been registered for use in this manner by USDA's Pesticides Regulation Division. Pesticide manufacturers wishing to label their products for ULV aerial applications must submit data on effectiveness, drift, plant damage, residues, hazards to fish and wildlife, and hazards to the aerial applicator, including his ground crew.

At present, relatively few compounds have been approved for ULV application by aircraft. These include malathion for a fairly wide range of insect pests; azinphosmethyl (Guthion®) for boll weevil control in cotton and sugarcane insects, naled (Dibrom®) for adult mosquitoes on noncropland; a DDT-toxaphene mixture for a variety of pests of cotton and soybeans; and toxaphene for pests of bananas.

Numerous other materials have been tested as ULV sprays, many of them with promising results. It appears likely that additional chemicals ultimately will be approved for use in this manner.

Despite the progress with ULV aerial spraying, a concerted research effort will be required to fully exploit the technique. Aircraft spray dispersal equipment and pesticide formulations must be improved to permit better control of droplet size and, thus, drift. From the biological standpoint, optimum droplet sizes must be determined for each target pest. Likewise, more effective techniques are required to assess ULV spray deposits.

With the remarkable accomplishments recorded to date as a result of savings in application costs on large-scale programs, the increased effectiveness in control with less toxicant, and the speed of coverage against disease-carrying pests, ULV faces a promising future indeed.

Automatic Livestock Feeding

H. B. PUCKETT, K. E. HARSHBARGER, *and* E. F. OLVER

Automatic systems for mixing and distributing livestock rations can reduce the man-hours required for feeding cattle by 75 to 80 percent. Such systems are now mechanically and economically feasible. That is, with sufficient capital available for the necessary investment, the environment can be created (buildings, equipment, etc.) and a profit realized. And if the general conditions most affecting this process continue substantially as at present, the profit potential is likely to become even greater.

Mechanization of crop production—as this affects the production of feed grains—and more practical adaptations of mechanical advancements in feed handling have made possible the breakthrough for radically increasing the efficiency of livestock production. This means livestock production can now join the ranks of grain production and other fast-changing agricultural production systems in the upward cycle of efficiency increase.

Examples abound:

Broiler production had an increase in productivity per man-hour of 538 percent between 1945 and 1965. In feed-grain production (using the 1940–1944 period as the basis for comparison), the productivity increase per man-hour has exceeded 700 percent. On the same basis, that of livestock and livestock products has increased only about 215 percent.

Mechanization of livestock production has progressed at a slow pace because of the large number of small

and time-consuming operations that had to be meshed into a smooth and reliable system. Recently, however, livestock producers and equipment manufacturers have attacked the problem of mechanizing livestock production in earnest.

An example of the type of research and development unit that is serving to quicken the pace is the Dairy Mechanization Center at the University of Illinois. Established to explore the concept of automated, mechanized group feeding and handling of dairy cattle, it will take care of 80 dairy cows. And the system provides a precisely mixed feed ration.

A preset control system initiates all the actions automatically. The feed is mixed, ground, and conveyed to the desired points as directed by the automatic controls. One man can look after the whole operation—including grouping the cows for milking, feeding, and housing. Individual attention is required only during calving, breeding, or veterinary treatment for a particular animal.

To effectively apply modern, automatic equipment to dairying, the operator must accept the concept of group handling. Emphasis has to be placed on uniformly high production and on efficient use of labor.

The number of milk cows in herds of 50 or more increased 3.57 times between 1939 and 1959, according to the 1959 U.S. Census of Agriculture. Larger herds provide a more efficient base for mechanization.

One man can handle enough high-yield cows to produce 800,000 to 1,000,000 (or more) pounds of milk annually. The key is in arranging everything for maximum efficiency.

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At present in the United States, most feed preparation and distribution systems are of the semiautomatic type—an operator is needed to initiate the actions and to change the pattern. Recent developments in solid-state devices—diodes, transistors, silicon control rectifiers—have created the potential for the kind of fully automatic control system that can be preset and that is both reliable and efficient. This is the kind of control system now being perfected and tested in units like the Dairy Mechanization Center in Urbana. The time-rate method of control best describes the controls developed for the system in the Illinois project. One of the new items developed was the electronic silo unloader control, which makes use of the high-power-amplification capability of the silicon control rectifier.

