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WORK SIMPLIFICATION IN AGRICULTURE

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EFFICIENT agricultural production involves intelligent management decisions in two broad areas: (1) what to do, and (2) how to do it. Knowledge in these two areas is an essential prerequisite to the making of intelligent decisions. Scientific advancement in the area of what to do has provided the knowledge or facts for much of the increase in the efficiency of agricultural production.[1] Of key importance are principles of farm organization, advances in plant and animal breeding and nutrition, and the substitution of mechanical power for human energy. Organized research and education in how to do farm jobs have been incidental to the advances in farm organization and production sciences. In fact, acceptance and use of discoveries of the production scientists are sometimes inhibited by the farmer's inadequate knowledge of *how* to use these innovations. The cultural lag between the time a desirable new technology is developed and the time when it is placed into general use is frequently greater than is generally realized.

Most farmers learn how to do jobs primarily through the apprentice system, or by trial and error. On the other hand, many industrial workers receive definite on-the-job instruction. Industrial engineers have established methods or motion and time study departments as a part of their programme of scientific management. These departments search out and teach workers easier, better ways to do jobs.

Could easier, more effective, and economical ways of doing farm jobs be searched out, developed, and put into use? For example, could work methods for caring for a dairy cow in 60 hours rather than in 140 hours a year be developed and taught? E. C. Young and his associates both in agriculture and industrial engineering at Purdue University agreed that the answer was 'yes'. Limited earlier studies both in the United States and in other countries[2] supported this

[1] In terms of man's efficiency, output per agricultural worker in the United States rose about 70 per cent. from 1910 to 1940. Almost half of this total gain occurred during the thirties. Further substantial gains have occurred since 1940.

[2] Notably the work of J. J. W. Seedorf and associates in Germany. See 'Methods and Results of Research Work on the Efficiency of Human Labour on German Farms', *Proc. of Int. Conf. Agr. Econ.*, 1930.

conclusion. Accordingly, in 1944, research and educational programmes in farm work simplification were established on a cooperative basis in twelve states.[1] As is shown later, these programmes have, for the most part, achieved their objectives.

Farm management research has long shown wide variations in labour accomplishment among individual farmers—even where resources, production rates, and enterprise combinations are comparable. This variation is due, at least in part, to differences in work methods used—how the job is done. Work simplification research therefore searches out, develops, and makes available for use the easiest, most effective, and economical way to do a job. The ultimate objective is to reduce the labour and cost of doing a job. As a means of achieving lower unit costs, work simplification attempts to:

1. Eliminate all unnecessary work.
2. Determine the easiest, most effective methods and sequences for performing the necessary work, recognizing that situations vary from farm to farm.
3. Determine the most convenient and economical combination of tools, equipment, and facilities needed for effective job performance.
4. Standardize, in so far as possible, improved work methods and establish standards of performance as a guide to other workers.
5. Apply improved methods, techniques, and standards of accomplishment by preparing instructions on how to do certain jobs most effectively, and developing and teaching the principles and guides for improving the work methods used on any job.

RESEARCH PROCEDURE

Agricultural economists and agricultural engineers have directed most of the work simplification projects in the United States. Most of these men received special intensive training in industrial motion and time study methods of analysis. They therefore have at their command the research techniques of economists and of motion and time study workers. This is reflected in the five-step work simplification research procedure which has evolved: (1) define the problem; discover, describe, and measure existing methods; (2) appraise the effectiveness of existing methods; (3) develop improved methods;

[1] This experimental research programme, headed by E. C. Young at Purdue University, was made possible in a large measure by a grant-in-aid from the General Education Board. Since 1945 work simplification activities in the various states have gone forward without outside financial assistance. Some twenty states are now doing research and educational work along work simplification lines.

(4) test conclusions; and (5) make proven developments available for general use. A brief explanation of the techniques used in accomplishing these five steps follows.

1. *Define the problem; discover, describe, and measure existing methods.* The obvious starting-point in research is the definition of the problem. The work associated with a crop or livestock enterprise has been the usual starting-point, although several studies have been narrowed down to one or more jobs.[1] Other studies now under way examine the performance of one function for all enterprises, as water distribution, grain processing, roughage storage, or feed distribution. This type of study is sometimes desirable because the economics of changing a work method can be evaluated for the farm business as a whole, and is not limited to one enterprise.

Having selected a job or series of jobs for study, the different work methods in current use should be inventoried and described. This is probably best accomplished through a work methods survey.[2] Enough records should be taken to familiarize the researcher with the work, the farmers' problems, and the variety of existing practices, equipment, and methods.

