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REPORT OF ENGINEERING RESEARCH
WITH RECOMMENDATIONS FOR
STRENGTHENING THE PROGRAM

Prepared by

Vaughn E. Hansen
Director

June 1959

Engineering Experiment Station
College of Engineering
Utah State University
Logan, Utah

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PROGRESS OF ENGINEERING RESEARCH

The growth initiated with the reorganization of the Engineering Experiment Station in 1957-58 has been steady and consistent through 1958-59. Every sign points to continued expansion through the coming year. This growth is shown in Table 1. The number of active projects this year has increased to nineteen, the funds allocated for Engineering research were \$53,861 plus \$17,826 for contract research, exclusive of approximately \$75,000 in the Agricultural Experiment Station. The number of staff members engaged in research is now twelve. Contract research money has been obtained to finance four projects which were financed previously with Uniform School Funds.

Funds now available for research during 1959-60 total \$96,147, with an additional \$228,860 under negotiation and development. There is good reason to believe that within six months as much as \$146,000 should be procured of the \$228,860 pending. Thus the program of the Engineering Experiment Station could well reach \$233,000 by January, 1960. These estimates do not include any of the funds expected within the framework of the Utah Scientific Research Foundation. The division of funds is shown in Table 2, and the contract research in Table 3.

A list of project numbers, titles, and leader is appended as Table 6, and

the research studies from 1952 to 1955 are appended as Table 7. These are included to summarize the type of projects under study and to make readily available a brief history of activity since 1952.

PROGRAM OF THE UTAH SCIENTIFIC RESEARCH FOUNDATION

An outline of the magnitude and general operation of the Foundation is presented to explain the need to coordinate this program with the program of the Engineering Experiment Station for the mutual benefit of both units.

Table 4 shows the growth in the program of the Foundation through the period 1955 to 1959; it is evident that the Foundation now has an annual gross business in excess of \$225,000. Table 5, showing the possible program within 1959 to be 525,000, illustrates that significant growth can also be expected this year, as well as in the future.

A close look at the operation of the Foundation also shows wide fluctuation in the program from quarter to quarter during the year, due to the seasonal nature of the Snowmobile program. Greater diversity of operation is essential to a stable program. The creative genius of Mr. James H. Hardman has produced several items that can serve as the basis of an expanded program. A few are listed below.

1. A general purpose, off-highway vehicle can be developed, utilizing the concepts and basic designs of the Snowmobile.

2. A combustion engine, involving the motion transformer mechanism is a reality. One has been developed; adaptation can be made to a wide range of sizes from an engine for small cars to an engine for large military tanks.

3. The power lane now used in the Snowmobile can be used in many places. One of the most promising uses is as a power divider in commercial crawler-type tractors. Also, it can be used as a power take-off.

4. The suspension system now used in the Snowmobile has several applications. A modification of this design is now being studied by Thiokol and the Space Technology Laboratory to determine its utility for ground support equipment handling rocket motors.

Development of these real potentials necessitates close support of the Research Foundation by the Engineering Experiment Station and the Engineering staff. In like manner, full development of the program of the Engineering Experiment Station requires the support of the Foundation. The following section outlines an organizational pattern under which this needed cooperative action can be obtained.

RESEARCH ORGANIZATIONAL PLAN FOR ENGINEERING RESEARCH

The organizational pattern shown on the following page has been developed in close council with Mr. James Hardman, Project Director of the Foundation. It will be noted that the program is divided into two basic units; one is under the Utah

Research Organizational Plan

for

Engineering Research

Utah State University

Utah Scientific Research Foundation

Board of Trustees

President

Board of Directors

President

Dean of Engineering

as

Coordinator

Engr. Exp. Sta.

