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A Step Toward Automatic Weighing of Range Cattle[1]

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Highlight

A battery-operated electronic scale recorded range cattle weights accurately on oscillograph charts without disturbing the animals. With refinement, the system could operate automatically.

The purpose of this study was to develop a cattle-weighing system that would operate under field conditions without affecting the animal's rate of gain. The weighing system was designed for research on such questions, as: When do cattle gain or lose weight? How are gains or losses related to vegetation, rainfall, temperature, or other factors? And, how do gains and losses correlate with the quantity, chemical composition, and digestibility of forage eaten by the animals?

The system was also designed to answer such practical questions as: When do calves or yearlings reach their peak weights? and, how are these peak weights related to the end of the spring or summer growing seasons, the drying of the perennial grasses, maximum and minimum temperatures, etc? Answers to these questions will help ranchers determine when animal weights and market prices combine to give maximum returns.

The usual way to weigh range cattle is to round them up, sort them, and weigh them over conventional level-fulcrum scales. This procedure is adequate for determining the value of cattle bought and sold, but it has serious shortcomings for research either in range animal husbandry or range management. One obvious disadvantage is cost. Few research projects are well enough financed to afford several sets of corrals and scales and a full-time weighing crew of two or three men equipped with saddle horses and the means for transporting them. A second disadvantage of conventional weighing is that range cattle lose weight in the process, and may not recover fully for several days. Thus, frequent weighing by conventional methods may be expected to underestimate rates of gain and exaggerate rates of loss.

With these thoughts in mind, we set out to devise a system that would meet the following minimum requirements:

1. The basic system should consist of:
   a. An inexpensive platform which the animals would cross naturally to get to water or feed (identical platforms could be built at several locations).
   b. Weight-sensing devices and a remote recorder that could be quickly connected to any platform where animal weights might be taken.
2. The scale should weigh animals individually as they cross the scale platform.
3. Operation of the system must not disturb the normal routine of the animals.
4. The system must be operable at remote locations not served by central station electric power.

Design and Construction of the Scale

The design criteria allowed for one animal entirely on the scale at one time, and restricted the animal from turning around on the scale. The width dimension was taken from a large Hereford bull. The length was determined by measuring the tracks of a 900-lb cow walking through sand. With these measurements as a guide, a platform 42 x 90 inches and a supporting structure were built (Fig. 1). The supporting structure was constructed from 6-inch channel iron and a 3-inch I-beam. The platform was constructed from angle iron and 2 x 8-inch planks. The platform rests on the base or below-ground portion of the supporting structure, except when cattle are being weighed. Four links attached to the platform and supporting structure allow sufficient vertical movement of the platform but prevent horizontal movement.

Since one criterion of design was that the system weigh animals as they moved across the scale without stopping, an electrical method was considered most feasible.

Four electrical resistance strain-gage load rings were made up in the Department shop[3]. Each load ring was a 2-inch section of standard 5-inch-diameter black pipe with wall thickness of 0.258 in. Eyebolts were attached to opposite sides of the ring along one diameter for loading. Strain

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[3] *The design, construction, and calibration of the load rings and completed system are described in "An automatic animal weight recording system," by Leroy Leonard Bashford. MS Thesis, University of Arizona. 1966.*

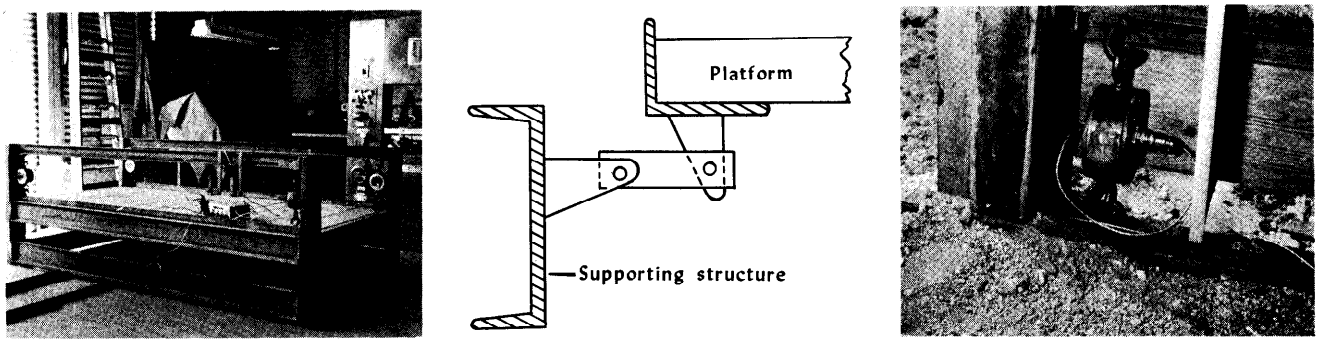

FIG. 1. To weigh cattle the scale is installed in a pit with the platform about 3 inches above the ground line. *Left*, the scale platform, supporting structure, and load rings. *Center*, link used to prevent lateral movement of platform. *Right*, single load ring in shade box after installation in the field.