To collect data for the measurement of existing methods, detailed input-output case studies are made. Usually these cases are selected from the survey group to represent the different work methods known to exist. The total number of cases is usually small, as the objective of the analysis is to seek out and develop improved methods, not to establish a normal distribution.

An adaptation of certain motion and time study techniques is used in the collection of the data. Most of the information on the case studies is obtained by direct observation. If space relationships are important a layout sketch[3] is made. As most farm work involves the movement of a worker from place to place, process charting[4] is

[1] A job is any definite, complete piece of work such as milking or feeding cattle. It includes one or more operations.

[2] In a few studies, committees of farmers have been called together to describe and discuss work methods in common use. This technique may enable the researcher to discover variations in methods more quickly and easily than by making numerous farm visits.

[3] A layout sketch is a scale drawing of the arrangement of facilities involved in the work process (farmstead, building, or farm layout) which shows locations, arrangements, chore paths, and other space relationships.

[4] The process chart is sometimes called a job-breakdown. It is a chronological outline and description of the operations involved in doing a job. Distances travelled, quantities or kinds of materials handled, and time consumed are usually recorded alongside a brief word description of each operation. The original process chart is made by the researcher as he observes the worker or workers actually doing the job under study. A ruled sheet of paper with columns for time readings, operation description, distance, and notes is commonly used in making a process chart.

almost essential. On the process chart objective measurements of area (acreage, distances, dimensions), quantities (pounds, bushels, tons, gallons), and time are recorded as the work progresses. The work process is broken into subdivisions to the extent feasible for the work under study. That is, the process is divided into its component jobs. Likewise, the jobs are usually subdivided into individual operations.[1] Finally, on crew work or repetitive hand work, operations are sometimes further subdivided into work elements.[2] To obtain even more detailed data, original records are often made in the form of 16 mm. motion pictures. From these the process chart can be made. Each job may be analysed in as great detail as desired for time, travel, method, and accomplishment by projecting the film, one frame at a time, with a special projector.[3]

Using these techniques, the physical inputs and outputs—man-labour, equipment and machinery use, materials, and amount of work accomplished—are measured. If the farmer's actual monetary costs and returns (not just time, travel, and quantities) are to be reported, his equipment values, labour rates, building charges, materials costs, and product prices must also be obtained.

2. *Appraise the effectiveness of existing methods.* Effectiveness is appraised by comparative analysis of data collected and by checking methods used against tested principles of work economy. Comparison may be made on an input-output basis by calculating such factors as labour (time, machine work) per unit of output, travel per unit of output or per animal, and cost per unit. Advantages and disadvantages of different work methods which are not measurable objectively, as flexibility and ease, are listed. Quality of work may also be evaluated, perhaps by testing samples of the product. A comparison of the number and kind of work-elements entering different

[1] An act performed as a part of a job is an operation. To do the job of feeding the hogs, for example, these operations may be performed: walk to crib, fill basket, carry basket of grain to hogs, empty basket, return to crib.

[2] Work elements are subdivisions of complete operations. They are usually made up of as small a group of motions as it is possible to define in a few words or time accurately with a stop watch. A great variety of individual operations may be broken down into work elements, as: travel loaded, travel empty, work in place, unavoidable delay, avoidable delay, &c.

[3] Fundamental motions, therbligs, are found in this manner. A therblig is the 'true' work element from which all other elements, operations, and jobs are built. The term 'therblig' refers to any one of the eighteen elementary subdivisions of motions defined by the Gilbreths. While the motion-picture camera provides an excellent means of collecting data, its use for job analysis research purposes should be restricted to the filming of operations where greater detail is desired than can be accurately recorded from direct observation. Film analysis has been helpful in agricultural studies of hand harvesting, processing, and tobacco work.

methods of doing work may reveal some of the reasons for differences in accomplishment. Proportion of time consumed in delays, idleness, working in place, empty travel, and productive travel may be related to output.[1]

Such a comparative analysis of work methods may in itself provide farmers with data previously unavailable. It is essentially an extension of orthodox farm management techniques into detailed studies of individual jobs. The check-list analysis goes a step farther. The tested principles of motion economy, effective utilization of equipment, good layout, proper flow of materials, and good work sequence, in themselves may explain why one method is easier, quicker, cheaper, or more effective than another. By systematically questioning each work method, either by actually using check-list questions or by subconsciously applying the principles, the researcher compares observed methods with tested principles of effective work and good working conditions. Knowledge of the common-sense principles involved is more important than systematic check-list questioning. Printed check lists are available for this purpose.[2]

