If You Enjoy Eating, Thank the Machines!

BY KENNETH K. BARNES AND JAMES H. ANDERSON

More machines, bigger machines, better machines—they help perform the near-miracle of keeping American agriculture rolling and of putting food on American tables in unequalled abundance. Housewives buy from a plentiful supply of food of incredible variety, high quality, and with built-in work- and time-saving features.

Mechanization of American agriculture has made it possible for less than 5 percent of our people to produce food for all the rest, thus freeing the majority of the population to produce the other necessities and luxuries of life.

Some of the most dramatic changes in mechanization of agriculture have come since 1940. During the depression years of the 1930's there had been a surplus of labor on farms, and there was no great incentive to use labor more efficiently. A farm worker growing corn or barley in 1940 produced for each hour of work only a third more than a worker had produced in 1910.

But in the years beginning with 1940 there was a sharp rise in the output per man in producing many crops. By 1950, a man could produce twice as much grain for an hour of work as he produced in 1940. In 1960, each hour of work produced three times as much as it had in 1950, and six times as much as in 1940.

The 1940's had set the stage for a rapid increase in mechanization. The 1950's were the years of major progress in mechanization of grain and forage crops. The 1960's saw rapid progress in mechanization of cotton and many of the fruit and vegetable crops harvested for processing.

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The 1970's will be the decade of mechanization of the fresh market fruit and vegetable crops, for many of the tasks in production of these crops are still done by hand. When the 20th century comes to a close, food production in America may well have become completely mechanized.

The State Agricultural Experiment Stations play many roles in mechanization. Sometimes it's the obvious one of inventing a new machine. Such was the case in the 1960's when W. F. Buchele, an agricultural engineer at the Iowa Agricultural Experiment Station, invented the giant hay baler. The machine produced a 1,000-pound package of hay in contrast to the usual 75- to 125-pound bale.

The giant bale system provided a completely mechanized means of handling the bale from field to feeding at a lower cost per ton than other baling systems. Farmers were interested. Farm machinery manufacturers recognized this interest and developed their own versions of Buchele's basic system.

This giant bale system is now used on many farms to cut costs and reduce labor in harvesting hay and feeding it to cattle.

There have been many developments in mechanizing the hay harvest. H. D. Bruhn, agricultural engineer at the Wisconsin Agricultural Experiment Station, set out to make handling hay as simple as handling grain. He speculated that if a few handfuls of hay were subjected to high pressure under just the right conditions, the hay might stick together in a small package.

Pancakes of Hay

These packages were originally called wafers, and were thick pancakes of hay an inch thick and six or eight inches in diameter. The wafers could be scooped, dumped, hauled or conveyed much like ears of corn. The Wisconsin work stimulated much interest in State Agricultural Experiment Stations, the U.S. Department of Agriculture (USDA) and the farm equipment industry. The basic concept proved correct, although as experience was gained the details changed.

Today, the commercially produced hay cuber picks up field-cured hay and produces "cubes" an inch and a half square and one to two inches long, at the rate of five tons per hour. This machine is widely used in areas where irrigated hay is grown; research on making hay cubing adaptable to the rain belt continues.

Top right, hay baler that makes 66-inch diameter "round" bales weighing about 1,200 pounds. Top left, Auburn has conducted studies of this type of labor-saving system, with bales stored in a central outdoor area. Above left, hay cuber at work. Above right, hay cubes can be handled and stored like grain.

During the period 1932–39, Agricultural Engineer T. N. Jones and Plant Physiologist L. O. Palmer, with the Mississippi Agricultural Experiment Station, did much work on field curing of hay. They found that in all cases Johnson grass and alfalfa cured substantially faster when the stems were crushed right after mowing. By crushing Johnson grass they found the usual curing time of 72 hours could be reduced to 24 hours.

Hay crushing reduces the weather hazard which is so critical to hay production, and the hay crusher has become a standard tool in haymaking.

Often the Agricultural Experiment Stations develop crop production technology which makes successful mechanization possible. In mechanization of cotton harvesting, Agricultural Experiment Stations helped develop cotton varieties and methods of fertilizing and irrigating which would produce a plant compatible with machine harvest.