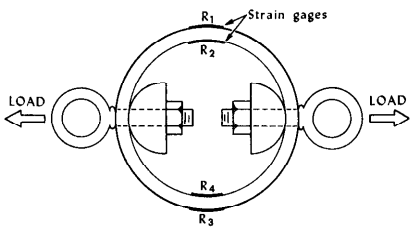

FIG. 2. Load ring showing the location of strain gages and direction of load.

gages were attached to opposite sides of the ring along a diameter perpendicular to the direction of load (Fig. 2). Hooks on the platform and on the underside of the top beam of the supporting structure permit the load rings to be easily inserted, thereby raising the platform off the base supports.

Adding weight to the platform stretches the strain gages on the inner surface of the load ring, compresses those on the outer surface, and changes the electrical output of the load-ring system. The magnitude of the electrical signal from the load rings is recorded on the oscillograph, and can be translated to weight by proper calibration[4].

In designing the load rings, it was estimated that the heavier range cows would weigh around 900 lb, but that occasional weights for bulls might approach 2,000 lb. The dead load of the platform was estimated at 400 lb. Thus, the total design load for the four load rings combined was 2,400 lb. To allow a safety margin of 200 lb. per load ring, each ring was designed to carry 800 lb.

Testing and Calibration

It was necessary that the sensitivities of the four load rings be as nearly equal as possible to insure that a given load applied at any location on the scale platform would result in the same signal output.

Before using the four load rings together in a system, they were labeled A, B, C, and D for identification, tested individually, and adjusted to approximately equal sensitivity by shaving metal off the ends of the less sensitive rings.

The four load rings were then electrically connected in parallel as they would be on the scale, and each ring was individually loaded to check its individual sensitivity as part of the weighing system. The individual ring sensitivities were within 3% of the mean of their sensitivities.

The completed scale was installed at the Campbell Avenue Farm of the University of Arizona for initial testing. The load rings electrically connected in parallel were used with a Sanborn 301 recording oscillograph[5]. Fifty-pound sand bags were used to load the scale in increments to 900 lb. When the platform was loaded at the corners, the sensitivity ranged within 1.57% of the mean. Thus, the position of the load on the platform had little influence on the reading

[4] *For a lucid discussion of strain gages see: Perry, C. C. and H. R. Lisner. 1962. The strain gage primer. McGraw-Hill, New York.*

[5] *Trade names are mentioned for the benefit of the reader; their use does not imply endorsement or preferential treatment.*

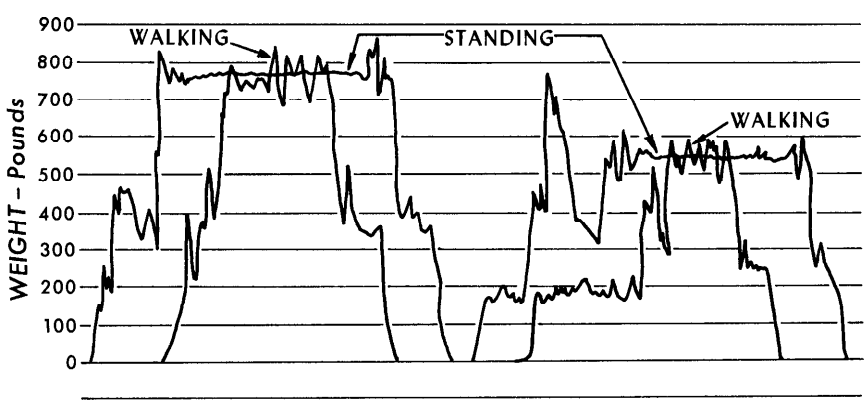

FIG. 3. Oscillograph traces taken from walking and standing animals, overlaid to demonstrate how charts can be interpreted.

obtained from the oscillograph.

Two steers of known weight were then led across the scale to observe the oscillograph traces that would be obtained with live loads. The true weight of each steer was obtained when it stood still on the scale. When their walking and standing oscillograph traces were overlaid, animal weights could be determined reasonably accurately by averaging the peaks and valleys of the oscillograph traces (Fig. 3).

The Completed Field Installation

After initial testing at the University of Arizona farm, the scale was set up at the entrance to a livestock watering place on the Santa Rita Experimental Range. A chute was constructed to force cattle to cross over the scale (Fig. 4). Trigger gates were built at the scale and at an alternate exit to force cattle to cross the platform in only one direction. The chute does not rest on the weighing mechanism and could be built narrower than 42 inches for smaller animals. At first the scale platform was covered with about 1 inch of soil so the cattle would not hesitate to cross the scale because of the wood floor. After a few days the soil was removed, and the cattle were given a few more days to become accustomed to the wood floor. When cattle were to be weighed, the load rings were installed and connected to the recorder, which was operated from a pickup truck parked about 50 ft from the scale. Since the cattle had little fear of the truck, it was not necessary to build a blind. The oscillograph was powered from the 12-volt truck battery through a convertor, which supplied 120 V, 60 c.p.s. current.

