MECHANIZATION IN AGRICULTURE

Norman A. Evans

"Bowed by the weight of centuries he leans
Upon his hoe and gazes on the ground,
The emptiness of ages in his face
And on his back the burden of the world.
Who made him dead to rapture and despair
A thing that grieves and never hopes,
Stolid and stunned, a brother to the ox?"

----Edwin Markham, The Man with a Hoe, 1899.

Given a modern day-farmer, Markham would have been hard pressed to see in him "A thing that....never hopes ....a brother to the ox." A man with a tractor has power in his soul as well as his arm; his eyes turn upward, his head is carried high. The hoe pulled him down--the tractor lifts him up.

The greatest problem facing agriculture today is that of coping with changes which accompany rapid adoption of new technology. New problems are created where older ones are solved. We have fared much better, it seems, with the technological problems than we have with the social and economic adjustments which have become necessary. Our interest in this paper is not in the latter, however; but rather in examining what is happening within the "technological revolution" which agriculture is undergoing. "Technological" is very broad, ranging from biology to nuclear science and to be sure, each technology is contributing in its own way to the changing scene. We shall, however, look first at the changes in broad perspectives, as perhaps through the eyes of the economist; then turn our attention

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only to the impact of mechanization and automation.

CHANGING AGRICULTURE

Changes are taking place in contemporary U. S. agriculture more rapidly than at any other time in history. Two changes are especially significant: (1) The release of labor for off-farm work as we get increased productivity per person on the farm, and (2) The relatively lower cost of food production resulting from greatly improved efficiency in farming. In 1900 about thirty per cent of the population was engaged in farming while sixty years later only five per cent are so engaged.

Total farm production doubled between 1918 and 1960. It has increased about thirty per cent since the end of the second World War, and a twenty-three per cent increase occurred in the 10 year period, 1950-1960. With a population increase of nineteen per cent in the same decade, it is clear that productivity has increased almost unbelievably in the last 10 years, ~~even exceeding the unprecedented rate of population growth~~. No increase in total cropland has ~~been made~~ occured since 1920, however.

Production resources going into farming have been altered in kind and amount. The total amount of labor used in farm production has been reduced by more than half since 1920, or from about 24 billion man-hours in 1920 to 11 billion man-hours in 1959. Most of this decline has occurred since 1940 when 20.5 billion man-hours of labor were still being used in farming.

More than 26 million people have emigrated from farms since 1920, with 18 million moving since 1940. To offset this shift in labor force, the output per man-hour rose 185 per cent between 1940 and 1960. The

real product per man-hour in industry increased only fifty per cent in the same period.

Substitution of capital for labor has marked another shift in production resources. The average investment per farm increased nearly fifty per cent during the 1950's. The investment per farm worker is around $27,000. Larger farm units have become necessary to make maximum use of more and larger power equipment.

Investment in machinery and equipment has mushroomed. From a total of 240,000 tractors in 1920, the present number has jumped to 4.75 million, a 19-fold increase. U. S. farmers are using now over a million grain combines, three-fourth million corn pickers, one-half million hay balers and one-fourth million forage harvesters. Farmers are the largest petroleum users in the country. Electrical consumpiton on farms has increased from 1.7 to 22 billion kilowatt hours since 1935, most of this in the last ten years.

Farm equipment and construction requires more than six million tons of steel annually which is more than the passenger car requirement. The depreciated value of machines and structures used in agriculture exceeds twenty billion dollars or more than five times the investment in automobile manufacturing.

In the course of a year's production the farmers of the U. S. handle about 600 million tons of materials. This includes crops, animal products, and soil and is five times the annual tonnage of steel production. A dairy farmer with thirty cows will handle over one thousand tons of hay, feed, and waste each year.

MECHANIZATION AND AUTOMATION

Victor Hugo once said, "Greater than the tread of mighty armies is an idea whose time has come." This perhaps applies to the present day sweep of the idea of mechanization across the land. The decline of labor availability and its high cost has forced all farmers to mechanize to some extent; but this is just the beginning.

The great American Industrial Revolution is said to have had two stages: first the mechanization of brawn, and second the mechanization of brain. The latter is very much in evidence in industry today with electronic computers and "automatic" factories. In agriculture, the current movement is mechanization of brawn-- the replacement of mechanical power for man power. Mechanization of "brain"; ie., automation, is yet to come in agriculture; but the innovators are at work and before we realize it the automatic farm will be a reality.

Already the egg factory is becoming commonplace. One man can handle 15,000 birds in a laying flock with properly designed housing and mechanical equipment. This is possible because of automatic feeding, watering, ventilation and lighting systems; automatic droppings removal; and mechanical devices for collection of eggs. One such installation near Denver uses a round house, sixty feet in diameter, and provides complete environmental control with refrigeration. The five thousand birds are kept in cages seven tiers high. The rows of cages form concentric circles, which are mounted on tracks and revolve at the rate of one revolution per hour.