Harvesters Get on the Boll

Cotton was one of the last major crops to be almost completely mechanized. A patent was issued for a picker as early as 1850 and in the early 1900's stripper-type harvesters were used, but they harvested green as well as ripe bolls. A harvester which would pick the cotton from ripe bolls and leave the green ones wasn't developed until 1942. After that development, cotton mechanization came in a hurry.

In 1948, about 140 man-hours were required to produce a bale of cotton. Now the requirement is in the neighborhood of 20 man-hours. Most of the reduction in labor demand has resulted from the virtual elimination of hand labor for weeding and harvesting.

Let's look specifically at the application of cotton pickers to irrigated cotton in Arizona. This crop is almost completely mechanized, although the first mechanical cotton picker didn't arrive in Arizona until 1946.

In 1958, some 51 percent of the Arizona cotton crop was machine picked. Machine picking jumped to 62 percent in 1959, 73 percent in 1960, 80 percent in 1961, 92 percent in 1962, and to virtually 100 percent before the 1960's were over.

Many factors have influenced the adoption of mechanization in cotton harvesting, as they have influenced the adoption of mechanization in any crop. Some of these for cotton were: (1) improvement of machines, (2) development and improvement of ginning facilities to handle machine-picked cotton, (3) lack of enough usable hand labor for the work, (4) increased knowledge of the proper application of harvesting machines, (5) development of machines for salvaging ground-loss cotton, and (6) development of varieties and growing practices which resulted in a plant particularly suited to machine harvest.

State Agricultural Experiment Stations were particularly active in development of growing practices which would produce a plant suited to machine harvest.

Uniformity of the cotton crop is critical to efficient machine harvest. That uniformity depends on getting a full stand of cotton at the first attempt.

The "W-Profile"

In Oklahoma, combined hazards of heavy spring rain and blowing sand often resulted in spotty stands and replanting parts of fields two or three times. So in the early 1950's, engineers of the Oklahoma Agricultural Experiment Station developed the "W-profile" planter to solve the problem.

The new planter placed the seed in a low ridge at the bottom of a deep furrow where it was protected from blowing sand and standing water. Chances of getting a full stand at first planting went up to 80–90 percent. And cotton farmers saved millions of dollars.

Experiment station engineers and scientists have attacked many harvest-mechanization problems. Through the late 1940's, peanut producers used hand labor to harvest peanut plants and place them in stacks to dry. Then the North Carolina Agricultural Experiment Station developed a mechanical system for digging the peanut plant, windrowing for drying, and threshing with a peanut harvester.

The agricultural engineers not only devised an effective mechanical system but also learned how to prevent off-flavors in the peanuts by proper curing during the drying period.

Blueberries and cucumbers are two other crops which North Carolina engineers have done much toward mechanizing. Labor shortages had the blueberry industry headed for extinction until agricultural engineers developed a mechanical blueberry harvester which vibrates the bush, catches the berries as they fall, and conveys them to a wagon.

At the frontiers of mechanization in the 1970's are fruit and vegetable crops. Many of these crops are particularly critical in their present requirements for hand labor—labor that is fast becoming unavailable at any price.

This unavailability of labor may result in the loss of some vegetable crops from the market unless they are mechanized. And labor for the producing and harvesting fruit and vegetable crops is lower in productivity than any other labor in the Nation today.

The U.S. economy will not indefinitely tolerate labor at this low level of productivity. The huge U.S. corn crop was once picked entirely by hand, but people had better things to do, and corn harvest is now among the most highly mechanized of harvest operations. This same change will take place in vegetable and fruit crops, and many of the changes are being made through leadership of the State Agricultural Experiment Stations.

Mechanization of fruit and vegetable harvest is a complex problem. Complex, of course, because of the fragile and perishable nature of the harvested materials. Complex also because vegetable mechanization will not be achieved by mechanical design alone.

Top left, over-the-row blueberry harvester is shaped like an inverted "U". Top right, electrical hand-held vibrator is used to shake berries loose in harvesting small plantings. Both machines were developed through USDA-Michigan research. Above left, harvesting peanuts by hand in Georgia, 1941. Above right, modern corn picker.

Man—a Superior Machine

As a harvest machine, the human body is indeed remarkable. Through its sense of sight and touch, it measures the quality of the product to be harvested. This information is transmitted to the brain, where it is compared with standards stored in the "machine's" memory.

