A Mechanical Beet Digger

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Tt has been rather conclusively demonstrated that the most precise method of topping sugar beets so far investigated is that in which the beets are topped in place, that is. before they are loosened from the ground. However, these ground-topped beets when plowed loose are very difficult to distinguish from the clods and soil, making manual pick-up a relatively slow and costly operation. Tests have shown that the considerable savings that accrue from mechanical in-place topping are consumed in the increased effort necessary to find the topped beets. Therefore, to be practical from a labor-saving standpoint, a harvest system employing in-place topping requires a mechanical lifter which will economically dig the beets, separate them from the soil and clods, and load them or place them in a convenient position for loading.

Need for Simple Mechanism.

For the United States the average acreage of sugar beets per grower is about 20 acres. A lifter to be justified for such acreage should be low in first cost and consume a minimum of power in operation. In addition, it should lift and separate topped beets from the soil and clods and elevate them sufficiently high that they may be conveyed to wherever necessary for loading.

Thus the problem was to find a machine that would handle as little material as possible and, of course, the absolute minimum of material would be the beets. Obviously by lifting beets free from the soil and thereby affecting the separation at the ground surface, the machine could be made smaller at less cost and require less power than if both beets and the surrounding soil were lifted and the separation made in the machine. The problem was then reduced to devising a simple mechanism to lift beets without lifting the surrounding soil mass.

A mechanism capable of performing this operation would have to distinguish between beets and clods. Fundamental differences between beets and clods are found in the characteristic shape and toughness of the two. A beet is conical in shape and is able to withstand considerable impact, whereas a clod is random in shape and breaks more easily.

During the past 2 years of this co-operative research project, 2 experimental lifters have been developed which use as a basis of beet and clod differentiation these two differences. The 2 lifters per-

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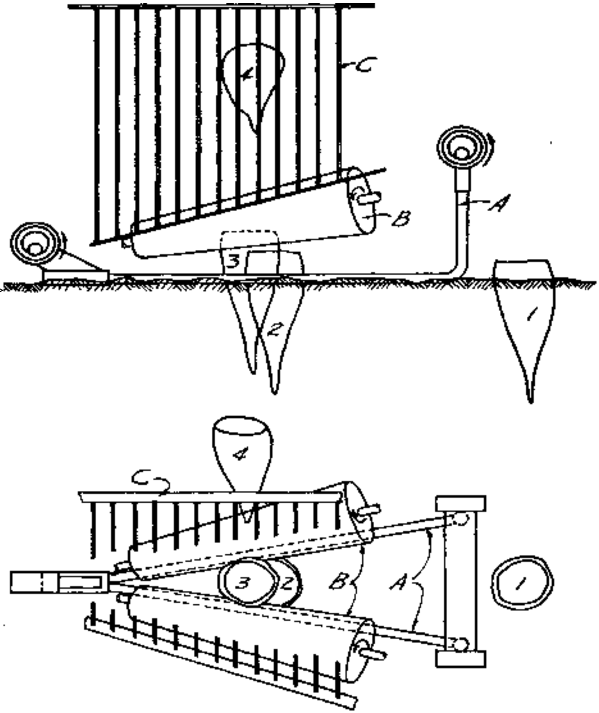

Schematic drawing of a mechanical digger

Path traced by any point on "V" Fork

form the same function but operate on slightly different principles. The primary lifting element of the **first** machine considered is an oscillating V-fork. The latter machine employs rotating square shafts instead of the V-fork. The remainder of this discussion is devoted to the description of their operating principles.

Operation of Two Experimental Lifters

Figure 1 is a schematic drawing of the first experimental lifter showing the 3 essential operating elements in their proper positions with respect to the ground. Part (A) is the lifter fork, (B) designates the two tapered compressible rolls, and (C) is the inclined deflector grill. Also shown is a loosened beet in various stages of being lifted. The beets are loosened ahead of the lifter by a conventional 2-bladed beet plow. This type plow was selected because of its comparatively low draft and because it tends to align off-row beets. The plow is operated with less take angle than is normally used to prevent the beets from being lifted so high that they topple over.