U.S.U. Facilities

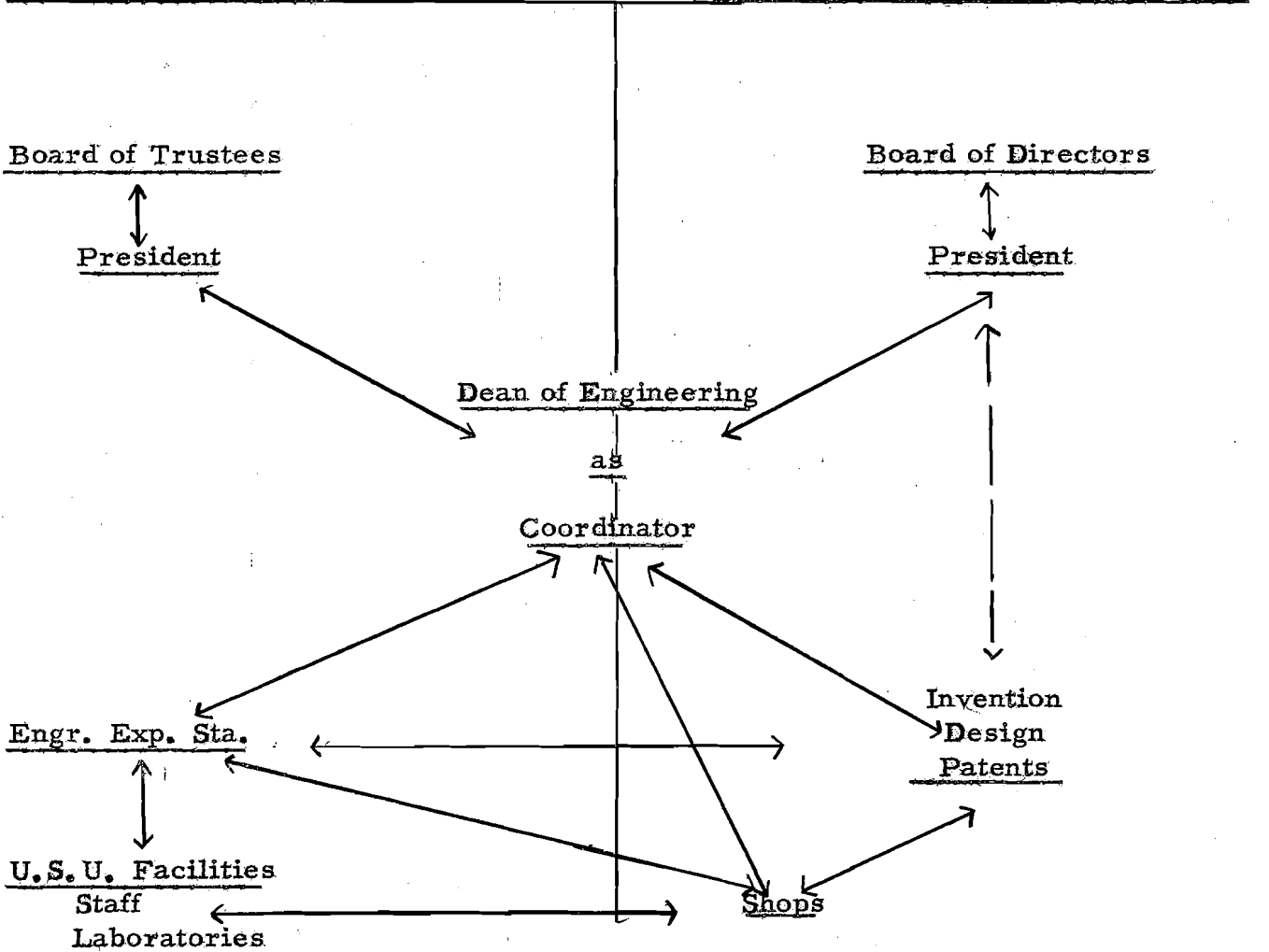
Staff
Laboratories

Invention

Design

Patents

Shops



State University, the other under the Utah Scientific Research Foundation. It is highly desirable to have the two as separate but cooperating units. The key in this coordinated program is the Dean of Engineering, who would represent the presidents of both organizations. The chart outlines two complementary components under the jurisdiction of the Utah Scientific Research Foundation. One is the Invention, Design, and Patent Section, and the other is the Mechanical and Fabrication Shops. However, the shops would be a flexible organization, primarily geared for production and support for the Invention, Design, and Patent Section of the Foundation, the Engineering Experiment Station, and the other facilities of the University.

