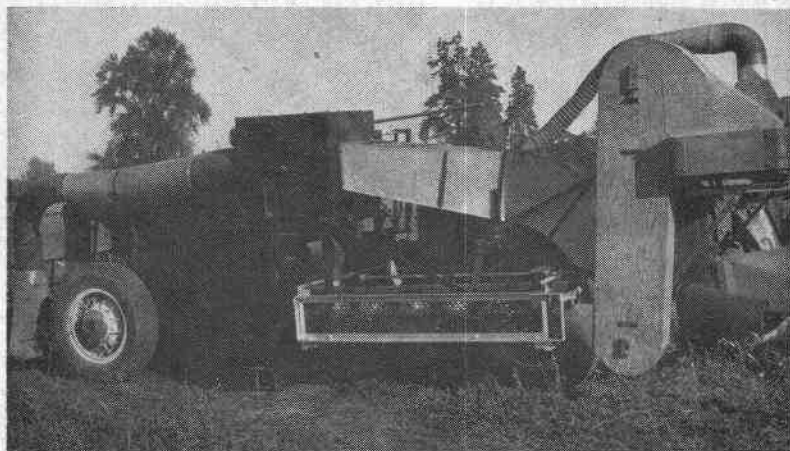


Design for a

Suction-Type Filbert Harvester



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Technical Bulletin 14

November 1948

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Design for a

Suction-Type Filbert Harvester

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THE FILBERT CROP is of considerable economic importance in western Oregon. Harvesting represents 10 to 20 per cent of the selling price of the crop because picking nuts by hand is slow and laborious.

A machine with ability to harvest efficiently and rapidly offers the most logical solution to high-cost harvesting. Reducing the cost per pound is especially important if the market price of filberts declines while the cost of hand picking stays up—a condition which is likely to prevail in the near future.

Development of a suction harvester

After a careful study of the problems involved, the suction method of machine harvesting seemed to the engineers of the Agricultural Experiment Station to offer the most possibilities. Preliminary trials were made with an experimental machine of this type. The results were encouraging.

The first trials were made during the harvest season of 1943. Extensive field trials were made in 1944 and 1945, and limited trials in 1946 and 1947. It now appears that most of the serious problems have been solved and enough data and tested ideas compiled to specify how a successful filbert harvester of this type can be designed.

Component units of the harvester

The suction type harvester naturally evolves or breaks down into several major groups of component units. These units can be assembled in various ways into a workable machine, according to the ideas of the individual builders. So far, most of the machines constructed are of the self-propelled type, using one engine for driving the suction fan and other parts, and another for propelling the machine. This arrangement gives the needed flexibility in operation, since neither function is tied in with the other, and ground speed can be entirely independent of the suction mechanism.

The major component parts are as follows and will be described in detail later:

1. The suction fan and power unit to drive it.
2. The rotating bar grid separator and air-lock unit.
3. The suction nozzle system.
4. A dirt-cleaning unit.
5. Conveying equipment.
6. Husking unit.
7. The final cleaning unit.
8. The sacking device.

Mounting the harvester on a tractor and using the power take-off for driving the suction fan and other machinery has not proved satisfactory. In the first place, the tractor lacks space to mount all the necessary parts without getting the machine too high or too cumbersome. In the second place, the tractor engine must be operated at speeds approaching full-governed speed in order to produce sufficient power for driving the fan, and the ground speed of the tractor, even in low gear, is entirely too fast. The maximum ground speed possible under the best conditions is about $1\frac{1}{2}$ miles per hour. Quite often a speed as slow as $\frac{1}{2}$ mile per hour is necessary—too slow for any standard production tractor with the engine running much above idle speed. In starting, the operator has to “get back and take a run at it.” In stopping, the momentum of the fan will continue to drive the tractor for some distance after the clutch is disengaged. Such factors make handling the tractor-mounted machine awkward and even dangerous in the orchard. It is practically impossible to stop quickly or handle such a machine properly on turns at the end of the row. The one exception is a clutch-steered crawler tractor which can be stopped or maneuvered with the steering clutches while the engine is still driving the power take-off at normal speed. But, it appears that a separate fan engine would be more satisfactory.

The chassis

The chasses for most of the machines constructed have been made from an old automobile or truck chassis, with certain modifications. Truck frames must be lowered, while the average automobile frame will need to be lengthened slightly. Oversize single tires or dual tires on the rear are usually necessary with the automobile. Airplane tires with a 10-inch cross-section work very well. The use of duals widens the tread considerably, necessitating a wider swath of the suction nozzles in order to clear a path ahead of the wheels. It is desirable to have some excess swath over tread requirements. This excess should be to one side, thereby permitting the nozzles to be

operated closer to the tree row. The driver should be on this same side, where he has a good view of the operations next to the tree. His seat must be low to permit his head to clear low limbs.

Overall height

Limb-lifting bars over the entire machine have been found necessary in most cases. The lower the machine can be made overall, the more satisfactory it will be. Anything above 5 feet is too high for the average orchard. A machine not over 4 feet high at any point would be about ideal, but such a low design is hard to attain. Keeping it low on the side next to the tree is the best compromise. The side away from the tree should cause little trouble if it is kept under 6 feet and protected by limb-lifting bars. These bars should rise gradually from the front and go back over the entire machine. They can be made of one-inch pipe, and should not be over 16 to 18 inches apart.

Suction Fan and Power Unit Specifications

The only satisfactory type of fan is the paddle wheel. This fan is a standard type built by a number of fan manufacturers under the names "Planing Mill Exhauster," "Industrial," or "Centrifugal." Blowers usually designated as "Multivane" or "Squirrel Cage" are not satisfactory for this machine, nor is the propeller type.

Heavy steel impellers

Fan impellers should be made of steel plate heavy enough not to be damaged by stones or other debris that may pass through it. The impellers usually have six blades or paddles, and in some makes these blades may be secured to a circular plate on the side opposite the intake. One should take care not to select an impeller with a circular shroud ring on the intake side. For other uses this ring tends to improve the efficiency of the fan, but this type is not recommended where a large amount of coarse material is to be handled. A "long shavings" wheel is the best type of fan for a filbert harvester. This type has the open blades or the plate on one side only.