3. *Develop improved methods.* If the analysis goes no farther than to describe the most effective method found for doing a job and explains why that method excels, the better method may be transplanted to other farms. Usually, however, opportunities exist for improving even the more efficient work methods observed if creative thinking is attempted. In this creative work the researcher, from his observations, analysis, and knowledge of the principles of effective work, formulates hypotheses for the improvement of the better work methods which were observed. These three approaches are being used:

First, a new method may be developed from the better parts of methods observed. Comparative analysis usually shows that no one farmer performs all of the jobs in a process, or all of the operations in a job, in a superior manner. Farmer A does part of the work well, while farmer B has a more efficient method of performing another part of the work. Therefore it is possible to synthesize a new work

[1] An Indiana study of tomato-picking methods revealed that 70 per cent. of the expert picker's time was consumed in moving the hands from vine to picking container and from container to vine (hand travel loaded and hand travel empty). An improved method was developed to decrease this travel requirement. Faulty crew organization and work methods were responsible for individual members of a Kentucky tobacco harvesting crew spending as much as 75 per cent. of their time on 'avoidable delay'.

[2] For an industrial list see M. E. Mundel, *Systematic Motion and Time Study*, New York, Prentice Hall, 1946. For an agricultural adaptation see L. S. Hardin, *Study Your Own Farm Work Methods*, Purdue Exp. Sta. Circular 307, 1947, Lafayette, Indiana.

process or a new way of doing a job from the better parts of observed methods studied in comparative analysis.

Second, the routine check-list analysis often suggests possibilities of improvement. Innovations such as elimination of unnecessary operations or delays, combination of separate elements into a new operation, and sequence rearrangements usually suggest themselves after observation. These innovations may or may not have been observed on other farms.

Third, the need for non-existent facilities, equipment, or small tools may be suggested by the analysis. Equipment occasionally is invented or a device from another field is transferred in an attempt to develop a new, improved method of doing a job. Equipment conceived in this manner frequently enjoys rapid and widespread adoption because its design is based upon a careful analysis of the functions it is to serve and the area in which it is to operate. Agricultural engineers should assist with equipment and layout problems. Equipment developed in work simplification research has thus far been primarily small hand tools and facilities within buildings.[1]

4. *Test conclusions.* Proposed changes can be checked on a laboratory basis by developing a process chart for the new method and comparing it with the old. Synthetic charts for new methods often include some estimates. Estimates are usually limited to a few elements or small operations of a job, and the total time, travel, and cost requirements thus developed have generally given reliable indications of the possibilities of the new method.

If this 'synthesized' test shows the new method to have promise, a worker or workers are then trained in the new method. After practice, workers are timed while actually performing the work according to the prescribed new method. In this way supervised case-tests or controlled experiments prove or disprove the validity of the conclusions drawn.[2]

5. *Make proven developments available.* Improved methods have been carried to farmers on a demonstration basis, through motion pictures,

[1] In Kentucky a one-man plant bed board (for pulling or weeding tobacco plants), a new hook-type topping and suckering knife, a self-releasing hook for lowering tobacco, and an improved type of cutting and splitting knife have been developed. As a result of Florida celery studies, a new type of field crate, a crate-closing device, and a new type of packing table have been developed.

[2] In Kentucky, where tobacco plant pullers average around 1,200 plants per hour, a totally inexperienced worker, after one half-day's practice following the suggested procedure, pulled 1,560 plants per hour. An experienced worker, whose previous output was 970 plants, pulled 1,550 plants an hour using the new method. An above-average worker, whose previous average was 1,660 plants, pulled over 2,500 using the new method.

slides, and publications. Some demonstrations have actually been detailed 'before' and 'after' studies.

If the work involved is relatively uniform from farm to farm, as in hand-harvesting, definite step-by-step instructions may be distributed. Detailed instructions may be accompanied by working standards stating expected accomplishment per unit of time for the method described.[1] If farm-to-farm variation exists in physical facilities or in size and type of enterprise, suggestions and general guides to improvement may be given.[2]

BASIC LABOUR CONSUMERS

On analysis we find that most work may be classified under one of these three headings:

1. *Movement of worker from place to place.* By this travel the worker merely gets himself to the place where he does the work. Such travel is time-consuming, particularly in chore work.

2. *Movement of materials and equipment.* To produce a crop, equipment is moved to the field. The soil is moved over and over in ploughing, fitting the seed bed, planting, and cultivating. Fertilizers, seeds, and insecticides are moved too. When mature, the crop is moved off the plant to storage or to market. Movement of materials is the big energy- and time-consumer in agricultural work.

3. *Work in place.* In this type of work only part of the body is moved, as in milking a cow, cleaning eggs, and repairing machinery.

