Development and Application of an Axial Flow Trash Separator

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The mechanical harvest of sugar beets in California has grown to such an extent that about three-fourths of the state's acreage is harvested by machine, principally Marbeet harvesters. The growth curve of mechanical harvesting has been almost paralleled by the curve of increased tare percentages of the beet-receiving stations of the Spreckels Sugar company. From an average tare percent of 3% over the years preceeding 1943, the tare percent of this company reached a high of 6.92 in 1949.

The management of the Spreckels Sugar Company as early as 1946 recognized the need for coping with the rising tide of trash delivered with the mechanically harvested beets. Discussions were held to determine the most effective method of attacking the problem. Ihe management was agreed that the ideal situation would be to so alter mechanical harvesters as to prevent their delivery of anything but clean beets. Unfortunately, a realistic examination of the problem revealed that the mechanism of harvesters was not so much the cause of excessive trash as were the cultural habits of growers which had been created by the advent of mechanical harvest.

Figure 1. This car load of beets illustrates the extreme amount of trash delivered by mechanical harvest. Conventional screening methods are ineffective on such trash.

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Figure 2. The pilot model of the fluted roll screen was a level bed of *ten* oppositely rotating rolls, 4 inches in diameter. A 15 HP motor drove the rolls and paddle wheel for transferring discharged beets.

Along with the mechanical harvest had come a reduction of quality standards of delivered beets. This reduction in standards led inevitably to a relaxing of cultural standards in the fields. The result was that thinning and hoeing operations were generally limited so as to produce crops which would submit to mechanical harvest but which would present a minimum cost of field operations.

Therefore, it became necessary to cope with the trash problem at the beet-receiving stations and the problem, at least temporarily, became a stepchild of the processor.

A review of mechanisms designed to eliminate leafy material from root crops revealed a considerable background of development work, some of which had culminated in commercially successful topping machines for such vegetables as red beets and onions.

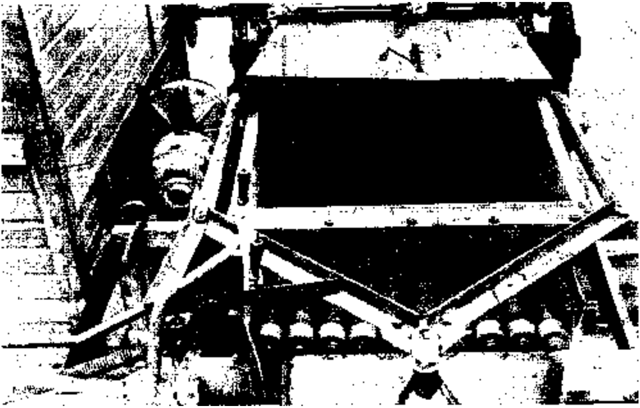

Figure 3. The second model used $4^1/_2$ diameter rolls with $^3/_8$ round flights. 3,500 tons of beets were cleaned by this screen, before the open driving gears were worn out.

S. W. McBirney[2] had done some experimental work in connection with the removal of trash from beets delivered by the Scott-Urschel harvester in the years following 1940. The oppositely rotating, helically-fluted rolls employed by McBirney were inadequate (because of space limitations) to solve the trash problem of the Scott-Urschel harvester. It showed every indication, however, that such rolls presented a means of sharply discriminating between sugar beets and the foreign matter (leaves, weeds, clods, et cetera) which formed the complex of sugar beet trash.

It was recognized that, to handle a flow of beets of such magnitude as is handled in a receiving station, a relatively large bed of helically-fluted rolls would be required. Accordingly a pilot machine was built in which all dimensions were based pretty much on guess, since *in* the experience of the designer no machine had ever been built to handle a flow of beets at rates on the order of two tons per minute. This pilot machine employed

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ten oppositely rotating rolls, 4 inches in outside diameter and rotating in alternately opposite directions. Rotation speeds ranging from 225 to 350 r.p.m. were tried.

Some rather astonishing results emerged from these early trials. The bed of rolls extracted very nearly 100 percent of all material other than sugar beets, including artificially introduced masses of soil, mud, rocks, weeds and

Figure 4. Left—beet fragments delivered by the fluted roll screen. Right—beet fragments delivered by a conventional Rienks screen.
The fluted roll screen delivers more fragments than does the Reinks screen, but their small size makes the total weight about one-half as great.

beet tops. Unfortunately the machine was equally effective in removing the tails from nearly all beets, and delivering to the trash discharge an alarming percentage of useful sugar beet tissue.

There appeared to be one definite point of attack on the problem of tail breakage. The rolls were so located as to present a space % of an inch wide between each pair of rolls. The helical flights on the rolls consisted of a *i/$_2$* inch square iron rod forming a double lead with a pitch of 18 inches. Therefore, a closer spacing of rolls suggested itself. A second model was constructed in which *$4^1/_2$-inch* diameter rolls were employed, spaced $^1/_2$ inch apart. The flights consisted of $^3/_8$-inch round iron rod, again arranged as a double helix with 18-inch pitch. This roll bed was mounted on a Silver-Roberts piler, replacing the usual Rienks screen.

In this application the screen was subjected to all of the abuse incidental to the piling of beets received from unselected truck loads. Thirty-five hundred tons of beets passed over the screen during its installation in this piler. This accomplishment was not without some rather heroic maintenance measures. The open gears which transmitted motion from roll to roll were virtually destroyed by abrasion, even though direct entrance of abrasive matter was eliminated by shielding. Driving the rolls by means of a serpentine roller chain was tried, but this arrangement proved even less durable than the original gear drive. It became evident that a totally enclosed, oil-immersed gear drive, following the practice of automotive transmission construction, would have to be employed if durability were to be achieved.