If the fruit or vegetable is ready to be picked, the arm and hand get a signal to grasp the fruit or vegetable, remove it from the plant and put it in a box or sack. The hand and arm are capable of moving through tortuous paths—a different path for each unit of product harvested—and of selecting only the desired unit without taking any trash along with it.

Does the mechanization of vegetable and fruit harvest imply development of machines which will duplicate these sophisticated abilities of the human body? The answer is clearly no. The effective approach is to modify the plant to reduce the degree of selectivity required in harvest and to place the harvested parts in a predictable position in relation to the harvest machine.

Thus vegetable mechanization is not a problem for the engineer alone. It must be worked out through close collaboration with plant scientists, ultimately with commercial producers of vegetable crop seed, and with vegetable growers.

This was uniquely illustrated in California in the early 1960's when work of the experiment station engineer-horticulturist team, Coby Lorenzen and G. C. Hanna, revolutionized tomato harvesting. A tomato and system of tomato culture for uniform maturity was developed, and a machine which could take advantage of this uniformity was simultaneously perfected. As a result, processing-tomato harvest changed from a hand-labor to a machine job in a few years.

Saving the Pickle Industry

A similar team went to work in North Carolina when labor shortages threatened the pickle industry. Labor for harvesting cucumbers was especially critical. The Agricultural Experiment Station began a joint project with both engineers and horticulturists to develop a mechanical harvester for cucumbers. The plant breeders developed a cucumber plant most adaptable to mechanical harvesting, and the engineers developed a harvester which can go through the field many times without damaging the plants.

Engineers of the Agricultural Experiment Station in South

Top, cucumbers pour from conveyor belt of harvester in Michigan. USDA and Michigan teamed up to develop cukes better suited for mechanical harvesting and handling, and to improve the whole pickle production process. Above left, technician tests slice to determine internal strength of cucumber. Above right, ag engineer and processor check vines.

Carolina began developing a mechanical harvester for fresh market peaches in the 1960's. Working closely with horticulturists, these engineers have developed a machine from which the harvested fruit is entirely acceptable on the fresh market.

The same engineers have applied the experience and knowledge gained from their work with the peach harvester to develop a prototype fresh market tomato harvester. Peaches and tomatoes are highly susceptible to bruising and other damage from machines. But these new machine marvels promise to change the harvesting of two of our most desirable fresh market products from a hand to a machine job.

Agricultural Engineers Bill Harriott and Roger Garrett of the Agricultural Experiment Stations in Arizona and California began working on machine harvest of lettuce in the early 1960's. They worked closely with each other and established basic principles of lettuce harvest mechanization. USDA engineers built upon their work and developed a machine compatible with practices of the lettuce industry.

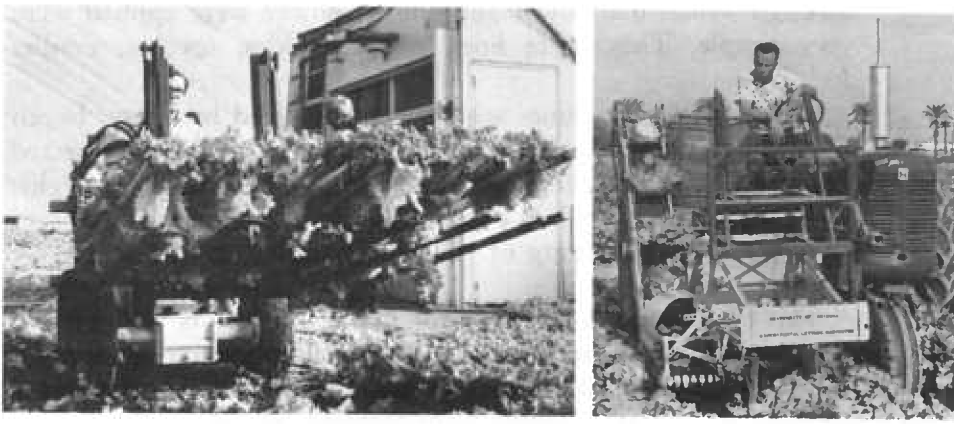
The lettuce industry, with the advice of the State-Federal engineer team, has now taken on development of a commercial prototype.