If farm work is made up of these three users of labour, what determines the worker's rate of output? Production rate on any job is broadly determined by the work method used and rate of worker activity[3] (assuming that amount and quality of resources are

[1] Examples: I. R. Bierly and E. V. Hardenburg, *Suggestions on How to Pick Up Potatoes*, Cornell Ext. Bul. 656, 1944, Ithaca, N.Y.

J. W. Oberholtzer, *Making Movements Count in Picking Tomatoes*, Purdue Ext. Leaflet 258, 1944, Lafayette, Indiana.

G. B. Byers, E. J. Nesius, and Earl Young, *Easier Ways To Do Farm Work*, Series of University of Kentucky Ext. Leaflets on Tobacco, Nos. 75, 76, 79, 84, 86, 90, 92, 1944, 1945, Lexington, Kentucky.

[2] Examples: R. M. Carter, *Modern Milking Methods*, Vt. Ext. Circular 111, 1944, Burlington, Vt.

J. W. Oberholtzer and L. S. Hardin, *Simplifying the Work and Management of Hog Production*, Purdue Exp. Sta. Bul. 506, 1945, Lafayette, Indiana.

[3] In collecting data on time requirements for different workers to compare and analyse work methods, rate of worker activity should be taken into account. Actual time requirements for defined methods are sometimes adjusted to 'normal' or 'standard' times by levelling. In taking the time record the worker's pace is rated in per cent. of normal. Normal speed is the unstimulated effort of a normally competent person doing a job correctly by a given method. Books on time-study explain the several rating procedures in detail.

held constant). Work simplification is directed towards easier, better ways of working, not towards working harder or faster. How fast a man works depends upon his skill, physical condition, effort exerted, and working conditions. But work methods may be changed regardless of the worker's rate of activity. Movement of the worker may be reduced or made easier. Materials handling can often be reduced, and perhaps mechanized. Arrangements may be made to maximize accomplishment while working in place. Types of changes which result in these improvements may also be classified.

CLASSES OF WORK SIMPLIFICATION CHANGES

A classification of possible changes which may be made to improve work methods systematizes the researcher's analysis. In this classification the higher the class of change, the greater is the number of desirable changes likely to accompany it.

Class 1. Changes in physical work. Such changes usually involve reductions in travel, elimination of unnecessary work, and use of easier hand and body motions. Also involved may be: fuller use of both hands; arrangements for less stooping, lifting, and carrying; greater safety and comfort for workers; changes in hours; provision of rest periods; adjustments in crew size; assignment of definite responsibilities to individual crew members; and better integration of man and machine work.

Class 2. Changes in equipment and layout. The kind or design of the machine, tool, or device may be altered to fit the job. Mechanical power may be substituted for human power, particularly in the movement of materials. Man's time should be used to direct the energies of machines or animals more powerful than he. In the United States man's time is generally too valuable to be used merely as a source of power—unless the job is too complicated, short, or unimportant to justify a machine. Equipment, supplies, and animals may be relocated for easier access and greater convenience. Building and fence locations and building interiors may be rearranged to decrease travel and permit improved work routines.

Class 3. Changes in production processes and practices. This involves rescheduling certain jobs to less busy seasons, increasing the timeliness of crop and livestock operations, and rechecking time-honoured practices as: fall versus spring ploughing; drilling versus checking; around-the-field versus back-and-forth planting; self-feeding versus hand-feeding; and hand stripping versus machine stripping with short, timed milking of dairy cows.

Changes may also include modifications in the product (form, condition, quality) and changes in raw materials (seeds, feeds, fertilizers). Whether or not changes in the product or changes in raw materials should be made is largely a problem of general management. But if changes of the latter two classes are made, it is the job analyst's problem to follow through and study the possibilities of making improvements in the production process, equipment, and physical work. Most of the method improvements have been concerned with changes in physical work (class 1) and in equipment and layout (class 2).

RESULTS

The degree of success achieved by work simplification projects has varied widely, as would be expected in a relatively new field. Studies of repetitive hand jobs have generally produced readily applicable, quickly accepted findings. Studies of livestock work have necessarily proceeded more slowly because of the greater number of variables involved. Measurement of farmer acceptance and use of findings is difficult.

The success of some projects has been spectacular. In Kentucky studies of tobacco production and harvesting, improved methods that save from one-fourth to two-thirds of the labour previously required have been developed and tested. These improved methods were placed into use through an intensive educational programme. As a result, it was estimated that in 1946 the use of these improved methods saved 745,200 man-days of labour in the state of Kentucky alone. Even under the improved methods, tobacco production remains essentially hand work. Jobs are repetitive. This means that a specific improved step-by-step procedure can have broad general application.