In order to further facilitate the program of the Foundation, it is urged that a Shop Superintendent be appointed to relieve Mr. Hardman of the detailed duties of this activity, thereby permitting him to devote more of his time to the creative development for which he is so admirably adapted.

The duties and functions of the coordinator are not fully defined in this report. Neither is the necessary authority and staff outlined. These details will need to be formulated by the coordinator utilizing as far as possible the existing staff, facilities, and organizational patterns. However, it will be impossible to obtain a functional, coordinated program unless additional staff time is allocated. This accelerated and expanding program cannot be carried by existing staff.

Another feature implicit in the organization chart is broader representation of the University on the Board of Directors of the Foundation. If the Foundation program is to be strengthened in research, it is essential that at least one, and

preferably two, board member have strong backgrounds in research.

These changes, although not very extensive, will provide the liaison and the implementation of a program which has long been needed. It is strongly recommended that they be adopted at an early date.

NECESSITY FOR WELL-EQUIPPED SHOPS

The Foundation has assembled remarkable facilities for mechanical investigation and for model and prototype development, considering the handicaps under which this growth has occurred. Orders have been placed for additional machinery from government surplus properties, because capacity is needed to implement the growing research program.

Well-equipped shops are essential to an engineering research program, as well as to other research at Utah State University. The development of the Snowmobile and other off-highway vehicles, the new engine, the power lane, and the suspension systems, all require extensive development and experimentation to prove their usefulness and to create a demand so that a successful license can be given for commercial use. Shops and machinery are not only needed for the initial prototype, but limited production is also desirable for two primary reasons: first, modification of a new design can be more easily made and evaluated without jeopardizing patent rights; second, the Foundation needs the profits from models and prototypes to pay for additional research and development and to build facilities.

When returns from patents become appreciable, less need will exist

for production. However, until sizable patent royalties are a reality, the principal financing of the Foundation must come from profits obtained from construction of models and preproduction refinement of units--for without it the Foundation cannot exist.

LAND AND BUILDINGS NEEDED FOR EXPANSION

The increasing program of the research Foundation and the Engineering Experiment Station requires a suitable area where this activity can be conducted. The undesirability of the present location of the Research Foundation is well known. The encroachment of dormitories and buildings for academic instruction near the Engineering Building make this area undesirable. The research development and fabrication program of the Foundation and of much of the other Engineering research will always be noisy and thereby require relative isolation.

The most feasible, and indeed the ideal area for the Research Foundation and for an expanding program of Engineering research is the thirty-two acres of land belonging to Ernest Wuthrich on the "Island" near the Hydraulics and Canal Lining Laboratories. This area is ideally located for several reasons:

- 1) Comparative isolation;
- 2) Proximity to the Hydraulics and Canal Lining Laboratories, both of which will require near-by shops;
- 3) Proximity to the main campus;
- 4) This 32-acre area is sufficiently large to permit expansion

and development for several years without requiring additional purchases of residential properties.

Acquisition of the Wuthrich property is the key to an integrated Foundation and general engineering research program; without it, neither program can sustain but very limited additional growth.

SUMMARY OF MAJOR NEEDS

1. Coordinate Engineering Experiment Station and Utah Scientific Research Foundation

The programs of the Experiment Station and the Research Foundation need to be more effectively integrated. Each organization needs the support of the other. The Research Foundation needs the professional and management assistance that can be offered by the engineering staff, and the Experiment Station needs more effective liaison with the shops and inventive capabilities of the Foundation staff.