The fan should be able to handle 1,000 cubic feet of air per minute per foot of swath width of the machine, at a total static pressure of not less than $5\frac{1}{2}$ inches of water. In selecting the fan, it is advisable to choose one with a 6-inch static rating, and having the required volume at moderate speed. This added efficiency will give some reserve capacity in case it is ever needed. A small fan operated at high speed is less efficient and requires more power than a larger one operating at a slower speed.

Fan power unit

The horsepower given in the manufacturer's fan tables is the theoretical air horsepower delivered and not that required to propel the fan. One should allow about 10 per cent more for belt and other friction losses in choosing the power unit for driving the fan. The other mechanical parts of the machine require a relatively small amount of power, but there may be considerable friction loss in the various drives involved. In order not to overload the engine, one should allow about 5 horsepower over the fan requirements for the other parts.

The power unit should have a clutch, in order that the engine can first be started and warmed up without load, and the machine then started and brought up to operating speed smoothly.

Details of Suction Nozzle Design

Extensive tests with nozzles of a wide variety of shapes and sizes have proved that the most efficient type is one having a straight vertical lift for some distance above the opening. This is necessary in order that the nuts will have sufficient time to accelerate to the air velocity before any bend or turn is attempted. In a bend, the air naturally tends to flow to the outside of the bend; and the nuts, due to their weight, will drop to the inside where the velocity is lower unless they are already traveling at a speed approximately the average air velocity.

Nozzles with a bend close to the opening pick up the nuts from the ground, but do not get them past the bend. The nuts drop out of the high velocity air, float around in the lower velocity air at the inside of the bend, and eventually drop back out of the nozzle. It takes about two feet of vertical lift before the nuts fully accelerate to the air velocity, after which they can be conveyed by the air stream around any type of reasonably smooth bend in the duct.

Tests also showed that the air entering the nozzle can be made several times more efficient in its lifting effect if it enters in approximately equal volumes from both sides of the nozzle and parallel to the ground. This can be accomplished by placing a horizontal lip or skirt about 3 inches wide on each side of the nozzle opening. (See Figure 1-A.)

The nuts lying on the ground in front of the nozzles as the machine moves along tend to block off some of the air flow on the front side. The nozzle design should compensate for this condition and maintain the optimum balanced flow. This is done by lowering the lip on the rear side of the nozzle one-half inch below the lip on the front side. (See Figure 1-B.)

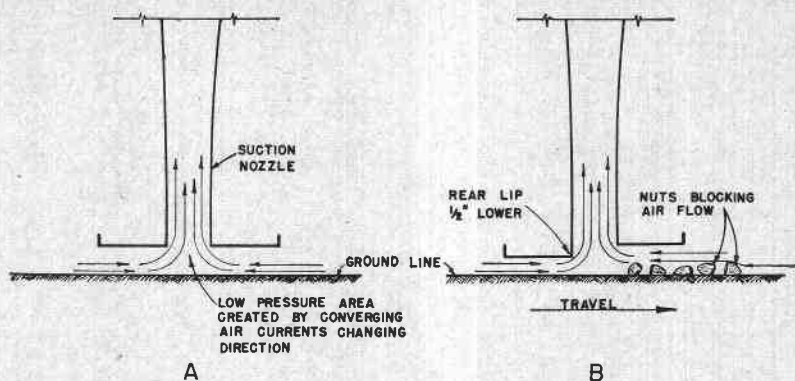


Figure 1. Principles of suction nozzles.

This modification, when tested side-by-side with the type shown in Figure 1-A, showed about 50 per cent better picking ability when the nuts are very thick on the ground. In other words, it would pick up all the nuts at 50 per cent higher travel speed. This extra height in front also aids the nozzle to ride over heavy leaf blankets and large clusters of nuts still in the husk, instead of pushing them ahead in an ever-increasing mass. Carrying the front skirt on forward for 3 or 4 inches in a gradual upward speed and past the usual 3-inch limit helps where the leaf condition is serious.

Nozzle height

Height of the nozzle opening from the ground is very important. It is controlled by a glider shoe behind the nozzle. This glider shoe should be 2 to 3 inches wide and about 5 inches long, in order to have sufficient area to support the nozzles without cutting into the ground surface. Because the height of the nozzle will vary slightly with different soil conditions, it is best to have the glider shoe adjustable.

The glider shoe and its supports should not interfere with free access of air to the nozzle on the rear side. For average conditions, the front lip should be about $1\frac{1}{4}$ inches above the ground surface. For very hard and smooth surfaces it can be a little less, giving better suction and, therefore, permitting faster travel speed. For rough and uneven surfaces the height will needed to be increased, and travel speed reduced. (See Figure 2.)

It was also found that it is very important to design the nozzles to have constant air velocity from the opening at the bottom all the

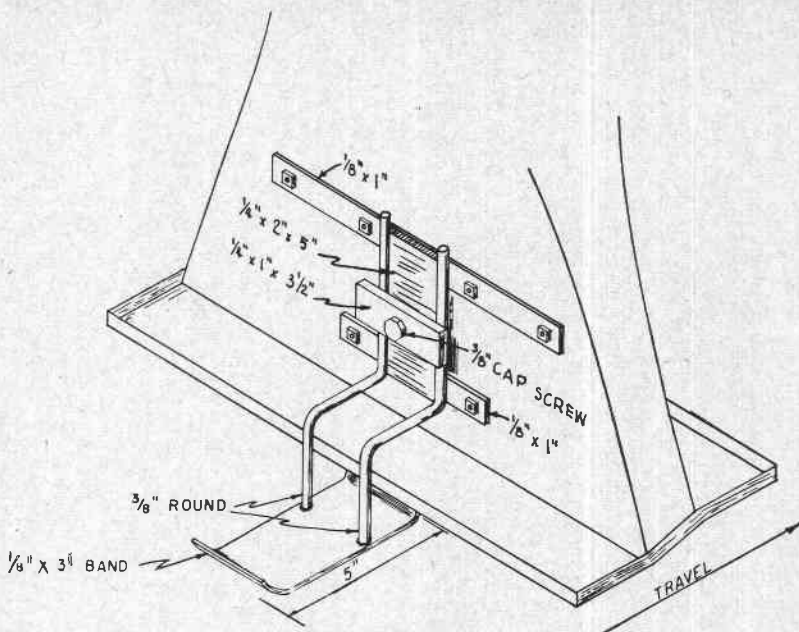


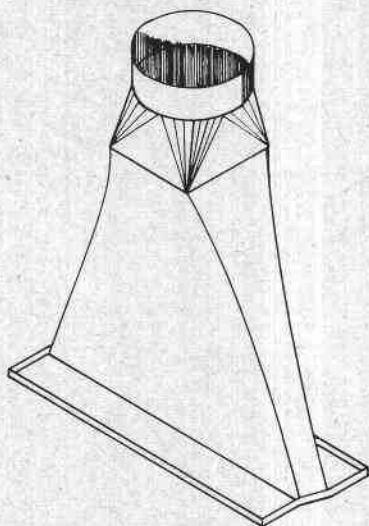
Figure 2. Rear view of suction nozzle showing adjustable glider shoe.

way through to the flexible hose at the top connection. The nozzle must be designed for constant cross-sectional area at all points.