Several states have undertaken studies of dairy chore work. In a 'before' and 'after' study on a 22-cow Vermont dairy farm, daily savings of 2 hours and 5 minutes of work and of 2 miles of walking, or about one-third of the time and two-thirds of the travel, were made.[1] Over a period of about a year's study, with gradual change, dairy chore time on a Minnesota farm, where 13 cows and 14 other cattle were kept, was reduced by 27 per cent., and about 37 per cent. of the travel was eliminated. The research procedure resulting in these significant accomplishments was in both cases approximately that outlined above. Four classes of changes were made. Virtually all of the changes either reduced the physical work, made it easier, or

[1] R. M. Carter, *Labor Saving Through Farm Job Analysis. Dairy Barn Chores*, Vt. Exp. Sta. Bul. 503, 1943, Burlington, Vermont.

more effective. Strictly class 1 changes included the establishment of new work routines more economical in time and travel, and reduction of the time the milking-machine was on the cows. Class 2 changes in equipment and layout resulted in additional changes in the physical work. New equipment—carts, brooms, shovels, forks—was developed or obtained after study of the job requirements. The Vermont farm's stables were rearranged and, in both cases, locations of feed, livestock, and supplies were changed to provide work centres, permit circular travel, and eliminate empty travel. On the Minnesota farm a production practice was altered (a class 3 change) by replacing hand stripping with machine stripping. Also on the Minnesota farm the product marketed was modified by selling whole milk rather than cream.

Once their importance had been discovered, some of these changes could have been made without a detailed study of the work. But because the entire process was carefully analysed, many changes, individually small but collectively large, were made which would have been overlooked in a less systematic study where only the more obvious opportunities for improvement were examined.

Work methods used by five efficient Indiana hog farmers were studied for a year. These farmers were able to produce 225 lb. market hogs in an average of 1·7 hours of work per head, compared with a state average of 5 to 7 hours. Thus they produced 100 market hogs (raising spring and fall litters) with a total of about 7 weeks (500 hours) less work than the average.

Study of haying jobs on 72 Vermont farms demonstrated that how a man works may be just as important as the equipment with which he works.[1] The 10 farmers handling hay the fastest used 62–85 man-minutes per ton to move hay from the windrow to the mow. These 10 farmers used all types and combinations of equipment. Other farmers, with similar equipment, used as much as 313 man-minutes per ton. A careful comparative study of hay-making methods has just been completed in New York.[2]

Significant improvements in methods of harvesting vegetable crops—celery, potatoes, tomatoes, green beans—have been made through the synthesis of good parts of methods already in use and the application of tested principles. For example, in Colorado an improved method of cutting seed potatoes was developed which utilized our knowledge of the effective use of both hands, gravity

[1] R. M. Carter, *Hay Harvesting*, Vt. Exp. Sta. Bul. 531, 1946, Burlington, Vermont.

[2] I. R. Bierly, *Comparative Hay Harvesting Methods*, Cornell University, 1947, Ithaca, N.Y.

feed, and drop-chute delivery.[1] This equipment, used in the prescribed manner, enables the average worker to increase his output on this job by 25 per cent. The investment required is 10–20 dollars. These studies have repeatedly emphasized the necessity of adequate job instruction if the potential savings of improved work methods are to be realized.

Essentially this research technique is being successfully applied to marketing and processing operations. Significant studies of celery wash-house and packing operations in Florida[2] and of Indiana tomato-canning factory operations have been completed. These two studies show that variations in efficiency and cost among these processing and marketing organizations are about as great as among farms. Through the use of work simplification research techniques, some specific reasons for these variations in costs and efficiency have been ferreted out. Improved methods, the full application of which would result in an overall saving of about 40 per cent. in labour, were developed in the Florida study. Comparable results were achieved in Indiana. This suggests that work simplification research techniques will have practical applications in marketing investigations equal in importance to the farm-work applications.

Many problems in work simplification research methods remain to be solved. Thus far, broad studies of work processes, planning of work routines, and layouts have generally been more productive than detailed analyses of work elements. This generalization, however, may be made. Careful work simplification analysis can usually cut chore time with livestock about one-third. Chore travel may frequently be reduced even more. Where hand work, rather than mechanical harvest, is still used, increases in output of from 20 to 40 per cent. may be expected.[3] Greater use of incentive wages appears desirable in agriculture. Increases in custom farming (hiring men and equipment by the job rather than by the hour or day) is a trend in this direction.

Work simplification research emphasizes the dynamic features of any job and develops a desirable questioning attitude towards precedent as a guide to adequate job performance. New emphasis is placed upon the importance of the individual as a factor in production.

