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THE APPLICATION OF ENGINEERING TO THE AGRICULTURAL INDUSTRY[1]

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IN a recent discussion of trends in business, Merle Thorpe, editor of *Nation's Business,* said that the first quarter of the twentieth century would probably be known as the age of mass production.

With the great industrial developments so immediately before our eyes it seems unnecessary to make further mention of them here. Rather it is our intention to speak regarding the progress which has been made in the agricultural field and the obligation of the engineer in helping it to keep pace with other enterprises. William M. Jardine, former secretary of agriculture, once said, "Could the farmer of the Pharaohs' time have been suddenly reincarnated and set down in our grandfather's wheat-field, he could have picked up the grain cradle and gone to work with a familiar tool at a perfectly familiar job." Imagine the amazement of the ancient Egyptian if he were to be set down in a present-day wheat-field with the combined harvester-thresher in full operation.

Less than a century ago more than 90 per cent. of our total population were directly dependent upon agriculture for a livelihood. In 1928, with fewer than 24 per cent. directly dependent upon the industry, our nation produced a surplus of agricultural commodities. American agriculture may be said to have had three power epochs: (1) human, (2) animal, (3) mechanical. The change has brought not only a more efficient production but also a relief from the drudgery and monotony which doubtless contributed to the encouragement of slavery.

Mechanization of agriculture has made the Ameri-

[1] Paper read before Section M—Engineering, American Association for the Advancement of Science, Des Moines, Iowa, December 30, 1929.

can farmer the most efficient farmer in the world. According to data compiled by the division of agricultural engineering, Bureau of Public Roads, U. S. Department of Agriculture, the estimated total primary horse-power available on farms increased from approximately seven millions in 1850 to nearly 47½ millions in 1924. The direct relationship between power used and the value of crops produced is strikingly shown in the following table.[2]

Country or state	Primary power per agricultural worker	Value of crops produced annually
Italy	.19	$ 45.00
France	.37	90.00
Germany	.55	119.00
United Kingdom	.88	126.00
Alabama	.81	112.00
New York	1.69	250.00
Indiana	2.46	365.00
Iowa	3.86	595.00
Nebraska	4.71	910.00

According to Davidson,[3] the United States exports rice in increasing amount to China. Here we have the extreme in contrasts; rice production in China by hand labor at a low wage, fifteen cents a day, and rice production in California by machine methods with the highest-priced agricultural labor in the country, or fifty to sixty cents an hour with "found." The Chinese laborer boards himself. Is it reasonable to believe that engineering will continue to contribute to the progress and development of agriculture? Engineering more than any other factor has enabled the American farmer to compete with foreign competitors. A few years ago several German scientists visited this country, and the outstanding feature of their report on American agriculture was the large production per worker.

Nevertheless, the increased production per worker in agriculture has not kept pace with that of many of the other industries, and the return to the individual worker has been a problem which has received the serious attention of our federal government. In the final analysis, the returns per worker are of greatest importance in establishing a stabilized situation. The American Farm Bureau Federation has adopted the slogan, "A higher standard of living on the farm and an income from the farm to pay the bill."

Davidson has expressed the relationship by the simple equation, $I = (S - C)\ Q$, in which I signifies the income, S the selling and C the cost price of the farm produce and Q the quantity produced. Obviously I can be increased by increasing S or Q or by decreasing C. S is difficult to control especially when agricultural products are produced on some six million farms. Competition is severe in agriculture since we have not only the competition of individuals in our own country but also a stimulation of production in other countries. Prices raised by legislative action are likely to be short lived as a relief measure. Increased prices are always followed by increased production and land prices. Increased production usually leads to overproduction, a glutted market and falling prices. An increase in the efficiency of production probably offers one of the most encouraging possibilities of increasing the income of the individual.

This through the decrease of C or the increase of Q in the formula becomes, or may become, very largely a problem for the agricultural engineer.

The primary function of the agricultural engineer is to determine, recommend and promote the best solutions of engineering problems peculiar to the agricultural industries. His responsibility is—through modern operating equipment and practices—to aid in developing higher efficiency and greater productive capacity, thus making agriculture more profitable, lifting the burden of drudgery from agricultural people and raising their standard of living. Recognizing this, the American Society of Agricultural Engineers, as the national organization representing the agricultural engineering profession, has adopted the following platform as a statement of its objectives and of the principles and policies governing its activities.