Since flexible hose is obtainable only in even-inch sizes in inside diameter, the nozzles must be designed from the hose end down, rather than from the opening on up. Figure 3 shows the general features of nozzle design, with the variable dimensions expressed in terms of hose diameter and area. The smallest practical nozzle opening width for filberts was found to be 2 inches. A wider opening will require larger air volumes for comparable performance, a proportionally larger fan, and more power to drive it.

Concave sides for nozzle

The constant cross-sectional-area feature requires that either the two side pieces or the two end pieces of the nozzle be concave curves. If both ends and sides were made as a straight taper from top to bottom, the area near the center would be nearly 50 per cent greater than at either end. The result would be lowered air velocity at this point, just where it should be high enough to get proper acceleration of the nuts. A nozzle with curved ends is harder to make than one with curved sides. There is also more chance for uneven distribution of



ASSEMBLY VIEW
SUCTION NOZZLE

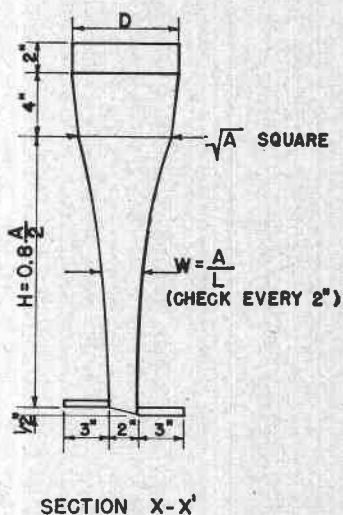
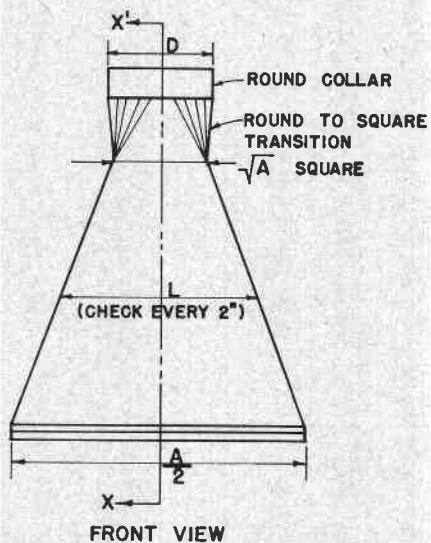


Figure 3. Details of suction nozzle design.

air flow. Figure 3 shows a nozzle with straight ends and curved sides for this reason.

Nozzle mounting

Nozzles must be mounted so that they can follow uneven ground contours independently of the others. It is necessary that the nozzles be constructed so they can be lifted simultaneously for transport and for turning and maneuvering in the orchard. The nozzles will follow the ground better and with less disturbance if they are mounted so as to be pulled instead of pushed. The general mounting and lifting features are shown in Figure 4.

Rotating Bar-Grid Separator and Air-Lock Unit

Some device must remove the nuts from the air stream before they get to the fan or they will be cracked into small pieces. Because of the large volume of leaves, husks, twigs, and dirt that also passes

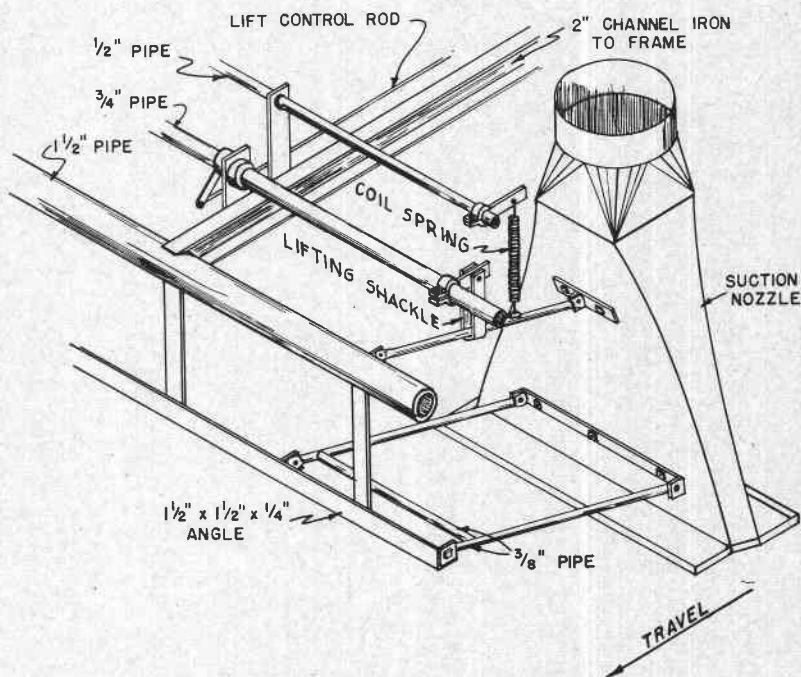


Figure 4. Details of suction nozzle mounting and lifting mechanism.

through with the air and nuts, the device used to catch the nuts must be self-cleaning. Otherwise it will become choked with leaves and other trash.

Bar-grid separator

The rotating bar-grid separator is the best type of unit for this job because it is thoroughly self-cleaning. The rotating bar-grid is an old principle that has been used for many years in various types of pneumatic conveying systems.

The separator unit has a horizontal shaft centered in the air duct and at right angles to it. This shaft carries four rows of bar grids spaced close enough so that the nuts cannot pass between the bars. The rows are located at 90° intervals on the shaft. As grid rotates slowly (about 50 RPM) the top side moves against the air stream. The nuts are caught on the grid, regardless of the position it is in, and as it rotates, they are dropped off the bottom side. Leaves and other light materials are held against the grid by the air stream until they get to the back side. Then the air flow reverses over that row of bars and the materials are carried on to the fan.