There are many reasons why this coordination should be accomplished at an early date.

One of the most pressing needs is the development of the engine utilizing the motion transformer. A contract now pending with the army would be much more favorably received if these two agencies were unified.

Another very pressing reason for coordination is the needs of the Engineering Experiment Station. To implement the program immediately ahead this year, the resources of the Foundation are a necessity.

2. Consolidation of Engineering Research

It is difficult to obtain proper coordination between the research supported by University Research and the research of the Engineering Experiment Station. Usually the project leaders are involved in both programs. However, due to the split administration, the desired flexibility is not present. One of the major advantages of a unified engineering research program would be

2. (Continued)

to permit more flexibility to shift Uniform School Funds from projects where contract support develops to new projects or to projects needing additional support. The operating efficiency measured in terms of research growth would increase considerably by consolidating all Engineering Research.

3. Close Research Tie with Departments of Mathematics, Physics, and Chemistry

Close ties are needed between Engineering and the physical sciences. Each needs the support the other can offer. This suggestion does not mean to imply that all research should be coordinated, but rather that channels of administration need to be established permitting free, uninhibited cooperation.

4. Space for Engineering Research

Plans for the immediate future must include space for engineering research. It will not be long before the existing space will no longer house the research staff and program. The hydraulics laboratory, if significant construction is initiated in the next biennium, will meet the needs in fluid mechanics, irrigation, and drainage. However, the needs in mechanical engineering cannot be met unless additional space is allocated. The Ernest Wuthrich property near the site of the hydraulics laboratory is needed as the nucleus for the mechanical engineering research program. The Foundation should also center here. The programs of the Foundation (the engine, power lane, and special vehicles)

4. (Continued)

would be an excellent spring-board for an effective mechanical engineering research program. Also, the shops of the Foundation need either to be near the hydraulics laboratory or separate shops will need to be built. It would be a duplication of facilities and a waste of potential not to utilize fully the shops of the Research Foundation in the research program of the Engineering Experiment Station.

5. Professional Secretarial Help

An indispensable need exists for professional, experienced secretarial assistance. Sufficient salary must be paid to insure adequate help.

6. Additional Management Staff

The program of engineering research has grown to the point where additional management is indispensable. Numerous prospects for research are developing which cannot be carried to a fruitful conclusion because of a lack of staff time. Existing staff are so loaded with academic programs that they do not have the time to devote to potential projects.

Much of the detail of preparing reports, estimates, and business contacts could be carried by an individual specializing in these matters. Quarterly reports could be published and brochures prepared. Several programs which are now lagging could be implemented.

7. Additional Research Personnel

Additional research personnel are needed to reduce the load being

7. (Continued)

carried by the academic staffs. In most cases, the research projects are being carried without appreciable reduction in teaching loads.

Special effort is being made during 1959-60 to use the limited funds available to give relief to staff members who have been carrying extra heavy loads in order to initiate the research program. However, the demands for staff time for new projects appear to be increasing faster than relief is being offered.

8. Quarterly Engineering Research Reports

Sufficient research is now underway to sustain a quarterly publication. Such a publication would strengthen the entire program and could be very helpful in conveying results of research as well as selling research potential.

9. Weekly Research Seminars

Weekly research seminars should be held, both in Civil and Electrical engineering throughout the fall, winter, and spring quarters. Many advantages would be gained.

10. Bulletin and Report Handling Service

Bulletins and reports written by the Engineering staff need to be assembled and made available for ready access and general distribution.