Stationary feed and water trays allow the birds a brief chance to eat and drink once each hour as the cage moves past. Low mortality and high egg production are the result of positive environmental control in this unusual plant.

But mechanization and automation doesn't stop here--- the eggs can be graded, inspected for blood spots, and packaged without being touched by human hands. Furthermore, the electronic equipment does a better inspection job than people can do. A spectrophotometer for detecting blood spots in eggs reduced the error by ninety per cent while operating at 7200 eggs per hour. Licensed graders missed 3.9 blood spots per 1000 eggs, the detector missed only 0.38.

Chick brooding under infra-red lamps with electronic temperature controls which respond much like the chick is making this phase of the poultry industry more efficient. A black globe, which loses heat by radiation and convection in much the same way as does a chick, operates under the brooder and maintains the temperature exactly the way a chick likes it.

Other livestock production is not so close to complete automation although much mechanization is applied. Hogs are being raised in environmentally controlled chambers with partially automatic and mechanical feeding, watering, and waste removal systems. Experiments have indicated that pigs thus housed respond to environmental control as significantly as to feed rations.

Many dairymen handle little, if any, material by hand. Feed rations are removed from storage and mixed in proper proportions by automatic devices. In many cases this is

done by a time-clock control so the operator does not even need to be present. Feed thus prepared is delivered to point of use by mechanical or pneumatic conveyor. Safety devices such as pressure and limit switches will stop the whole operation if anything goes wrong. Milk is conveyed from cow directly to refrigerated bulk tanks--no labor involved. Some innovators are even now planning to eliminate the personal attention of attaching the milking machine to the cow's udder.

Crop mechanization is taking giant strides. Cotton harvestors replace the work of one hundred men. Tractor steering by electronic devices makes possible cultivation to closer tolerances, not to mention reducing fatigue in the operator. Air-conditioned cabs and "space-suits" provide for health and comfort of the machine operator who often has to work under nearly intolerable conditions of heat, wind, and dust.

Mechanization of vegetable and fruit harvesting is proceeding at a phenomenal rate. Tomatoes, asparagus, cucumbers, green beans, grapes, cherries, berries, apples, peaches, and a host of other crops are now harvested mechanically. We must remember that the plant breeder has, in most cases, modified the physical character of the plant to make mechanical harvest possible.

Take tomatoes for example. The horticulturalist reached into his bag of tricks and produced a tomato plant which stands upright, matures the fruit uniformly, and has a stem joint which will break easily to free the fruit from the stem. It was a relatively simple matter from here for the agricultural engineer to devise a machine to pick up and

shake the vines and collect the fruit. Sixty hand pickers are replaced by eight men.

Cherries and other fruits are harvested by shaking the tree with a giant vibrating arm mounted on a tractor. A canvas catching frame is positioned beneath the tree to catch the fruit. A conveyor removes the fruit from the catching frame and deposits it in boxes or pallets ready for the grading and packing shed. Cherries are deposited in water tanks for minimum bruising and rapid cooling. Thirty three hand pickers are replaced and harvest costs are cut in half.

Colorado onion growers are looking forward to the complete development of a radically different onion harvester by agricultural engineers at CSU. Present machines will not work in several areas of the state because of soil conditions and so mechanical harvesting is not widespread. A blast of air from a large fan will orient onions on a conveyor with their tops down where they can be sheared off with a reciprocating knife. This will shear tops at uniform length and thus minimize storage and keeping problems associated with shearing tops too short or too long.

Complete mechanization of potato harvest is not yet a reality in much of Colorado because of excessive numbers of clods which have to be separated by hand. Potato growers of the state are financing development of sorting equipment by agricultural engineers at the Colorado Agricultural Experiment Station. Unless this problem, related to labor cost, is solved the future of the twelve million dollar potato industry is in doubt.

Sugar beets, a twenty-nine million dollar crop in Colorado and an important one throughout the Western U. S.,

felt the first impact of mechanization fifteen years ago. Today's grower is within reach of one hundred per cent mechanization. All that remains is the development of a seeding device which will precisely space seeds at the twelve inches desired for the final stand in a seedbed properly prepared so that one hundred per cent germination can be obtained. Then, with chemical weed control, all hand labor will be eliminated. The three problems mentioned--precision planter, proper seed bed conditions, and chemical weed control--are being intensively studied by agricultural engineers and botonists at the Colorado Agricultural Experiment Station.

What is the impact of mechanization and automation on farming? In brief, it is taking the labor out of more and more of the tasks. It is producing more on fewer acres with fewer man-hours but higher capital equipment investment. It is changing the look of agriculture. Only the best managers can succeed and only by applying new technology. Mechanization has contributed to crop surpluses and we haven't yet found a workable way to cope with them. Displaced farm labor with no special skills finds difficulty in moving to industry where skills are almost essential.

Environmental control is the new watch-word. This ranges from weather modification to chick brooders. Perhaps the final result will be the true "farm factory" where even the biological processes will be controlled and food and fiber will be produced to specification.

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