The "catching area"

The grid must be located in a larger compartment than the regular duct area. In this larger area the air velocity will not be as high across the grid and the nuts will drop off.

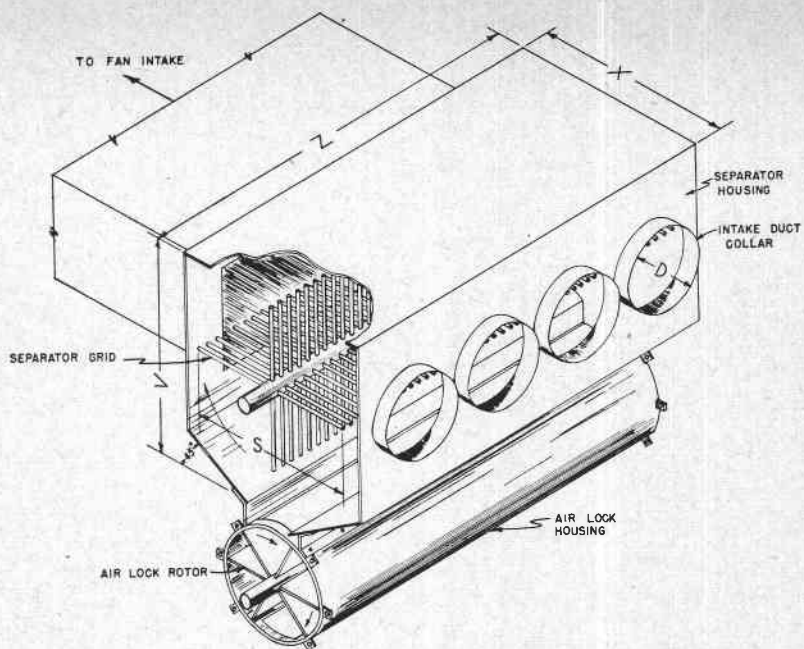
The grid diameter should be about twice as great as the depth of the entering duct and a little longer than its width. This insures enough "catching area" so that the nuts cannot get around it. (See Figure 5.)

The cross-sectional area, as measured vertically through the center of the separator compartment, needs to be about four times that of the total cross-sectional area of the incoming ducts.

The bars are sufficiently strong and rigid if made of $\frac{3}{8}$ " round iron spaced $\frac{13}{16}$ " on centers. (A small diameter unit might be $\frac{5}{16}$ " bars spaced $\frac{3}{4}$ " on centers.) The bars must be straight, evenly spaced, and parallel to each other at all points. The outer ends should be rounded and smoothed, but they should not be fastened together at that point. Each bar must be unsupported and free at the outer end in order not to interfere with the self-cleaning action.

The center shaft can be made of solid bar stock, or $1\frac{1}{4}$ -inch to $1\frac{1}{2}$ -inch pipe, with holes drilled through it to locate the bars, which are then welded in place.

The separator housing should be made of 16-gauge sheet steel, and designed so that the cover can be quickly removed for cleaning or inspection.



ISOMETRIC SECTION

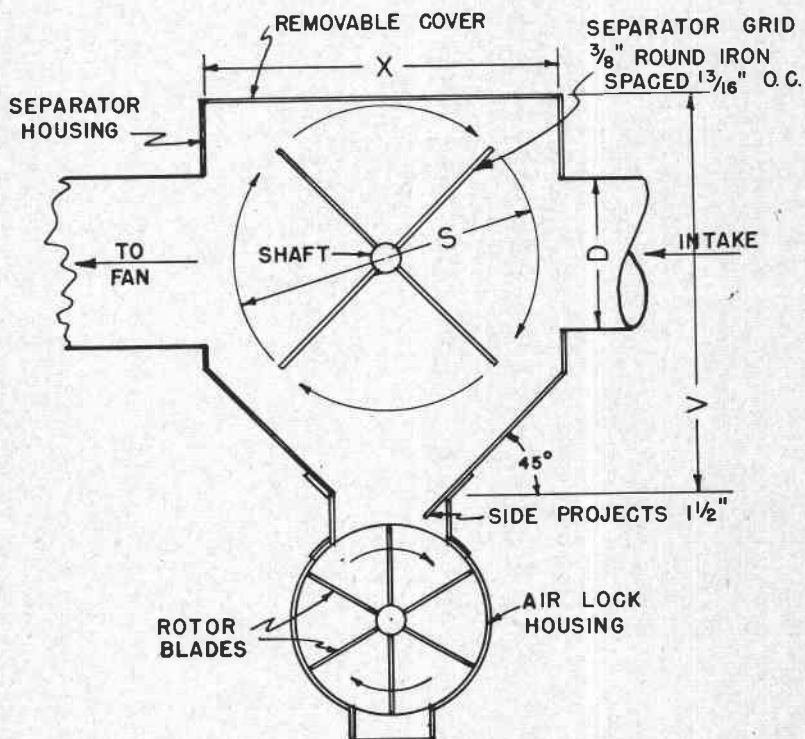


Figure 5. Rotating bar-grid separator and air-lock unit.

In most designs, it will be advantageous to bring the hose line from each individual nozzle directly to the separator compartment, locating the collars in a row across the front of it and as close together as possible. This will make for a smaller diameter grid unit (although it must then be longer) and will enable some reduction in height. A smaller diameter grid works particularly well where the separator is located in the front and as close as possible to the nozzles.

If the distance from nozzles to separator is very great, it will be better to wye (Y) two nozzle hoses together into one large duct having an area equal to twice that of one hose. This duct then will go to the separator. Of course the large duct will have less frictional loss than two small ducts.

Figure 5 shows the general design of the rotating grid and housing, with dimensions expressed in terms of diameter of the incoming ducts.

Referring to Figure 5, we find the following relationships prevail in determining the dimensions of the separator:

Let D = individual inlet hose or duct diameter

S = diameter of bar grid rotor = $2D$

N = number of individual inlets

V = vertical height through center

X = width of housing = $S + 3$ inches (minimum)

Z = length of housing

Then VZ = area through center of housing = 4 times total inlet area

$$VZ = 4 \times \frac{\pi D^2}{4} \times N$$

$$VZ = \pi D^2 N$$

$$V = \frac{\pi D^2 N}{Z}$$

Let $Z = N(D + 1\frac{1}{2} \text{ inches})$ (It will take a minimum of $1\frac{1}{2}$ inches more than the diameter of each individual entering duct for fastening these ducts into the separator housing.)