TABLE 1

Summary of Engineering Experiment Station Program from 1945 to 1960

| Years | Number of Active Projects | Number of Project Leaders | Combined Budget |
|------------|---------------------------|---------------------------|-----------------|
| 1945-46 | - | - | 1,700 |
| 1946-47 | - | - | 3,600 |
| 1947-48 | - | - | 4,200 |
| 1948-49 | - | - | 5,200 |
| 1949-50 | - | - | 4,100 |
| 1950-51 | - | - | 3,700 |
| 1951-52 | - | - | 1,800 |
| 1952-53 | 6 | 5 | 2,900 |
| 1953-54 | 3 | 3 | 2,500 |
| 1954-55 | 1 | 1 | 1,100 |
| 1955-56 | 0 | 0 | 600 |
| 1956-57 | 2 | 5 | 2,000 |
| 1957-58 2) | 16 | 8 | 17,540 |
| 1958-59 3) | 19 | 12 | 71,687 |
| 1959-60 | 21 4) | 12 4) | 96,147 5) |
| | | | 325,007 6) |

1) Combined budget includes moneys budgeted to and spent by the engineering experiment station, contracts and grants, and funds made available through the University Research Program.

2) 1957-58 was the year uniform school funds were first allocated for engineering research.

3) In January 1958 the Engineering Experiment Station was reorganized.

4) Estimates only - Number will increase as the year progresses.

5) Funds which are now available (June 1959) for research.

6) Funds now available and funds for projects under negotiation and for proposals now being prepared.

TABLE 2

Financial Summary of Engineering Experiment Station

| | 1957-58 | 1958-59 | 1959-60 |
|--------------------------|----------------------------------|---|---|
| <u>Engr. Exp. Sta.</u> | | | |
| Operating Salaries | 9,900 <u>8,500</u> 18,400 | 17,700 ¹⁾ <u>16,608</u> 34,308 | 12,400 <u>34,680</u> 47,080 |
| <u>Univ. Research</u> | | | |
| Operating Salaries | 12,780 <u>2,420</u> 15,200 | 14,675 <u>4,878</u> 19,553 | 16,495 <u>7,420</u> 23,915 |
| <u>Contract Research</u> | | | |
| Secured | 2,000 | 38,178 | 3,300 |
| Expended | 500 | 17,826 | |
| Carried Over | | | 21,852 |
| Under Development | | | 25,152 ²⁾ |
| | | | <u>228,860</u> |
| | | | 254,012 ³⁾ |
| Total | 17,540 | 71,687 | 96,147 ²⁾ 325,007 ³⁾ |

1) Including \$6,700 allocated for a quonset building.

2) Funds which are now available for research.

3) Funds now available and funds for projects under negotiation and for proposals now being prepared.

TABLE 3

Contract Research of the Engineering Experiment Station

| | 1957-58 | | 1958-59 | | 1959-60 | | Contr. under Development |
|-------------------------------|--------------|------------|---------------|---------------|---------------------|--------------|------------------------------|
| | Contr. Sec. | Exp. | Contr. Sec. | Exp. | Contr. Carried over | Contr. Sec. | |
| Rainbird | 2,000 | 500 | | 1,500 | | | |
| Portland Cement Co. | | | 5,000 | 2,808 | 2,192 | | 5,000 ¹⁾ |
| Ideal Cement Co. | | | 2,500 | 2,500 | | 2,500 | |
| Utah State Road Commission | | | 4,000 | 1,526 | 2,474 | | 10,000 ¹⁾ |
| Thiokol | | | 5,978 | 5,978 | | | 20,000 ¹⁾ |
| Wellsville | | | | | | 800 | |
| Mendon Canal | | | | | | | 2,500 |
| Behner Block Co. | | | | | | | 5,000 |
| U. S. Steel Co. | | | | | | | 25,000 |
| Morrison-Knudsen | | | | | | | |
| NSF-Back Scatter-Clark | | | 20,700 | 3,514 | 17,186 | | |
| Tidement-Flammer | | | | | | | 21,360 ¹⁾ |
| Surface Irrig-Hansen | | | | | | | 15,000 |
| Tumbling Flow-Peterson | | | | | | | 15,000 |
| Diamond Ord. Fuze Lab - Clark | | | | | | | 25,000 ¹⁾ |
| AF Cambridge-Baker | | | | | | | 65,000 ¹⁾ (2 yrs) |
| Office Naval Res-Clark | | | | | | | 20,000 |
| TOTALS | 2,000 | 500 | 38,178 | 17,826 | 21,852 | 3,300 | 228,860 |

1) These contracts totaling \$146,000 are well along and completion at an early date is expected.