And Even Strawberries

Much effort is being directed to mechanizing fruit and vegetable crops. Now new machines are being developed for havesting such crops as cantaloupes, oranges and strawberries. Basic principles of mechanization are being worked out by growers, scientists, and engineers wherever these crops are grown.

State and Federal agencies share with agricultural producers, and with the agricultural equipment industry, interest and responsibility for improving the productivity of labor in agriculture. These groups continually share and exchange ideas and information.

As fruit and vegetable mechanization is a major thrust of the 1970's, perhaps mechanization of production of marine animals and plants will be the breakthrough of the 1980's. Even now, Agricultural Experiment Station engineers in such seacoast States



Lettuce harvesters developed by Ohio (left) and Arizona scientists. Ohio machine, tested in commercial greenhouses, may result in more greenhouse lettuce grown in rotation with tomatoes and during winter months.

as Maryland, Massachusetts and Oregon have set their sights on mechanizing the clam, oyster and lobster industries.

Mechanization of agriculture has all come about in little more than 100 years. As the United States prepares to celebrate its 200th birthday in 1976. It's well to remember that an American farmer of 200 years ago would have been perfectly at home with the tools used by farmers in Biblical times. And if we had no tools but those, almost every American would spend most of his working day just producing his own food. Americans would have little time left for exploring space and carrying on the activities which are the backdrop of our life today.

When prehistoric man first began to rely less on gathering his food from untamed nature and began to cultivate plants and keep animals, the energy he used was his own. As he toiled in the field with crude hand tools, he dreamed of ways to do his jobs in the field more rapidly and with less labor. He yearned to control more power than he himself could supply.

He developed tools which could be drawn by animals, and thus became a controller of energy instead of a source of energy for agriculture. That was just the beginning. The desire to control and apply more and more power in food and fiber production continues. Thus, a farm worker who can develop only one-tenth horsepower himself can effortlessly control a 200-horsepower tractor.