Substituting:

$$\text{then } V = \frac{\pi D^2 N}{N(D + 1\frac{1}{2})}$$

$$\text{or } V = \frac{\pi D^2}{D + 1\frac{1}{2}}$$

In designing a unit for four 8-inch nozzle lines, then, the various dimensions would work out as follows:

$$S = 2 \times 8 = 16 \text{ inches}$$

$$Z = 4(8 + 1\frac{1}{2}) = 38 \text{ inches}$$

$$V = \frac{\pi \times 64}{8 + 1\frac{1}{2}} = \frac{201}{9.5} = 21 \text{ inches}$$

$$X = 16 + 3 = 19 \text{ inches}$$

$$VZ = 21 \text{ inches} \times 38 \text{ inches} = 798 \text{ square inches.}$$

$$[\text{Area of 8-inch diameter duct} = 50.25 \text{ square inches}$$

$$4 \text{ ducts} = 4 \times 50.25 = 201 \text{ square inches}$$

$$4 \times 201 = 804 \text{ square inches (VZ)}]$$

The air lock unit

The air lock unit is located directly below the separator unit so that the nuts will fall into it and be carried around by the rotating blades until they drop out the bottom. This enables the operator to remove the nuts without letting in enough air to cause any loss in fan suction. The action is similar in principle to that of the revolving doors in hotels and public buildings. The air lock, however, should have 6 blades or "doors" instead of 4 in order to maintain a better seal. Two blades then will be in the sealing position on each side at all times.

This unit should be about 10 inches in diameter, and its length the same as the separator housing. It is important that the sloping side project over the corner of the rotor housing about $1\frac{1}{2}$ inches on the side toward which the rotor is turning, in order to give the nuts time to fall down where they will not be caught by the edge of the rotor blade and cracked against the corner of the housing. (See Figure 5.) The rotor should turn about 50 RPM, or the same speed as the grid in the separator.

The rotor housing

The rotor housing must be round, straight, and smooth on the inside. It is best to use a piece of standard pipe cut to the proper length and bored out on a lathe until it is true. The openings in top and bottom can then be cut in. The top opening should be 6 inches wide and the bottom opening 4 inches wide for a 10-inch unit. The ends can be made of $\frac{1}{8}$ -inch plate and fastened to the ends of the housing by bolting to angle clips welded on the outside of the housing. The end plates carry the rotor shaft bearings and these should be accurately centered.

The rotor should be made with at least a $1\frac{1}{2}$ -inch shaft (or $1\frac{1}{4}$ -inch pipe) through its center and blades of $\frac{1}{4}$ -inch or 3/16-inch plate

welded to the shaft and between two circular plates at each end. These circular plates should have the minimum possible clearance inside the end plates of the housing.

The whole rotor, after fabrication, should be turned in a lathe so that the edges of the blades and the circumference of the end plates will be completely machined and have only about .025 inch clearance on the diameter inside the housing. The close clearance will provide sufficient seal against air leakage, and if the unit is made as described above, it will be heavy enough to shear off the pieces of small branches and twigs that are sure to get caught in it occasionally.

The drive for the rotor should incorporate a slip clutch or shear pin at some point so that in case a stone or other non-shearable object gets caught between a rotor blade and the housing edge, nothing in the driving system will be damaged.

Use of sealing strips

In some tests, sealing strips of rubber belting were used on the edges of the rotor blades. These strips were set out so that they rubbed against the inside of the housing to effect a better seal. But the idea did not prove satisfactory because of wear and the tendency for twigs passing through to bend the sealing strip and force it back so it no longer made the necessary seal.

Sturdy rotor blades and the sharp edges from machining on the blades and housing opening provide the shearing action that snips the twigs in two instead of letting them jam in. Figure 6 shows the details of construction of housing and rotor.

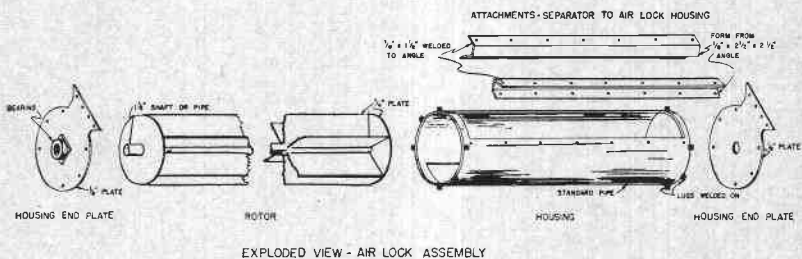


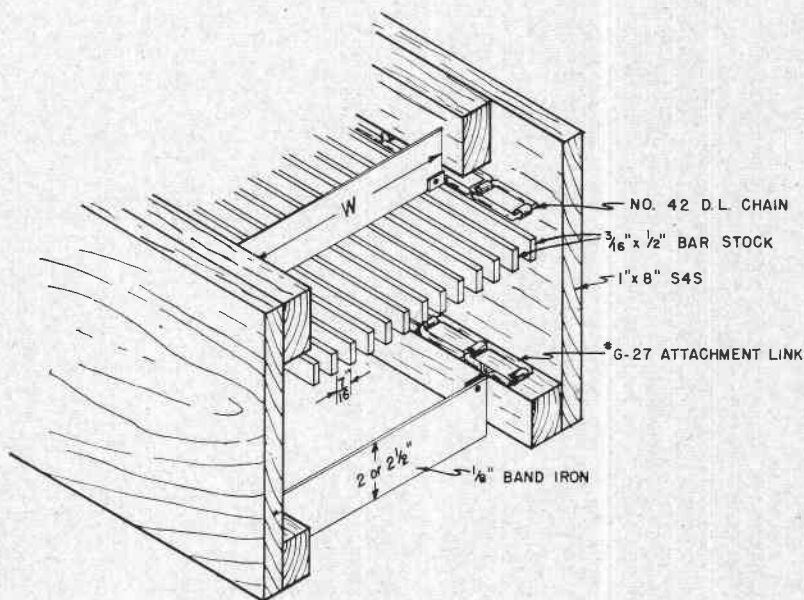
Figure 6. Details of air-lock unit.

Housings rolled to shape from heavy sheet metal are not as suitable as pipe because they are not as accurate and more leakage occurs. Sealing strips are necessary with this construction.