[1] J. L. Paschal, G. H. Love, and W. A. Dreutzer, *The Double-Edged Stationary Potato Cutting Knife*, Colorado Exp. Sta. Bul. 493, 1946, Fort Collins, Colorado.

[2] M. E. Brunk, 'The Application of Work Simplification Techniques to Marketing Research', *Journal of Farm Economics*, vol. xxix, No. 1, Feb. 1947.

[3] E. C. Young and L. S. Hardin, 'Simplifying Farm Work', *Yearbook of Agriculture*, 1943–7, U.S.D.A., Washington, D.C.

It may well be that case studies have not been exploited to their full potential in agricultural research and teaching. The above outlined research procedure involving numerous detailed observations, adjusted or levelled for individual differences, may make case studies of broader use for research purposes. Many observations are taken on a few cases rather than the usual statistical approach of taking a few observations on many cases. Because of the great detail which is obtained, the analyst has the basis for reasonably accurate projection. In economic research in general, and in farm management in particular, we have traditionally described what has happened. Rarely have we projected our findings so that persons making current operational decisions could make maximum use of the results. Work simplification research potentially can bring interpretation of research out of the past and project it into the future. Specific suggestions can be made, and the importance of a particular method or practice may be measured and demonstrated. Thus the researcher may lead, rather than follow.

In summary, work simplification attempts to sift out the best of work methods already in use, evaluate them, and carefully analyse them for further improvement. At its best it goes beyond the actual experience of farmers to develop and test other possible improvements. In this way, operation and management information is developed which should be of value to all farmers irrespective of the efficiency or scope of their operations.

DISCUSSION

J. R. CURRIE, *Dartington Hall, England.*

I did not mean to take part in these discussions, as of necessity my time and attention at this Conference are preoccupied with other duties, but the subject and nature of Mr. Hardin's paper have so interested me that I cannot resist the temptation to say a few words on it.

I only wish that the techniques of which Mr. Hardin has spoken to us to-day had been evolved twenty years earlier, as it would have made some of our problems here at Dartington a little easier of solution. And the kind of problem I have in mind is typical of almost every farming situation in the world to-day. I particularly wish to make mention of the dynamic nature of those farming problems, with their changing emphasis on labour, capital, and general organization, as circumstances make changes desirable in a competitive world where supply and demand are seldom in perfect equilibrium for long.

When Dartington Hall was established, over twenty years ago, by the very nature of its objectives it set itself the kind of problems that farmers and others are continually having to face where efficient management is the goal. The survey of farming in this area, which Harwood Long and I carried out as a preliminary, gave us a clear picture of the agricultural situation in this district at that time, but it could only point to some of the desirable objectives, and could give little help in determining the exact nature of the improvements that could be effected, e.g. the layout of better farm buildings where capital expenditure could be made and justified to cut down labour costs, &c. At that time we did not know of any organized studies similar to those indicated in the discussions to-day, so I started on my own to carry out 'time and motion studies' of the more important tasks that have to be carried out on a dairy farm throughout the year. Incidentally, I did not like the term 'time and motion studies' with its tainted objectives, which was borrowed from industry and savoured too much of that harsh repetitive efficiency of the factory machine, but we were soon given a better one by John Maxton, who referred to them as 'observational tests'. We have continued to carry out these observational tests on every important aspect of dairy technique ever since, and I feel confident that this kind of method is necessary if we are to determine the best economic structure, combining labour costs and capital expenditure, to meet any farming situation, as in this way the functional relationships between the various factors are made clear.

Some examples of our experience in that connexion may be of interest. One of the first problems we tackled here at Dartington was to discover the most efficient way of producing 'clean milk', at that time designated as Certified Milk, that is, Tuberculin Tested milk containing less than 30,000 bacteria per c.c. There was only one producer of this quality milk in the county at that time, so we consulted various authorities from all over the country and ultimately made use of much of their advice. It was not possible, however, to get specific information on many points which interested us on the type and nature of cow-shed to build. Some of the questions we had in mind were as follows: Does the American yoke, confining the cow in her stanchion, really keep the cow clean? What are its limitations? Does it have any detrimental effect on the cow's yield through restriction of her movements? Since erecting and using a cow-shed with these, we have been able to study these points by the 'observational tests'. We find that the restriction does tend to reduce the yield of cows giving fairly high yields, say, of over 4 gallons of milk per day, but that it is a satisfactory method of keeping the cows clean. Thus, by observations taken over a three-year period, we found that the heavy-yielding cows gave about 15 per cent. more milk when transferred from stanchions to a loose box where they had complete liberty, but we also found that it took three times more labour to keep the cows clean under the loose-box conditions.