The calibration of the scale was checked again after it was moved to the Santa Rita Experimental Range. This field test was accomplished with five men and several 10-kg weights to provide a range in loads from 151 to 862 lb. The test showed that the weight, as interpreted from the oscillograph, was slightly but consistently higher than the applied load. The cause of the change in the sensitivity of the system was not isolated. This bias could have been eliminated by recalibrating the scale. For our purpose, however, satisfactory corrections were made by a regression formula computed from applied and observed weights.

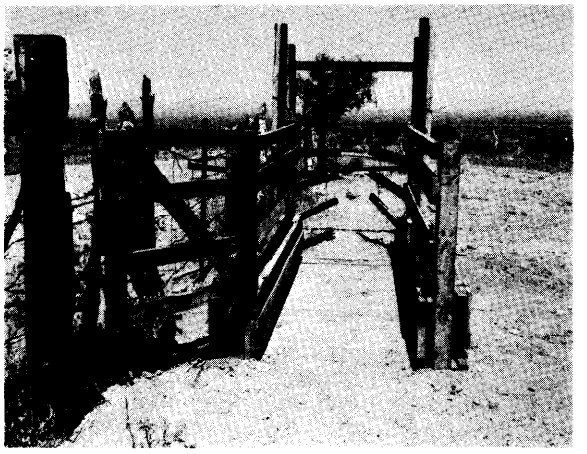

FIG. 4. The scale installed at the Santa Rita Experimental Range. Trigger gates keep cattle from recrossing the scale after watering.

When cattle were first weighed at the Experimental Range, some of the animals still hesitated to cross the scale platform. The charts for these animals were sometimes uninterpretable because the animals jumped or ran across the scale, causing extreme fluctuations on the oscillograph. These results indicate that longer conditioning periods are needed for some animals. Whether the nervous animals were excited by the wood floor, by the narrow passageway, by the presence of the truck and operator, by the faint hum of the recorder, or by a combination of these factors was not determined.

Most cattle weighed in the field crossed the scale more leisurely than those that were led across the scale during calibration at the Campbell Avenue Farm. Their oscillograph traces (Fig. 5) were less variable than those obtained by leading tame animals over the scale in the calibration studies.

Discussion

The results demonstrate that, by using load rings or equivalent

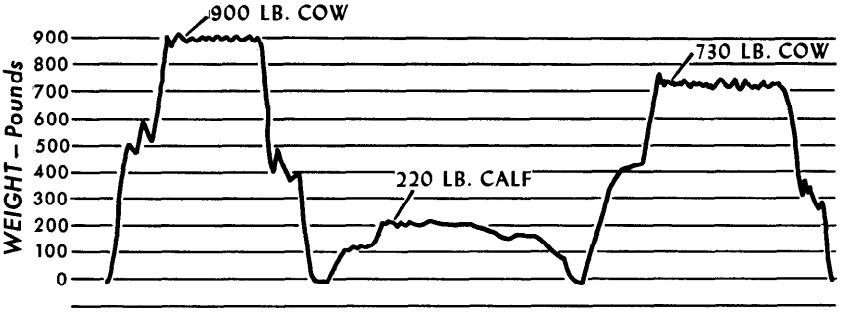

FIG. 5. Oscillograph traces obtained as two cows and a calf each crossed the scale.

transducers and a recording system, range cattle can be weighed without disturbing their normal routine. The weighing procedure does not require elaborate preparation. One person can insert the load rings and prepare the instrument for recording in about 30 min.

It should be stressed that the weighing system described here is a pioneer model, and that many refinements are possible. The use of commercially built load cells or transducers might well improve the performance of the instrument. For example, the experimental load rings must be shaded because they are not temperature-compensating, as most commercial units are. Adequate scale platforms can be built more cheaply from lighter weight materials. Some mechanical means of damping the scale, or a method to momentarily stop the animals on the scale, would eliminate some of the oscillating traces due to movement.

Cattle weights can be obtained with the experimental scale, but an operator is required. To fully automate the scale would require the following additional features:

1. A recorder with sufficient range to accommodate the full range of weights anticipated. The recorder we used required a change of attenuator setting for heavy animals.
2. Remote control of the chart drive, such that an animal would start the chart by stepping on the platform, and that the chart would run 1 or 2 seconds after the animal leaves, in order to establish the base or "no load" line. Since long intervals may elapse between animals, it is essential that the chart not run all the time.
3. Where individual animals must be identified, numbers could be painted on the animals. These numbers could be recorded by a camera tripped by the signal that starts the chart drive.

A scale with these additional features will soon be completed. If it is successful, we will proceed with tests to learn how to distinguish between gain or loss of tissue and changes in fill.

When perfected, the electronic scale will offer several cost advantages. One set of instruments can be moved about to obtain cattle weights on inexpensive, permanent platforms at several locations. Since cattle are not restrained, elaborate, expensive corrals are not needed. One man can set up and calibrate the system and record weights as animals cross the platform, or, he can set the system to operate automatically.

In its present stage of development, the system should work well where cattle visit a certain area regularly for feed or water. Weighing at water offers promise in the Southwest, where many animals drink daily during warm, dry weather, and where cool, moist weather is unusual. Until automatic operation is worked out, however, much operator time can be saved by closing the water the day before weighing, and allowing most of the cattle to gather before letting them cross the scale.