"Engineering is the science of controlling the forces and utilizing the materials of nature for the benefit of man, and the art of organizing and directing human activities in connection therewith." Agricultural engineering deals with the application of the fundamental branches of engineering to the specific conditions and requirements of agriculture as an industry, as a mode of life and as a field of applied science. Subdivided on the basis of engineering technique, it now embraces (1) power and machinery, including rural electrification, (2) buildings and other structures, including sanitation, materials of construction and equipment, and (3) land reclamation, including irrigation, drainage, soil erosion control and other forms of mechanical improvement of agricultural lands.

An agricultural engineer is one who has been trained in both engineering and agriculture with experience in combining the two, and who is qualified to develop, design, organize and direct engineering

[2] Taken from Bul. 1348—U. S. Department of Agriculture, p. 17.

[3] J. B. Davidson, "Agricultural Engineering," *Journal of Engineering Education*, New Series, Vol. XIX, No. 3, November, 1928.

work of or closely related to the agricultural industries.

Agricultural engineering is fostered by land-grant institutions. Thirty-seven of forty-eight agricultural colleges in the United States provide agricultural engineering training to five thousand agricultural students annually. Technical engineers for this field are trained in seventeen of these institutions. Research work in this field is conducted by 103 full-time workers in thirty-four institutions.

FARM STRUCTURES

According to the latest census figures, the American farmer maintains a total investment in farm buildings of $11,750,000,000. How much it would cost to replace these buildings at the present time would be difficult even to guess. In order to maintain the buildings which he deems necessary for his farm, he spends several millions of dollars every day of the year. Unfortunately this money is often not well spent. Materials are frequently used where they are not at all suited, and sufficient consideration is not given to the actual requirements of the product housed.

With the recent agricultural depression the soundness of the farmer's investment has been seriously questioned, and since buildings appear to afford the easiest method of reducing his overhead, those in position to advise may have been guilty of preaching false economies in building construction. How many times has he been urged to reduce the cost of his buildings without due regard to the effect which this reduction might have on production or annual depreciation?

Industry buys equipment on a production cost basis. The ability of a given machine to bring returns is just as important a consideration as its original cost. A seemingly cheap machine may prove to be very expensive when its influence on production, labor, length of productive life and other factors are considered. Farm buildings constitute a part of the farmer's working equipment and deserve to be evaluated upon a production cost basis. The cost per quart of milk is more important than the cost per cow or the cost per barn. This attitude does not infer that we should neglect beauty or harmony in design, which have a very direct bearing upon morale, but that the emphasis should be put upon the securing of lower production costs by giving attention to management and fundamental housing requirements. The manner in which the farm building problem is handled is reflected in labor of operation, the quantity and quality of production and, in the case of stored products, the preservation for future needs.

One of the serious problems for farm management is that of labor. I am told that this is particularly true in the dairy industry. Recent studies show that the labor involved in dairying may be increased upwards of 30 per cent. by faulty arrangement of the barn and its relation to the other buildings in the farmstead. Fortunately it costs no more to arrange a barn efficiently. Often the saving in labor alone may be as large as the entire charge which may be placed against the dairy cow for rental.

If one expects to make dairying profitable, can he afford to neglect to plan the layout of his farmstead to assure efficiency in the use of labor?

The dairy cow is a warm-blooded animal. She may be likened to an engine operating under a fairly constant temperature. Fuel burned within the body generates heat which tends to raise the body temperature. She is provided with certain automatic means which dissipate this heat in order to keep the body temperature constant. Heat is radiated from the body surfaces. Moisture evaporated from the skin and thrown off by respiration carries off relatively large quantities of heat and helps keep the body temperature down. The rate at which this process goes on depends very largely upon the environmental conditions of air temperature, relative humidity and rate of air movement. If their combined effect is greater than the normal heat production of the body, more fuel must be consumed or body tissues destroyed to maintain comfort.

Experienced dairymen say that stable temperatures affect milk flow, and a cold spell may reduce the production by 5 per cent. or more. This reduction is frequently not temporary but continues throughout the current lactation period. Heavy feeding may prevent this reduction but is in itself an additional expense.