Another example, although a simple one, may be of interest. We were advised to put in an overhead conveyor in one of our cow-sheds to remove the dung from behind the cows to a manure pit. When the operation of this was observed, we found that it took longer to clean the cow-sheds by this means than by the older-fashioned one of the traditional wheelbarrow. I might quote yet another and a more recent example of the value of this technique. As a result of the valuable work carried out at Minnesota on milk secretion, by a colleague of Professor Jesness, a new technique of milking called the 'Hot cloth' or 'Quick Milking' method has been widely applied in this country. We have found it to be a considerable improvement on the old method, but by the 'observational tests' we disproved some of the claims made for it. Many of its advocates here stated that it saved time in the cow-shed and therefore it was a way of doing with less labour. We found it to be nothing of the kind as, although the actual time of milking the cow was considerably reduced, the extra time taken in applying the hot cloth and keeping up the supply of hot water almost balanced the time saved in milking. The virtue of this system of milking does not lie in the time saved, but in the fact that the more rapid milking encourages the cow to give more milk. Now that we know the facts, it may be possible to invent or organize a better means of procuring the results of the hot cloth which will really save time. This is where the 'work simplification' technique is so valuable—it breaks down the labour requirement into its separate components and makes a thorough analysis possible of the various ways of doing a job.

There is still another experience of rather a different kind which I should like to relate while I am at it. In this country it is the custom of the head cow-man in a sizeable herd to do the machine-milking and for the second cow-man to do any hand-milking that may be thought necessary or expedient. However, the head cow-man needs his week-end periods off and his annual holiday. On these occasions it is usual for his assistant to take over the machine-milking. This arrangement gave us a good opportunity of studying the efficiency with which the machine-milking had been carried out by the different individual operators. As I expected, each man had his own particular way of handling the machines, especially at the finishing of the operation and the order in which the cows in the shed were milked. I was very much surprised, however, to find the size of the margin between the best and poorest operators. The results indicate the importance of this, as comparing the best with the poorest operator there was a 10 per cent. margin. Strangely enough, the man responsible for this low result with the machine had the reputation of being the best hand-milker in the cow-shed. Clearly it is not the job of the 'observer' to pass comments and query the efficiency of the worker. On the contrary, the 'observer' must be scrupulous in being a detached observer. His presence must not be taken to indicate a 'policeman's' job, otherwise his observations will be distorted from the normal. But I was puzzled about this low record until, by the man leaving his job, I was given the opportunity of showing him the results of his handling of the machine. The reason was clear immediately, as he opened up a tirade against the use of machines for milking, or rather the abuse of cows by putting machines to milk them. As a result he had neither pleasure nor pride in their efficient handling such as he had in his skilful hand-milking.

It may be stretching the use of the work of simplification technique too much to suggest that this last type of problem should come within its field. It certainly raises a tricky situation. I am confident that the movements of different operators should be observed and analysed, but for the management to make use of the tests to set up comparisons between individual workers is undesirable because of the repercussions it would have on the general application of the technique. The men must not be made to feel that they are being spied on. Yet these personal factors are important. The case quoted, I think, is not an isolated nor an exaggerated one. Maybe the solution lies in other fields, say, that of the psychologist whose technique could more likely discover aptitudes and attitudes conducive to efficiency in the cow-shed. Speaking generally, I think it is very important that the right type of person should be chosen to work in the cow-shed, where the individual temperament of cows has to be studied very carefully to get the best results. From the records of herd output I have examined from time to time, I feel certain that much of the credit or blame for the output which has been put down to breeding and feeding could with greater truth be attached to management in its detailed forms. Further, if we can get some way of measuring these details, we will have gone a long way towards solving the problem. For my part I think observations and recording of differences will help us greatly.

I should like to mention another example of where we have used this method to good effect. Those who went on a tour of the Old Parsonage Farm and its buildings saw there our first efforts at providing suitable accommodation for bulls. The premises when erected there were built to the specifications laid down for good bull management. Observation tests, however, have clearly shown the weak points, and the improvements suggested from that experience are now incorporated in the layout at the Artificial Insemination Centre, which I hope those of you who are interested will have the opportunity of visiting. There you will find that the premises are so laid out that the bulls have the maximum freedom consistent with the safety of the stockmen, and manual labour is cut to the minimum. The results are quite striking, as the cost of keeping a bull (apart from depreciation, which also may be affected when we get enough data to determine it) has been reduced by 50 per cent.