Constructing the air lock unit requires more accuracy and precision than any other unit of the machine.

Conveyor Design

A good type of conveyor construction is shown in Figure 7. This conveyor is the double-chain drag type, with covered chains. The chain used is a No. 42 detachable link type, either malleable or steel, having drags of $\frac{1}{8}$ by 2- or $2\frac{1}{2}$ -inch band iron located every fifth or sixth link on the chains, using No. G-27 style of attachment link. The drags can operate over a smooth solid bottom or over a grid-bar as shown, which will act as a dirt eliminator. These grid bars should not be thinner than $\frac{3}{16}$ inch and should not be spaced more than $\frac{7}{16}$ inch apart. The speed of this conveyor can be between 100 and 200 feet per minute, but 200 is the maximum.



ISOMETRIC SECTION

Figure 7. Details of double-chain drag conveyor with covered chains.

Conveyor capacity

Field tests demonstrate that the conveyor capacity necessary to carry the nuts away from the separator and air-lock unit is a minimum of two cubic feet per minute per foot of swath of the machine.

The capacity of a chain-drag conveyor as illustrated in Figure 7 is assumed to be the calculated displacement of the faces of all the drags passing a given point in one minute.

To find the width of conveyor needed for an 8-foot machine, if the drags are $2\frac{1}{2}$ inches high and spaced 8 inches apart, and the speed is to be 190 feet per minute, we would figure it as follows:

$$\begin{aligned}
 &\text{Volume in cubic feet displaced by} \\
 &\quad \text{each drag} = \text{width} \times \text{height} \times \frac{W \times 2.5 \times 8}{\text{distance between drags}} = \frac{1,728}{190 \times 12} \\
 &\text{Number of drags per minute} = \frac{8}{8} \\
 &\text{Volume needed per minute} = 2 \times 8 = 16 \text{ cubic feet} \\
 &\text{Then, volume per drag} \times \text{number} \\
 &\quad \text{of drags per minute} = 16 \\
 &\quad \frac{W \times 2.5 \times 8}{1,728} \times \frac{190 \times 12}{8} = 16 \\
 &\quad \frac{W \times 20}{1,728} \times 285 = 16 \\
 &\quad \frac{W \times 5,700}{1,728} = 16 \\
 &\quad W = \frac{16 \times 1,728}{5,700} = \frac{27,648}{5,700} = 4.85 \text{ inches}
 \end{aligned}$$

For convenience and safe capacity this conveyor would be made 5 inches wide.

The theoretical capacity of a belt-and-cleat conveyor would be figured in the same manner.

If either of these types of conveyors are to be operated as elevating conveyors their capacities will be less than when operating horizontally, and this decreased capacity will vary as the cosine of the angle of incline. In the following example, if an incline of 25° is to be used, the capacity would be .906 (the cosine of 25°) of the amount assumed. In other words, to get 16 cubic feet actual capacity, the theoretical capacity would have to be $16/.906 = 17.65$ cubic feet per minute.

An auger or helicoid type of conveyor should be figured for not over 50 per cent of its theoretical displacement volume. The displacement is equal to the volume included in one pitch length, times the speed in RPM, which should not be much over 150 RPM for 4-inch and 6-inch sizes, or 100 RPM for a 12-inch size.

To find the size of auger needed to carry the same volume as figured in the previous example, it would be done as follows:

Let D = diameter in inches

P = pitch in inches = $2D$ (for standard augers)

$$\text{Then } \frac{\pi D^2 \times P \times 150 \times .50}{4 \times 1,728} = 16$$

$$\frac{\pi D^2 \times 2D \times 150 \times .50}{4 \times 1,728} = 16$$

$$\frac{2\pi D^3 \times 150 \times .50}{4 \times 1,728} = 16$$

$$D^3 = \frac{16 \times 1,728 \times 4}{3.1416 \times 300 \times .50}$$

$$D^3 = \frac{110,592}{471} = 235$$

$$D = \text{cube root of } 235 = 6.2 \text{ inches}$$

Since the nearest standard size of auger is 6 inches, this is the size that would be used, with the speed increased enough above 150 RPM to make up for the slightly lower capacity. In case the calculated size does not come out close to a standard size, the problem should be reworked, substituting the standard size to be used, and solving for the proper speed.

Belt-and-bucket conveyor

The capacity of a belt-and-bucket type elevating conveyor is calculated by taking the volume of one bucket times the number of buckets passing a given point per minute. This latter figure is a function of speed and bucket spacing. The speed should be about 200 to 225 feet per minute for good discharge. Spacing is determined by the size and type of buckets. The steel "Salem" type bucket, with no more than a 4-inch projection, is the best. Proper capacity is obtained by selecting the correct length of bucket.

The actual capacity of the bucket conveyor will be not over 80 per cent of the theoretical displacement capacity, since the buckets will not fill to 100 per cent of their capacity at all times. Care will be needed in proper design of the loading chute to prevent cracking the nuts.

Dirt-cleaning Unit Design

In certain soil types, it has been found that a considerable quantity of fine soil, along with small clods as large as the nuts, may be picked up. If the soil is slightly damp, as it will be in the early morning after a heavy dew, fog, or light rain, it is likely to cause trouble by packing tightly in various units of the machine.

The obvious solution to this problem is to eliminate the dirt as soon as possible on the way through the machine. The location of such a dirt cleaner should be as close to the air lock as possible. Tests indicate that the best dirt removal will be accomplished in a rotating horizontal cylindrical-screen unit. The tumbling action of this type of cleaner seems to be most effective in preventing packing, and subsequent choking, of the screen.

Screens for cleaner

Perforated sheet metal makes a somewhat better screen than heavy woven wire, which can also be used. Oblong perforations $7/16$ inch wide and 1 to $1\frac{1}{2}$ inches long, spaced in staggered rows so that at least 50 per cent of the area is punched out makes a very good unit.

The cleaner used in the tests in 1946 and 1947 was a 12-inch-diameter cylinder 5 feet long with perforations $7/16 \times 1$ inch, with the long axis parallel to the axis of the cylinder. The screen was mounted on small trunnion rollers at each end and driven by a gear arrangement at one end at a speed of 15 RPM. The nuts and dirt were fed in at one end. Travel through the cylinder was produced by an auger, 9 inches in diameter inside, turning at 50 RPM in the opposite direction to the screen.