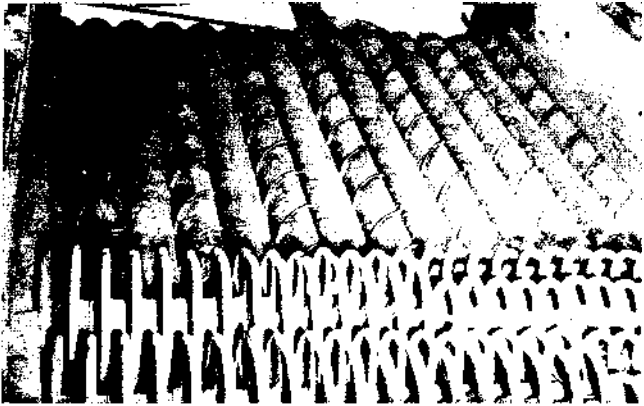

Figure 5. A fourteen-roll screen was preceded by a short Reinks screen at the Woodland truck dump.

The breakage of beet tails by this second screen was reduced to a point where it could be considered a secondary problem. There was, of course, some breakage of the beets. But tests indicated that this breakage amounted to about one-half the weight of the beet fragments found in the discharge of the conventional Rienks screen. The roll screen broke off a larger number of beet tails than the Rienks screen, but at such a small diameter that their total weight averaged about 1/2 percent of the total beet weight. The Rienks screen under similar conditions removed beet fragments and small beets weighing approximately 1 percent of the total beet weight.

The necessarily short rolls required for installation in the piler left something to be desired. It appeared that instead of 4 feet of length available in the piler, 6 feet would have provided almost complete trash removal. Even so, the beet piles made with this screen were strikingly free of visible trash, and did not create the heating troubles witnessed in the adjacent pile which had been deposited by a piler with the conventional Rienks screen.

During the latter part of the piling experience a problem with grave implications presented itself. As the rainy season approached, muddy beet loads became increasingly frequent. Certain types of sticky clay when present in the load would so envelop the rolls as to bind them completely and stall the 20-H.P. driving motor. There was a striking contrast between moist dirt and dry dirt in relation to the machine's performance. The capacity for

Figure 6. The roll screen installed at the Isleton dump handled close to 19,000 tons without major repairs.

dry soil was apparently unlimited as as much as 4,500 pounds of soil in a five-ton beet load had been extracted with no difficulty.

In an effort to improve the machine's ability to handle sticky mud, a new set of gears was installed so as to produce a difference in speed of rotation of adjacent rolls. At the same time the flights were removed from alternate rolls, since the difference in roll speed would preclude the possibility of proper timing and the meshing of flights.

After making this revision the machine was again installed in the piler and operation resumed. There was a marked improvement in the screen's ability to cope with the mud situation, but under extremely muddy conditions the screen became inoperable.

The third installation of a roll type screen was made on the Woodland factory truck dump. This dump is a very high capacity unit, the main belt delivering an average of 7 tons per minute, with peaks reaching 12 tons per minute. Two Rienks screens, each 7 feet wide, were usd originally for cleaning beets at this dump.

A roll screen containing 14 rolls, each 6 feet long, was installed in place of one of the Reinks Screens. This screen embodied all mechanical details which were considered necessary in the light of the rapid wear previously experienced. All gear and roller chain drives were enclosed in an oil bath and particular pains were taken in regard to bearing seals.

This installation proved to be a step backward in the progress of developing the roll screen. Limitations *in* space made it necessary to mount the screen in a horizontal position and this was fatal so far as properly handling the volume of beets presented by this high capacity dump. True, the removal of trash and dirt compared favorably with the adjacent Rienks screen, but it was painfully evident that discharge of beets by the roll screen was so slow as to cause the beets to pile up into a thick layer. (The prime requisite of any successful screen is that the beets shall be spread in a layer whose thickness is no greater than that of a single beet.)

After the screen had been used in this location for thirty days, unseasonal rainfall produced a severe mud condition and the time lost in cleaning the roll screen became so great that it became necessary to replace it with the original Rienks screen.

The fourth installation was made with caution as to location. A receiving station (Isleton, Calif.) was selected which handled only beets from peat soils and which was very unlikely to present a mud problem. The screen was mounted on a 10-degree slope even though this necessitated shortening the rolls to a length of 4 feet. Except for shortening the rolls, no changes were made in the screen as previously installed in the Woodland factory dump.

In general it may be stated that the season's experience at the Isleton dump w<as completely successful. The performance of the screen here tabulated:

	Percent Clean Beets			% Tare
Screen Type	**Maximum**	**Minimum**	**Average**	**Average**
Armer Fluted Roll	. 98.41	94.87	96.87	3.13
Eccentric Ring, 1948	97.06	86.87	93.52	6.48
Average, Dist. 2, 1949 (Exclusive of Isleton)	95.76	81.26	92.92	7.08

This comparison demonstrates the relatively high effectiveness of the roll screen. This effectiveness is emphasized by the fact that while Isleton has, historically, been an exceptionally trashy dump, carloads from this dump during 1949 were almost free of any visible trash.

Between August 1 and November 17 and 18, 826.5 gross tons of beets passed over the Armer screen. During this time wear on the roll tail bearings made their replacement necessary. These bearings are the weak spot in the design, since mud is forced into them despite the use of triple seals.

Conclusions

1. **The fluted roll type of screen is highly effective in the removal of all foreign material customarily associated with sugar beets.**
2. **This screen is incapable of operating in the presence of appreciable quantities of certain sticky clay soils.**
3. **The screen can be made mechanically durable by employing high class automotive type construction.**
4. **Horsepower requirements are high, since installed horsepower must be adequate to maintain rotation when large objects or bunches of trash are caught between adjacent rolls.**