TABLE 4

Total Gross Income of the Utah Scientific Research Foundation, 1955 to 1959

| <u>Year</u> | <u>Amount</u> |
|----------------|---------------|
| 1955 | 118,369 |
| 1956 | 176,828 |
| 1957 | 238,119 |
| 1958 | 228,408 |
| 1959 to May 15 | 77,986 |
| | <hr/> |
| TOTAL | 839,710 |

TABLE 5

Estimated Gross Income of the Utah Scientific Research Foundation during 1959

| | <u>Unit Price</u> | <u>Total Amount</u> |
|---|-------------------|---------------------|
| 1. Jesse Carr, San Francisco, California (1 vehicle) | \$ 6,000. | \$ 6,000. |
| 2. West Coast Transmission Company (1 vehicle) | 6,000. | 6,000. |
| 3. Western Electric (16 vehicles) Does not include spare parts | 7,000. | 112,000. |
| 4. Ballistic Missiles Early Warning System (3 vehicles) | 6,000. | 18,000. |
| 5. Soil Conservation Service (2 vehicles) | 6,000. | 12,000. |
| 6. Federal Electric (30 machines) Does not include spare parts | 7,000. | 210,000. |
| 7. Engine Development | | 100,000. |
| 8. Thiokol (wheel suspension) | | <u>60,000.</u> |
| | TOTAL | \$ 524,000. |

TABLE 6

RESEARCH PROJECTS
ENGINEERING EXPERIMENT STATION

July, 1957 to July, 1959

Civil Engineering Research Project Numbers

| <u>No.</u> | <u>Date</u> | <u>Title</u> | <u>Leader</u> |
|------------|-------------|--|-----------------------------------|
| EC-1 | 7/57 | Pozzolans as a Natural Resource of the State of Utah (U-22) | W. Cordon |
| EC-2 | 7/57 | Ability of Concrete made from Materials of the State of Utah to Resist Deterioration by Freezing and Thawing | W. Cordon |
| EC-3 | 7/57 | Testing and Training Program in Concrete and Bituminous Materials | W. Cordon |
| EC-4 | 7/57 | Hydraulics of Surface Irrigation (U-82) | V. Hansen |
| EC-5 | 7/57 | Evaluation of Ground Water Problem in a Non-homogeneous, An-isotropic Media Using a Variable Resistance | V. Hansen |
| EC-6 | 7/57 | Development of Low-cost Equipment for Water Measurement | V. Hansen |
| EC-7 | 7/57 | Negative Skin Friction along Piles due to Consolidation of Surrounding Clays | R. Watkins |
| EC-8 | 7/57 | Investigation of the Hydraulic and Mechanical Characteristics of Sprinklers | V. Hansen |
| EC-9 | 7/57 | Mathematics of Steady Flow toward an Unconfined Well (U-81) | V. Hansen |
| EC-10 | 7/57 | Development of Equipment to Determine Resistance to Denting Characteristics of Aluminum Pipe | J. Bagley E. Rich V. Hansen |
| EC-11 | 7/57 | Irrigation Principles and Practices | O. Israelsen |
| EC-14 | 1/58 | Evaluation of Gravel Envelopes for Wells | D. Peterson |
| EC-15 | 1/58 | The Dynamics of Tumbling Flow (U-80) | D. Peterson |
| EC-16 | 1/58 | Deflection of Rocket Adapters Under Static Loads | R. Watkins |