The auger was mounted in adjustable bearings at each end so its height and sidewise location could be shifted to get the best working position. It was found that the auger needed to be fairly close to the bottom and to the side of the screen that was turning up. The

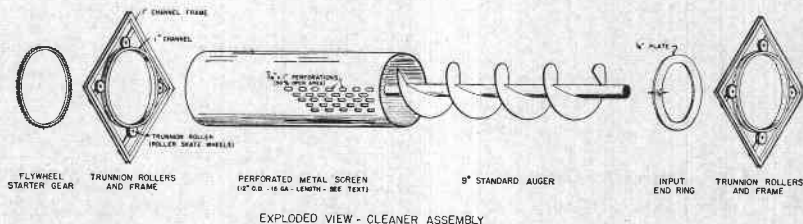


Figure 8. Details of dirt-cleaning unit.

best distance from the screen was just a little more than the diameter of the largest nuts going through, or about 1 inch.

Performance of cleaning unit

This cleaning unit performed very well, and all dirt was eliminated in the first 2 to 2½ feet of travel through the screen. The sharp edges of the perforations seem to shave down the clod sizes, which in conjunction with the tumbling action of the screen and the churning action of the auger, was very effective even on large clods.

Details of this unit are shown in Figure 8. It had ample capacity for a machine with 80 inches of swath, and would probably handle up to 8 feet without being increased in size. The auger speed, however, may need to be increased in order to handle greater capacity.

It is quite possible that this cleaning unit can also function effectively as a husking unit. If a lip of tough, live rubber, projecting about an inch, is attached to the edge of the auger so that it will just rub lightly against the inside of the screen in the zone of nearest approach, it should do a considerable amount of husking. A portion of the husk would then be gripped or caught between rubber and screen, and with both parts moving, the nut should be rolled or scrubbed out of the husk. The clod-breaking capacity should also be improved by the addition of the rubber lip.

Some difficulty will be encountered in obtaining the correct type and weight of rubber for this application. The lip will need to be in a curved shape when flat in order to project straight out when applied to the spiral auger.

Tests proved that no initially straight form can be applied without stretching the outer edge and causing it to curl over to one side. Curved pieces may have to be cut from sheet stock, and applied by riveting or bolting to the auger edge. It will need to be firm and stiff enough to grip the husks, and yet soft and flexible enough to yield before sufficient pressure is exerted on a nut to crack it.

Because of inability to procure a satisfactory rubber for this job in 1946 and 1947, this idea for husking has not yet been proved. It has definite possibilities, however, and further investigations will be made. Even without the rubber lip, the dirt-separation characteristics of this unit are the best of any tried to date.

Details of Final Cleaning Unit

The final cleaning of the nuts before they go into the sack probably can be best accomplished by using the suction method again. This set-up will be similar to that used for separating blank nuts in most of the nut-processing plants.

The nuts, with accompanying trash, such as husks, small twigs, and leaves, can be conveyed along under a suction nozzle on a chain-mesh type of conveyor belt. The open mesh of the belt will permit air to flow readily up through it to the nozzle and lift off any material lighter than good nuts. The connection for this nozzle should be between the fan and separator so that the material picked up will be fed directly to the fan and not go to the separator again. The nozzle will need to be mounted so that its height above the belt can be adjusted. There may need to be some means for regulating the suction intensity of the nozzle. This can be done by bleeding air into the nozzle duct at one or more points above the nozzle.

Cleaning nozzle similar to picking nozzles

The suction of this nozzle will not need to be nearly as great as that of the picking nozzles, and therefore the air requirements will be less. Its design, for best efficiency, should be similar to that of the picking nozzles, except for the omission of the skirt on front and back sides.

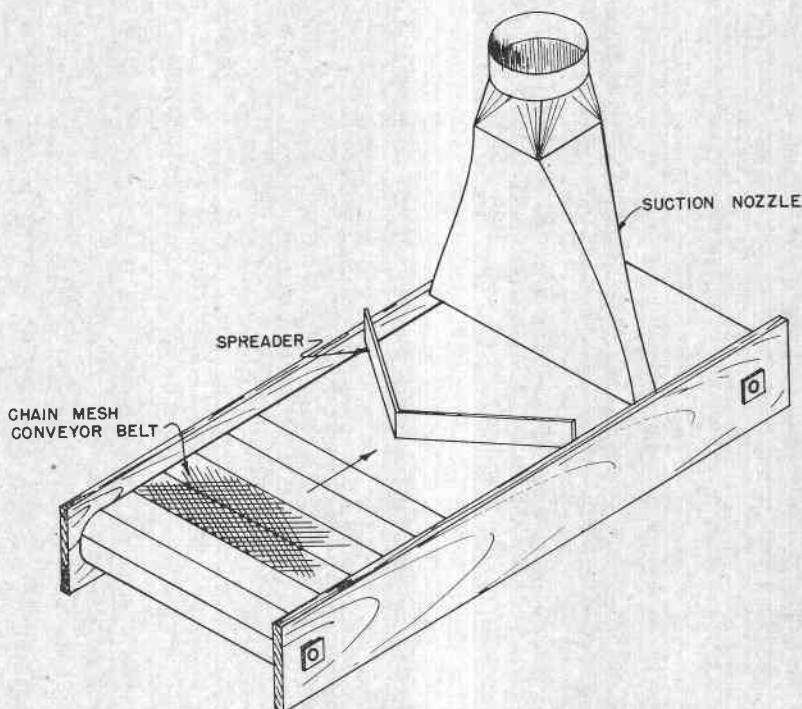


Figure 9. Final cleaning conveyor and suction nozzle.

The nuts will need to be spread out in a single layer on the belt before they reach the nozzle. This can be done with a spreader board set about one inch above the belt, located behind the point of discharge of nuts onto the belt and ahead of the nozzle.

This belt, if it travels 80 feet per minute—which would be about the maximum speed—will need to be $2\frac{1}{2}$ inches wide per foot of swath of the machine.

The general layout of this type of cleaner is shown in Figure 9.

Sacking Chute

The nuts discharging from the end of the cleaning belt can fall directly into the sacking chute. The chute should be open so the operator can see what is going through and have an opportunity to pick out sticks or other debris left after cleaning. An open chute is also less likely to clog.