When it is considered that the total charge against the cow for housing is usually less than 10 per cent. of the total cost of producing milk, it may readily be seen that any attempt to reduce the cost of barn construction below the point where it satisfies the housing requirements may increase other cost factors more than is saved in building.

One might elaborate to show how buildings may affect returns in other lines. Egg production reflects the comfort of the birds. Grains are matured and preserved, horticultural products are kept in prime condition and the marketing period materially extended by proper housing. Whether it be housing live stock, grains, fruits or vegetables, there are definite requirements placed upon the building by the product itself which must be met if the building is to fulfil its obligation to the farmer. In general, these problems relate to the efficiency of operation, the maintenance of effective production and the preservation or conservation of farm products.

Unfortunately, many of the fundamental housing requirements are not definitely understood. The importance of the building has not been fully appreciated. The small, scattered units have not attracted sufficient competent study. The comparatively long life of the buildings tends to minimize interest in the study of the problem.

Buildings are frequently constructed of materials produced on the farm or purchased in a semi-fabricated condition. More careful attention is then required than would be necessary in the case of machinery which has been manufactured and assembled by specialists and comes to the farmer all ready for operation. If the farm housing problem is to be solved in a way that will bring commensurate returns and constitute an investment rather than a liability, it is necessary that there should be a careful analysis of building methods.

The three major factors of design, construction and maintenance claim our attention. Utility being paramount, we should know definitely the requirements placed upon the building by the products housed. What environmental conditions does the dairy cow need in order to produce milk most efficiently? How can we house the hen so that she will lay eggs when egg prices are favorable? Is ventilation necessary, and if so, how can it best be accomplished? What are the sanitary requirements for producing clean milk and maintaining a healthy herd? What insulation is advisable? How can the building be constructed most effectively and economically?

While it may be difficult to put a cash value upon beauty and harmony, they are very important items in maintaining a wholesome atmosphere on the farm. How can the farmstead be made attractive without adding unduly to the cost?

Methods of construction should be carefully studied in order to obtain a building which will provide these requirements at a minimum cost.

The influence of destructive agencies must be understood if we are to build in a way which will lower the depreciation cost.

Since little information is now available, the solution of these questions calls for an extensive research program. Evidently the farmer as an individual can not conduct his own researches efficiently. The small units and scattered field have not been generally profitable to the architect, and the farmer will not usually employ professional service. A program of this kind is logically the responsibility of publicly supported agencies such as the land grant colleges and the U. S. Department of Agriculture.

Power and Machinery

The agricultural industry is a tremendous user of power. However, the nearly 50,000,000 horse-power available is not being utilized to its greatest efficiency. Engineering attention is necessary if we are to secure lower production costs through the more economical use of power. Farm equipment design and the mechanization of farm operations now done by hand offer possibilities which challenge the best effort. There has been great progress in the harvesting machinery, but much still remains to be done. The use of electricity as an agricultural power has gained considerable prominence recently. Much investigational work is now being conducted to find the most practical methods of using electrical equipment.

Land Reclamation

The agricultural engineer is interested in the improvement of land in so far as such improvement leads to lower cost of production. At the present time this means chiefly the improvement of land already being cultivated. Often economical cultivation is prevented by wet spots, open ditches, stumps or other conditions that prevent effective tillage or occupy land that otherwise could be cultivated.

Five types of problems are included: protection against stream overflow, drainage of wet land, irrigation of dry land, control of soil erosion, clearing of land obstructed by stumps or stones.

The agricultural engineer, as the term implies, is active primarily in the engineering relationships of agriculture. That engineering has had a profound and far-reaching influence on many of the developments in agriculture, especially during the past twenty years, is widely recognized. Engineering has been responsible, in a large measure, for creating a situation in agriculture comparable to that in manufacturing fifty years ago, when great industrial development in America had its real beginning. The evolution now going on in the agricultural industries emphasizes the importance of the engineering relationships and the increasing engineering responsibilities. The American Society of Agricultural Engineers therefore has pledged its activities to the further development and strengthening of the engineering relationships in agriculture and to the adaptation of the science and art of engineering to agriculture, to the end that the people engaged in farming may have increasingly better means for achieving a more stable prosperity and higher standards of living.