 1980-81 is likely to be challenging with problems of installing equipment and learning to work with new systems in new locations. Happily, the hardest part of relocating the Center is over, and only improvements are expected in the coming months.

The Texas A&M University System funded the new buildings, and the Texas Engineering Experiment Station provided special appropriations for new components, plumbing and electrical installations, and materials. But, most of the equipment moving and reinstallation has been done by the Center's staff. Besides placing equipment(and reconnecting utilities like compressed air, water, steam and air suction lines), reinstallation requires development of improved processing flows over those in the old building. Old equipment needs to be modernized (for example V-belt drives and separate electric motors substituted for flat-belts and open cage motors; and dust containing skirts and shields added). Numerous pieces of equipment have been donated to the Center which have to be integrated with previous equipment. Although all former laboratory and pilot plant equipment is operational except for the Seed Processing Line, completion of this facility will require considerable involvement of the engineering staff until mid-April, 1981. A formal Open House Program to present the Center to the oilseeds industry has been scheduled for April 14, 15, 1981 immediately after the 49th Annual Short Course for Oil Mill Operators.

A program review and plan was developed in early 1980 to identify the areas which the Center would most benefit in pursuing. Major emphasis will be on doing more complete jobs in the fields in which the staff is already involved, and on seeking new involvements which will extend use of current technologies and equipment. Specifically:

- Emphasis will continue on developing improved procedures for extraction of vegetable proteins, and development of low-cost food products; but

- More attention will be focused on oil mill operations problems (especially energy conservation, dust control and plant modernization), by recruiting an Associate Director of Engineering and designating a specific engineering and industry support staff;

- Since more than 98% of protein meal produced is used as animal feed, projects on problems of improving quality and value of oil mill feed products will be sought.

- Research in the oils and fats processing field has been minimal during the past 15 years, and alternative oil extraction techniques and solvents are needed. Oils extraction, refining and processing capabilities-including staff and pilot plant equipment will be expanded.

- Involvement will be sought with other industries that utilize essentially the same extraction principles and even equipment and solvents - including industrial crops, arid land crops such as guayule (a native source of latex), and development of existing and new crops for new purposes such as uses of vegetable oils as diesel fuel substitutes.

- Technologies developed at the Center will be applied to solving world hunger and international agricultural crops processing problems, whenever arrangements can be made on a self-funding basis.

An immediate goal is the Center's commitment to organize and present practical short courses in oilseeds milling to train oil mill first line supervisors. The oil mill industry, and particularly the cottonseed oil mills, are facing acute personnel shortages as present staffs age, and spread of other industries to the countryside results in strong competition for the choice trainable labor. With the advent of the new Research Oil Mill, the Center now has the space and suitable equipment to present "hands-on experience" short courses. Dormitories and a cafeteria are located near the new Research Oil Mill. Plans are to organize a 5-day in-residence practical course on cottonseed oil milling in cooperation with the Texas Cottonseed Crushers Association and the National Cottonseed Products Association; and a second course on soybean milling in cooperation with the American Soybean Association. Both courses would be presented in the fall of 1981, and would accommodate approximately 15 persons each. Additional courses on similar and allied subjects would follow as warranted by demand. and availabilitv of staff and appropriate equipment.