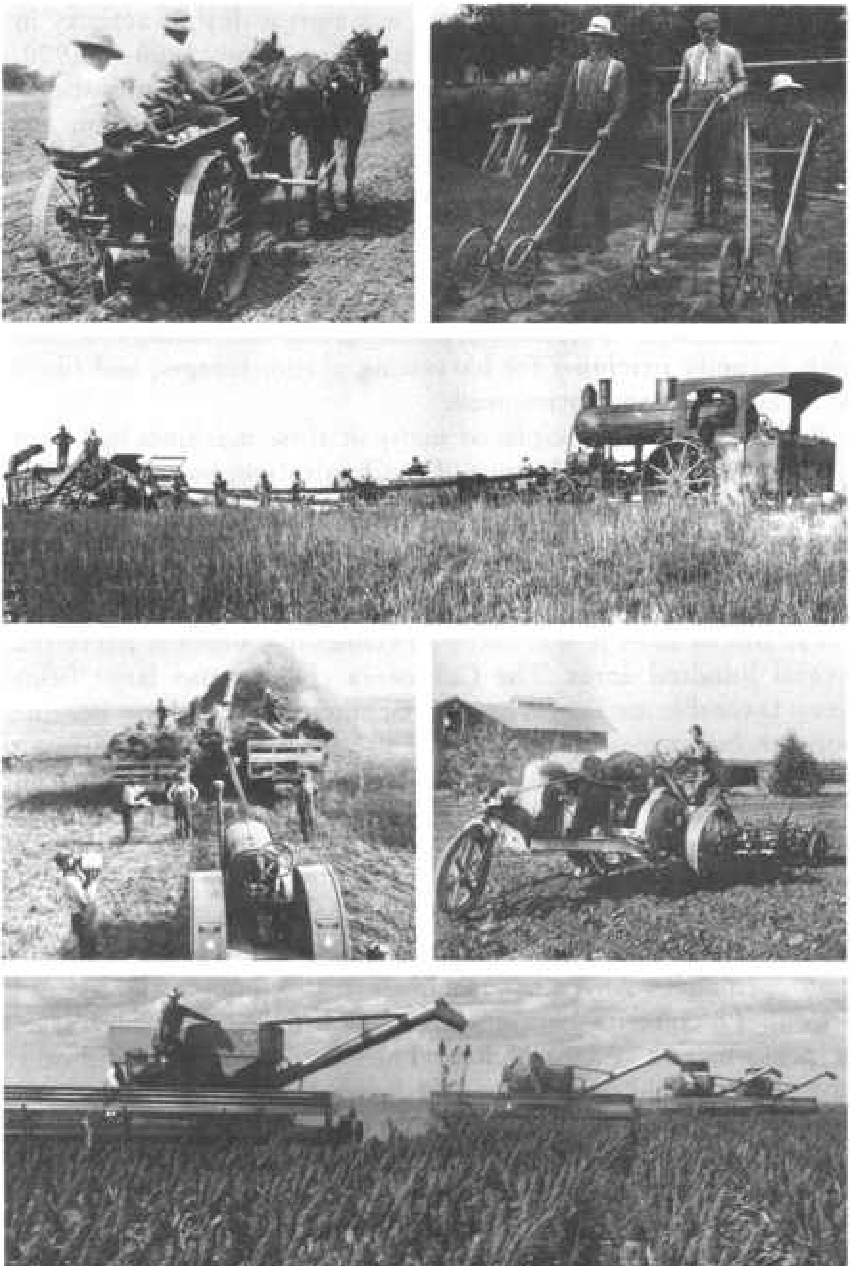
Hoe, Hoe, Hoe No Joke

During all time until the middle of the 19th century, tools through which manpower and animal power were applied were very simple. They were hoes, plows, sickles, scythes, cradles and flails.

In the 1850's machines which were powered by horses began to be adopted. Development of these machines certainly whetted the farmer's appetite for the heat engine, and the time was right. In 1769, James Watt had patented a steam engine which is recognized as the beginning of successful application of steam for power.

This event opened the door for many innovators to work toward the use of steam power. Thresher manufacturers undertook to make portable steam engines for agriculture. Farmers were also interested in steam engines for plowing, and in the 1850's successful steam-powered tractors were developed.

Application of steam engines to agriculture flourished from 1850 to 1900, but by 1920 the age of steam in agriculture was



Farm machinery through the years. Top left, planting potatoes, and top right, hand cultivators for onions, both scenes in Iowa about 1918. Details are unknown on next lower photo going across page, evidently a steam engine and threshing activities. Pair of photos show thresher, left, and gas tractor, right, in California. Bottom, combines harvesting grain sorghum in Texas, 1968.

about over. Starting in 1890 there was a great deal of activity in developing the internal combustion engine. From 1900 to 1920, great competition arose between steam (external combustion) and internal combustion engines. The internal combustion engine won out to revolutionize American transportation, and it won out to revolutionize American agriculture, too.

From 1920 to World War II the flexible, ever-improving internal combustion engine paved the way for the widespread development and adoption of the basic tools of modern American agriculture. High-speed tillage, planting, and cultivating tools and high-capacity machines for harvesting grains, forages, and fibers were developed and introduced.

Basic operating principles of many of these machines had been established early in the history of mechanization, but the internal combustion engine made effective application of mechanization possible.

40-Horse Combines

For example, a grain combine was developed in Michigan in 1832, and in 1854 it was taken to California where it harvested several hundred acres. The California climate and large fields were favorable to this type of machine. The combine became popular, but it required as many as 40 horses.

Compare the morning job of "starting up" 40 horses on an 1880 combine with the job of starting a 150 horsepower engine on a 1975 combine, and the role of the internal combustion engine in mechanization jumps into vivid relief.

When World War II created a sudden upsurge in demand for farm machinery, all the required elements had been marshaled. Basic principles of many machines had been developed and proved. The internal combusion engine had reached a high level of performance and reliability. The farm equipment industry was firmly established. State and Federal programs of agricultural research and development were on a firm base.

When 1940 brought a sudden need for production of food with less labor, America was ready.

Throughout the mechanization revolution, the State Agricultural Experiment Stations have served as a link between agriculture and the farm equipment industry. Experiment station staffs have included plant scientists, animal scientists, and engineers who have maintained a grass-roots contact with agriculture, developed knowledge fundamental to solving mechanization problems, and worked closely with agriculture and the farm equipment industry in applying this knowledge.