TABLE 6 (continued)

Civil Engineering Research Project Numbers
(Continued)

| <u>No.</u> | <u>Date</u> | <u>Title</u> | <u>Leader</u> |
|------------|-------------|--|----------------|
| EC-17 | 1/58 | Basic Properties and Quality Control of Concrete and Concrete Mortars (U-83) | W. Cordon |
| EC-18 | 1/58 | Coupling for Flexible Pipe | V. Hansen |
| EC-19 | 7/58 | Relative Productive Value of Land | V. Hansen |
| EC-20 | 7/58 | Effectiveness of Evaporation from Ground Foliage in Reducing Soil Moisture Depletion | V. Hansen |
| EC-21 | 7/58 | Measurement of Flow from a Horizontal Pipe by the Coordinate Method | V. Hansen |
| EC-22 | 7/58 | Mechanics of Transpiration | V. Hansen |
| EC-23 | 7/58 | Durability of Soil-cement Constructed of and on Sulfate Soils --Portland Cement Association | W. Cordon |
| EC-24 | 7/58 | Quality Control of Concrete for Utah Highways | W. Cordon |
| EC-25 | 10/58 | Ideal Cement Company Fellowship | W. Cordon |
| EC-26 | 3/59 | Development of Irrigation Water Meter | J. Christensen |
| EC-27 | 4/59 | Seepage Losses in Wellsville-Mendon Canal | A. Bishop |
| EC-28 | 4/59 | Hydraulics of Flow in Sprinkler Systems | J. Christensen |
| EC-29 | 7/58 | The Influence of Basic Soil Characteristics on Mechanical Performance of Flexible Cylinders Embedded in Soil Fill (U-84) | R. Watkins |
| EC-30 | 7/59 | A Study of the Effect of the Properties of Various Natural and Manufactured Sediments on the Attenuation of an Ultrasonic Plane Wave Passing Through a Sediment Suspension (U-100) | G. Flammer |

General Administrative

| | | |
|------|----------------|-------|
| ES-1 | Administration | Staff |
|------|----------------|-------|

TABLE 6 (continued)

General Administrative

| <u>No.</u> | <u>Date</u> | <u>Title</u> | <u>Leader</u> |
|------------|-------------|---|---------------|
| ES-2 | | Development | Staff |
| ES-3 | | Development of Hydraulics Laboratory | Staff |
| ES-5 | | Utah Scientific Research Foundation - Cooperative Grant | |

Electrical Engineering Research Project Numbers

| | | | |
|------|------|--|----------------------|
| EE-1 | 7/57 | Report on a Development in New Metal Soil Contacts to Reduce Electrical Resistance (U-21) | B. Watkins |
| EE-2 | 7/57 | Introduction to Electrical Engineering (Book) | B. Watkins |
| EE-3 | 7/57 | A Study of Upper Atmosphere Ionization Patches by Radio Methods (U-30) | C. Clark L. Cole |
| EE-4 | 7/57 | A Snow Survey Telemetering System(U-79) | L. Cole |
| EE-5 | 7/57 | The Development of Equipment and Techniques for Electro Fishing (U-50) | L. Cole |
| EE-6 | 1/58 | Development of Stabilization Technique and Design Procedure for High Temperature Operation of Germanium Transistor Power Amplifiers (U-85) | W. Jones |
| EE-7 | 1/58 | Use of Mobile Electric Generators on the Farm | B. Embry |
| EE-8 | | Electromagnetic Resonance in Multiple Dipole Antenna Structures | C. Clark W. Jones |

Industrial Engineering Project Numbers

| | | | |
|------|------|---|------------------------|
| EI-1 | 1/58 | Evaluation of the Variable Factors Resulting from Altitude Correction in Automotive Carburetion | O. Slauch R. France |
|------|------|---|------------------------|