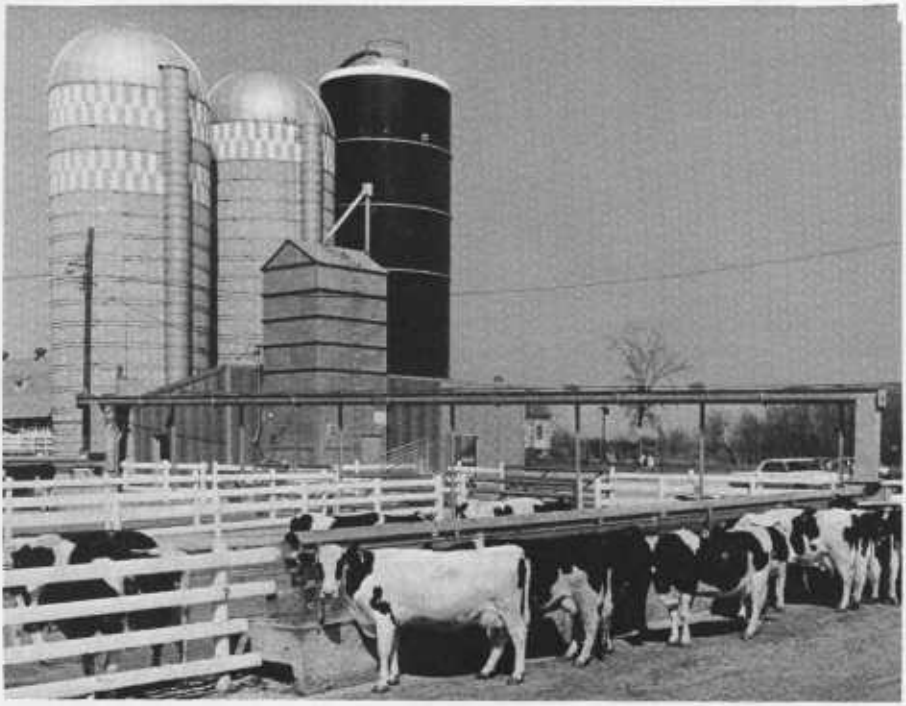
The University of Illinois system permits the dairy cows to be fed by automatic or manual control. Ingredients are removed from storage in the proper quantity and at the proper rate, mixed together to form a ration, and the ration fed in turn to each of the four lots.

Makeup of the ration for each lot and the quantity distributed are regulated by the control system.

Feeds handled are grass silage, haylage, corn silage, and a concentrate ration made up of a maximum of four ingredients or premixed combination.

The concentrates are blended in an automatic hammer mill and are pneumatically conveyed to a concentrates tank, which is equipped with a volumetric feed meter that regulates the proportion of concentrates to the silage. The hammer mill unit operates independently of the main control system.

The silo unloaders are in the top of two concrete-stave silos and are supported by cables. The unloaders consist of a gathering auger to bring the silage to the center of the silo and a blower-thrower to discharge it from the silo. A bottom-silo unloader is used in the third silo, which is a sealed storage unit.



Overall view of Dairy Cattle Mechanization Center, *above.* Grass silage, haylage, and corn silage from three silos and concentrates from tall building provide the ingredients for feed ration. After mixing in low building, ration is conveyed on 90-foot raised horizontal cross auger to feed bunks. *Right,* cattle at feed bunk on one of four lots. Milking parlor is in background.

Since the combination and proportion of the ingredients are under full control of the operator, the finished ration may consist of any one of the four major sources, a blend of all four, or any combination.

The ration is assembled from the four sources and delivered to the feed bunks in turn.

The feed-bunk distributor is a 9-inch auger that can discharge material into several small "cells" beneath it. When the last of these cells has been filled, a switch causes a second auger to empty the cells into the feed bunk.

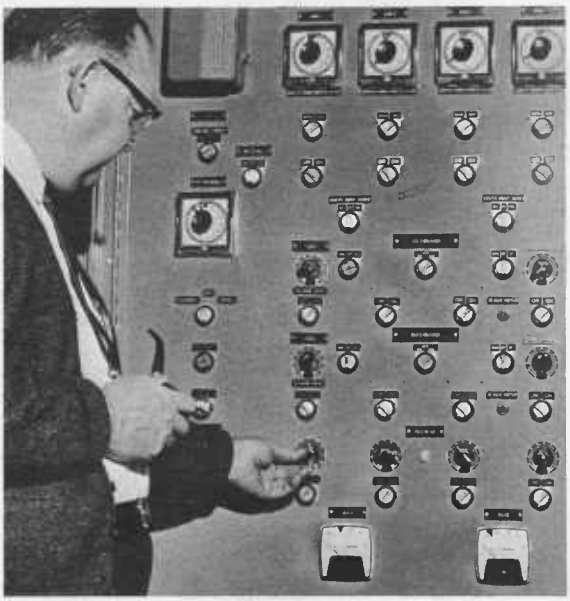
The ration can be delivered as often as every 2 hours or as infrequently as once each day. Delivery to any one lot is adjustable between zero and 30 minutes. After each delivery, the conveying equipment operates for a short time to completely clear the conveyors before feed is mixed for the next lot.

The control system includes safety features to prevent delivery of an improperly mixed ration. If a particular piece of equipment fails to do its job, automatic shut-off occurs and a warning circuit is energized.

Since 1936, mechanization in the field has increased by more than four times the work which one man can successfully perform in crop production. We are on the threshold of a similar upswing in efficiency (in terms of the human labor input) in livestock production.

The radical changes experienced in the broiler industry may only be a harbinger of what lies ahead in the production of livestock. And this, too, can be seen as taking its place in the massive pattern of change that has steadily increased U.S. agricultural production while steadily decreasing the number of people required to live and work on our farms in order to get the job done. It stands as a monument to the efficiency of mechanization, properly integrated into a total system which is dedicated to ever-increasing crop yields and ever-greater animal production.

Improved crop yields came first, followed by revolutionary changes in management practices and output in some types of animal production. The major holdout has been livestock production. Now, the means are at hand to begin to radically upgrade efficiency in that sector of agricultural production too.



H. B. Puckett at control panel for automated livestock feeding system.

City and Country