The bottom of the chute should have a slope of about 20° from horizontal, so the nuts will run freely along it. The discharge end should be divided, with provision for hanging two sacks, and have a simple gate which will divert the flow to either sack desired. Such an arrangement is necessary for efficient sacking, because a picking machine having the usual swath width of 6 to 8 feet is picking up nuts at a high rate, and a sack will be filled very quickly. On a small machine, the rate would be proportionally slower, so that by having some space in the chute for storage, the flow could be shut off for short intervals while the sacks are being changed. The double type chute will be found to be more satisfactory, however.

No attempt has been made to develop detailed construction plans for this machine. It is possible to build a workable nut harvesting machine in a variety of different arrangements. The type and size of chassis used, as well as the swath width of the machine, will have considerable effect on the general design chosen.

The best arrangement is to locate the bar-grid separator up front as close to the nozzles as possible. Each nozzle should feed into the separator independently, with the inlets arranged in a row across the front, as shown in Figure 10. This arrangement will contribute to a lower overall height, since the grid rotor will then have a smaller diameter.

The air-lock unit will, of course, be located under the separator; and under the air lock a conveyor of some type will be needed to bring the nuts all to one side. A good type of conveyor for this location would be a double-chain drag type with a bar-grid bottom or a double-chain cross-bar, where much dirt would be eliminated. The

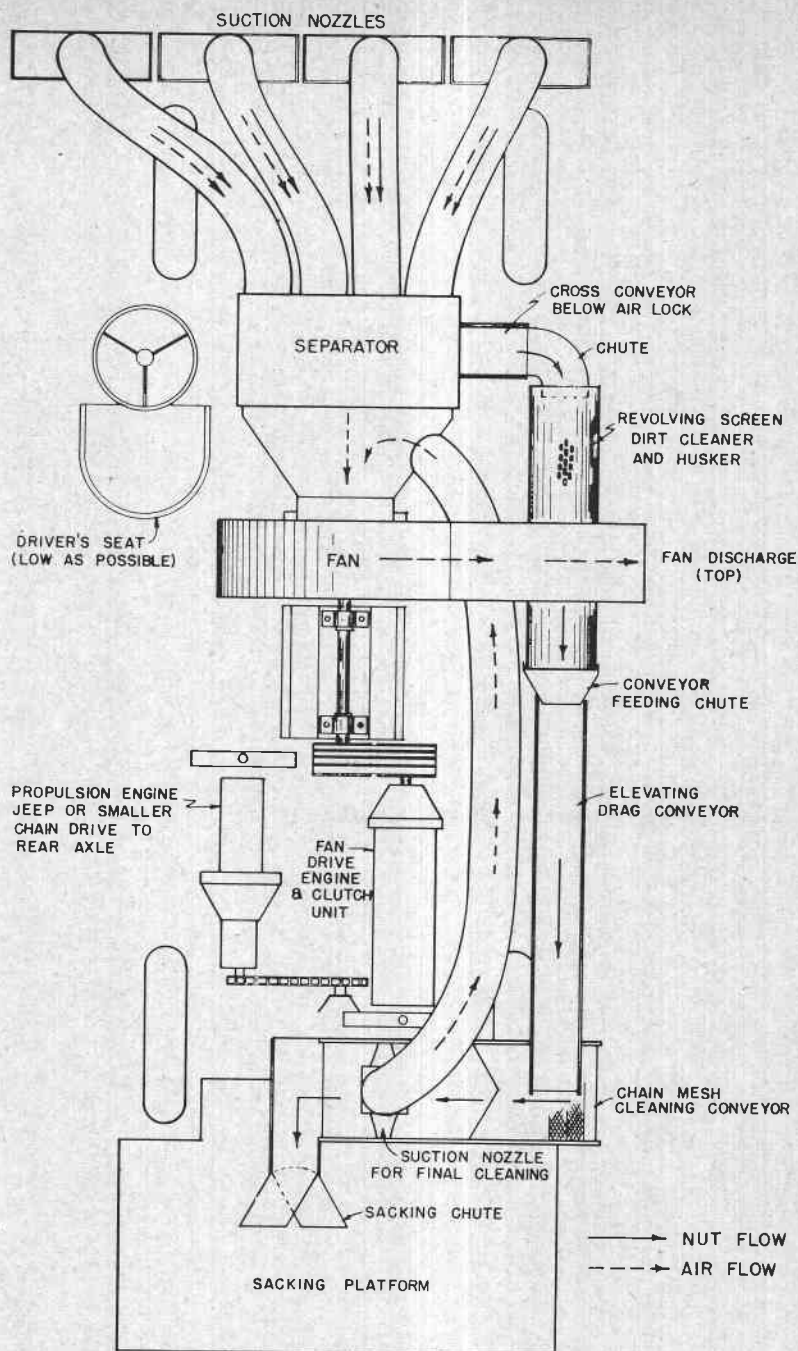


Figure 10. Suggested layout for complete machine.

conveyor could discharge directly into the cleaning cylinder, and the cleaner in turn could discharge into an elevating conveyor, of the belt-and-bucket type. This would carry the nuts up to the final cleaning conveyor from which they would fall by gravity into the sacks.

The fan can be located so that its suction opening will be close to the separator. Its shaft will then be parallel to the axis of the chassis. The fan engine would then be directly behind the fan; either direct-connected or driving through short multiple V-belts.

The engine used for propelling the machine does not need to be very large, because of the high ratio of reduction necessary for the slow ground speeds required. It should be located near the rear axle, where its power is to be applied, rather than up in front as in an automobile. Installing the propulsion engine in the rear also makes room for the separator and fan up front where they belong. An engine of 10 horsepower will be ample for propulsion.

Figure 10 shows a plan view of the layout as suggested, with the driver on the left. This layout can be reversed easily, if the builder wishes to have the driver on the right side.

Soil Preparation

In order to get the best results with a suction type harvester, it is necessary to get the soil surface in the orchard as smooth and firm as possible prior to the harvest. This can be done by using a drag to smooth and level the surface, followed by rolling with a fairly heavy roller.

Eliminating mounds around the base of the trees is especially desirable. A special drag for pulling the soil away from the trees can be used where the mounds have been permitted to become excessively high.

Rolling is best accomplished with a three-section roller having rather short sections, so that the ground contours will be followed more closely. The construction of such a roller is described in Station Circular of Information No. 355, "Three-section Orchard Roller," published in January, 1945. A copy may be obtained from Oregon State College upon request or from county agent offices in Oregon.