One last reflection on the 'Work Simplification' technique, although there are lots I would like to say on the subject in relation to outside field-work, and especially on the efficiency of substituting implements and machinery. This aspect may not be so important in America as it is here, where we are more in the transition stage between the horse and the tractor. In tackling this problem I have tried to devise my own method of study, but so far I have to admit I am stumped. My problem is to get at the real basis and assess the comparative efficiency of different implements, whether horse or tractor, in relation to the job they are supposed to do.

It is easy enough to measure units such as acres ploughed, cultivated, sown, or reaped, but it is only part of the problem. The other and more difficult, and possibly more important, part is the effectiveness of the operation. We know all too well from experience how much the tilling operations have to do with the subsequent crop output. I agree that good farming is an art, but the science side of it goes a long way before the art side becomes operative, and it is that important fraction that I should like to be able to measure effectively.

I am looking forward with great interest to seeing the results of further studies which are being carried out along these lines in America.

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In the brief time that remains I would like simply to list a few additional thoughts with respect to the topics discussed by Dr. Schmidt and Dr. Hardin. These have mostly to do with the definition of terms, and with the delimitation of the field of work simplification or scientific management.

It is not unusual for different members of a group of economists to use different terms to describe the same thing. But sometimes this leads to unnecessary confusion. Without pretending to put words in the mouths of either of the previous speakers, I would like to try to relate one to another several of the terms that have been used.

1. *Management*. This is the function of organizing and operating a business unit for the greatest continuous profit. In exercising this function, a manager in every decision is faced with choosing between alternatives; so the function is largely one of appraisal, within the limits of his understanding, of the best application of the laws of the combination of factors and of diminishing returns.
2. *Farm management*. 'Management' as applied to a farm business.
3. *Scientific management*. Connotes a more exact appraisal and choice of a course of action, but the distinction is one of degree, not of kind.
4. *Scientific management of labour*. This limits the concept to one of the factors of production and again connotes a rather sure and exacting process. As Dr. Schmidt pointed out, studies of the 'technical part of management' must go along with studies of labour management.
5. *Work simplification*. Management of labour to maximize output per unit and to make the work easier, apparently synonymous with 'scientific management of labour'. This is the newer term, but it has an advantage in its self-defining quality.

The question is sometimes raised as to why so much emphasis should be placed on labour, as is implied in the 'scientific management of labour' or 'work simplification', when labour is only one of the factors of production. The answer is implicit in the measure most commonly used to provide an index of the success of farm operation—namely, the return to the operator for his labour and/or management. Generally speaking it is the return to the operator that determines his and his family's level of living. The other factors of production, and hired labour as well, are combined with the family labour in such measures as to return the maximum payment for the labour and management of the farm family. The extent to which the proper combinations are made at any one time, or adjustments are made in the light of changing price-cost relationships for the several factors, is, of course, subject to the ability of the manager to appraise alternatives adequately and make the right decisions. Obviously the ability of farmers, as of others in this regard, varies widely, even assuming that all are equally well informed.

It is well also to recognize that work simplification in agriculture is not a new field, except perhaps as a field for formal research. In fact, work simplification in agriculture is as old as the desire of farmers to find easier ways to do their work. Farmers have always been seeking better methods. All that work simplification does is to provide for a more systematic approach to the problem and enable the researcher after some experience to appraise the effects of a new practice or procedure on time requirements before it has become a general practice on farms. This fact is probably of no great significance to research workers, but it is of considerable importance to those who expect to work directly with farmers in this field.

It is appropriate to recognize the relationship of work simplification to other methods of study and fields of work. The techniques of time and motion or travel studies provide detailed measurements that reveal reasons for efficiency or inefficiency in use of labour. But to the farmer who is operating a farm, the new methods, arrangements, or techniques that are developed must ordinarily show promise of reducing costs per unit of product, or enable greater output per unit of labour, or at least make the necessary work easier. To the extent that costs enter into the picture as an important consideration, the detailed work-simplification studies must be related to studies that will also provide cost measurements.

As management specialists, we are seldom trained to exploit fully the possibilities of mechanical power as a means of improving work-methods. Thus at least to this extent it is important that we work closely with engineers in our studies. Also we are not ordinarily trained to evaluate a new practice or method in terms of its effects on animals or plants, or their productive capacity over a period of time. So it is also important that we work with scientists in these fields. In fact it appears that the most effective procedure is to have specialists in management, engineering, and the other production fields working together as a team, so that all phases will be adequately considered.

Concrete suggestions of improved methods will aid materially in jogging the imagination of farmers. But farmers will always have to fit the suggested methods into their own situations. And there are so many farmers with different situations that the success of work simplification in farming will be determined by the extent to which we can arouse the imagination of farmers and thus get them to think through their problems anew.