The principal element, the V-fork (A—fig. 1) is composed of 2 rods joined to form a " V " with the open end at the front of the machine. The fork is circularly oscillated by means of phased eccentrics or cranks, 2 at the front and 1 at the rear, which are rotated counter-clockwise as seen in a right elevation view. The eccentricity of the cranks is % inch giving a stroke of 3/4inch. The rotational motion of the fork with respect to the machine combined with the translational motion of the machine with respect to the ground results in a cycloidal motion of the V-fork with respect to the ground. This is shown in figure 1 as the path traced by any point on the V-fork. As the machine moves down row the beet is contacted by each rod of the fork at some point along the fork where the separation is equal to the beet diameter at the depth at which the fork is operating which is usually slightly below ground surface. Since the V-fork rods converge at the rear, each beet is contacted and lifted regardless of size. For convenience of description, the stroke cycle (one loop of the cycloidal path traced by the V-fork) will be divided into four parts, beginning at that portion of the cycle where the V-fork is moving nearly vertically upwards with respect to the ground. It is during this period when the beet, wedged between the V-fork rods, is lifted a short distance. During the next quarter cycle, the fork moves back and down, releasing the beet. Then, for the third quarter cycle, the fork moves down and forward, and for the fourth quarter, up and forward again to make contact at a point lower on the beet. The cycle is repeated, the beet again being lifted a short distance. This short-lift process is repeated very rapidly, and the beet, because of its conical shape, continues to be lifted as the converging fork ad vances; whereas a clod, because of its irregular shape, is bounced

The principal difficulties experienced with the V-fork lifter were of a mechanical nature. Because of the high speed of operation, it was necessary to make the V-fork light in weight to keep the reactive bearing load within reason. Even though heat-treated high-strength alloy steels were used, the rods failed from repeated stress. Also, because the center of mass of the fork was not in the plane of the cranks, it was impossible to eliminate vibration with any simple counter balance. It was because of these and other design problems which did not admit of easy solution that it was decided to investigate other means of lifting beets free of the soil.

By substituting simple rotating members for the V-fork, the inherent shortcomings of the high-speed oscillating mechanism were eliminated. These rotating members are 13/8-inch square shafts, 25 inches long, placed to form a " V " with an included angle of 22°, much the same as the oscillating V-fork. The square lifter shafts are rotated in opposite directions and phased by means of a bevel-gear drive at the front, so that a beet fed between the shafts is gripped by the corners and raised. As the shafts continue to rotate, the beet is next released on the flats, then gripped and lifted by the following set of corners—-released, raised, etc. As is readily apparent, this short lift, release cycle occurs 4 times per revolution of the shafts and at a sufficiently rapid rate (800 r.p.m. per mile per hour) that the beet is forced upward into the pneumatic rubber rolls. The principal advantage of the rotary over the oscillating mechanism lies in the simplicity and ruggedness with which such a unit can be built.

A New Type of Harvester

The latest lifter unit built with the rotating square lifter shafts was mounted on the rear of a light tractor in conjunction with a topper. This combine, or harvester, was operated satisfactorily in California, Utah, and Colorado this season. The greatest difficulty insofar as the lifter was concerned seemed to be in the plowing. The plow did not function the same under the many different soil conditions encountered. In wet soils, particularly, the plow used would tip over and cover many beets so that they were well under the surface. The lifte'r shafts which operate only slightly below ground surface of course would not pick up these beets. In field trials, the pick-up efficiency of the unit was found to vary from 90 percent to 99 percent, peaking at approximately *95* percent. Beside the malfunctioning of the plow, there were several more or less minor problems of construction that became apparent as a result of increased field experience this season. However, with the work that is now being done on plows, it is hoped that in the near future a new design of this lifter can be made to operate continuously with practically 100 percent pick-up.