TABLE 7

Research Studies 1952-57 - Engineering Experiment Station
1952-53

| Title of Research | Conducted by | Supervised by | Cooperation | Year Completed | For Degree | Published | Possibility of further work |
|--|---|------------------|---|-------------------|---------------|-----------|---------------------------------------|
| A Study of Logan Sewage --its disposal and use as irrigation water | W. B. Shrieder | Bishop | Equip. Engr. Exp. Sta. City of Logan Cow Pasture Irriga- tion Co. \$300. | 1955 | Masters | No | Further follow up work. Summary |
| The Development of a Large Scale Electrical Fish Collection Apparatus | W. F. Sigler L. S. Cole Clayton Clark | | Wildlife Man. Elec. Eng. Dept. 3 years \$1800 | 1956 | | Yes | Yes Wildlife Journal |
| Infiltration in Furrow Irrigation as Affected by Furrow Shape, Size of Stream and Moisture Level in the Soil | C. T. Bourns | Hansen | Agron. Dept. Agric. Exp. Sta. Eng. Exp. Station \$1100 Soil Cons. Service \$1500 | Underway | Ph. D. | | |
| Effect of Temperature and Time of Freezing on Strength of Concrete | C. Bolingbroke M. Jensen | Christiansen | Eng. Exp. Sta. \$1400 | 1957 | Masters | | Yes |
| Effectiveness of Evapor- ation from Ground and Foliage in Reducing Soil Moisture Depletion | V. Wynn | Hansen | Ames Co. \$800 Agric. & Engr. Exp. Sta. \$250 Div. of Soil Management \$125 | 1954 | Masters | No | Should be published |

TABLE 7 (continued)

| 1952-53 (continued) | | | | | | | |
|--|-----------------|----------------|--|----------------|------------|-----------|-----------------------------|
| Title of Research | Conducted by | Supervised by | Cooperation | Year Completed | For Degree | Published | Possibility of further work |
| Soil-Moisture Depletion Patterns in the Root Zones | U. Patil | Hansen | Eng. Exp. Sta. \$250. Div. of Soil Management \$250. | 1954 | Masters | No | Should be published |
| 1953-54 | | | | | | | |
| An Investigation of Friction Losses in Fittings and Valves for Portable Sprinkler Irrigation Equipment | N. Paholyohn | Bishop Greaves | Eng. Exp. Sta. Irrig. Equip. Co. \$1000 | 1954 | Masters | No | No |
| Analytical Study of Determinates of Seepage Line in Earth Dams | S. Rizvoi | Greaves | Equipment Purchase | 1954 | Masters | | |
| Soil Moisture Depletion Patterns in the Root Zones | Patil | Hansen | Equipment | 1954 | Masters | | |
| 1954-55 | | | | | | | |
| Stability of Rocky Ford Dam | J. Christiansen | Greaves | Equipment | 1955 | Masters | | |
| 1956-57 | | | | | | | |
| Classification of Hard-Facing Alloys for Agricultural Use | C. Bowman | Hansen | Eng. Exp. Sta. 1 | 1957 | Masters | | In process |
| Particle Size Distribution and Stability of Bitumen Mixtures | K. Subbayya | Cordon | Eng. Exp. Sta. | | Masters | | |

TABLE 7 (continued)

1956-57 (continued)

| Title of Research | Conducted by | Supervised by | Cooperation | Year Completed | For Published Degree | Possibility of further work |
|--|-----------------|------------------|--|-------------------|-------------------------|--------------------------------|
| Pozzolans as a Natural Resource of the State of Utah | Students | Cordon | Eng. Exp. Sta. | 1957 | | |
| Hydraulics of Surface Irrigation | J. Bondurant | Hansen | Engr. Exp. Sta. Equip. Purchases | 1958 | Ph. D. | |
| The Maintenance of a Steady Soil Moisture Content During non- steady Extractions by Plants | J. Wolfe | Hansen | Eng. Exp. Sta. Equip. Purchases | | Ph. D. | |