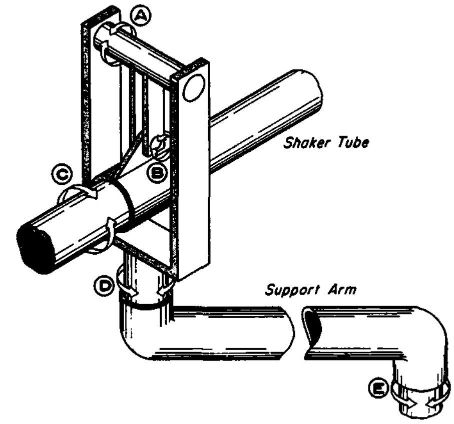
Excessive vibration eliminated by

New Tree Shaker

mounted on fruit catching frame

P. A. Adrian and R. B. Fridley



Pivotal mounting for inertia shaker, showing pivots A, B, C, D, and E.

Recent research on fruit harvesting machines in California has centered around two designs.

One of the designs involves the rotation of two equal weights placed on parallel shafts and turning at the same speeds but in opposite directions. A resultant linear, periodic force is produced with a minimum power requirement. This design requires excessive space for positioning on limbs and consequently led to the design of a piston and crankshaft mechanism.

In the second design, the piston and crankshaft mechanism connects directly to the tree limb clamp in such a manner that the inertia forces developed by vibrating the crankshaft housing are used to shake the tree.

In the design of an inertia tree shaker, a proper relationship of weights and eccentricity is necessary to produce a desired stroke on the limb at the point of attachment.

During three years of field tests on limbs of prunes, peaches, and olives, the effective weight of the limbs was about 20 pounds to 60 pounds for 2″–6″ limbs when the unit was clamped about one fourth of the way out from the main crotch.

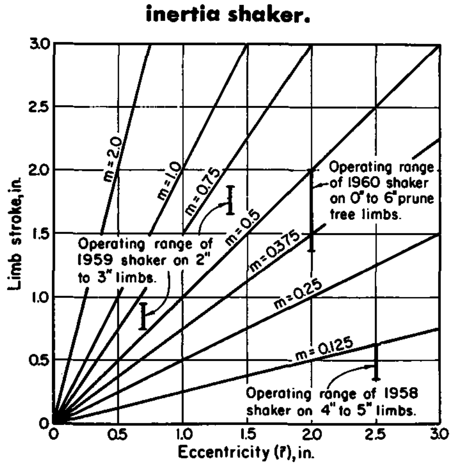
The shaker is flexibly mounted at its center of gravity on a self-propelled catching frame to permit maneuverability, to isolate vibration from the frame, and to reduce bark damage to the tree at the point of attachment. Maneuverability for positioning the clamp is accomplished with an arm—as shown in the diagram in column 3—with four pivots. The arm is free to rotate 360 degrees about pivot *E* in a horizontal plane, which permits movement toward or away from the tree. Rotation about pivot *B* allows elevation control, and rotation about pivots *C* and *D* allows alignment control.

The vibration produced by the shaker is isolated from the catching frame by each of two pairs of pivots. Pivots *A* and *B* isolate most of the vibration from the saddle—the effectiveness of this isolation being a function of the distance between *A* and *B* and also a function of the slope of the shaker during operation; the more nearly horizontal the shaker, the more effective the isolation. The vibration is further isolated by pivots *D* and *E*. Again, the effectiveness is determined by the distance between *D* and *E* and the horizontal projection of the angle between the arm and the axis of the shaker.

Bark damage is reduced by pivots *B* and *D*. These pivots allow three degrees of freedom in the motion of the shaker while in operation, because the direction of its axis is not confined by the mounting. The direction of axis of the shaker is defined by pivot *B* and the point of attachment at the tree. If, during the shaking operation, the point of attachment tends to move in any direction other than along the initial shaker axis because of the shaker's being at an angle other than 90° to the limb, pivots *B* and *D* permit this movement. Thus a minimum component of force perpendicular to the shaker axis is produced at the point of attachment, reducing the shearing force on the limb to minimize bark damage.

A C-type clamp was used to achieve simplicity, light weight, and minimum

Effect of eccentricity and weight ratio on stroke delivered to tree limbs by an inertia shaker.



$$m = \frac{W_u}{W_s + W_l}$$

	1958	1959	1960
W_u	10	65	80
W_s	48	83	160

The stroke to the limb is approximately two (2) times the weight of unbalance (W_u); times the eccentricity of the unbalanced mass ($\bar{r}$); divided by the total weight of the shaker plus the effective weight of the limb ($W_s + W_l$).

Inertia shaker mounted on self-propelled catching frame.

Ice skating rink permits studies on

Orchard Heater Plume Heights

under controlled laboratory conditions

Todd V. Crawford and Arthur S. Leonard

Previous tests have shown that 75% to 90% of the heat of combustion of the fuel oil burned in an orchard heater goes into producing the hot gases which rise as a plume vertically above the heater. As these hot gases rise, they cool by mixing with the surrounding air. Cooling is rapid until a height is reached where the temperature of the plume is near the temperature of the adjacent air. If the temperature of the air over the crop increases with height at this point—if a temperature inversion exists—continued upward movement of the gases soon brings them to a height where the surrounding air has the same temperature as that of the plume. Above this point, the plume's gases are actually colder than the adjacent air. Thus the gases in the plume are heavier than the surrounding air and their momentum is dissipated. This soon brings the upward motion to a halt. Then the gases fall part way back to the height at which they had the same temperature as the surrounding air and spread out at that level. This height at which the gases spread out and the height at which the upward motion ceases are measures of the depth of the air over the crop being heated.

In the development of frost protection systems, more information on the behavior of these plumes is needed.

Two different investigators have proposed theoretical descriptions of the behavior of a buoyant plume under temperature inversion conditions and for the case of no wind. In both treatments, the strength of the temperature inversion—temperature change per foot—is taken as a constant with height to well above the top of the plume. In nature, the strength of the temperature inversion usually decreases with height under frost conditions. The temperature inversion decreases to zero at some height above the crop land which then defines the top of the inversion layer. If the temperature of the hot gases in the plume does not become equivalent to that of the surrounding air within the inversion layer, then the foregoing description does not hold and the plume continues to rise almost indefinitely. The strength of the temperature inversion has its greatest effect on the vertical motion of the gases in the upper part of the plume; in the lower part, the buoyancy of the gases is so great that the strength of the temperature inversion has little effect on their upward motion.

Although the two theoretical formulations are somewhat different, they do result in almost identical formulae for the maximum height of the plume—the height at which the vertical velocity equals zero. A preliminary objective of current research was to check experimentally the validity of the theoretical approaches.

The instrumentation problem of lo-

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damage to the tree at the point of attachment. Minimum damage results from the linear motion for clamping. Regardless of limb size, the force applied to the limb is nearly in line with the direction of force application. Thus, the total force, and also any shear forces on the limb, are minimized. In addition, the hydraulic circuit used for clamping is also designed to yield a minimum force on the limb. This is accomplished by closing the clamp with a low pressure, then blocking the oil flow so as to be able to develop the higher pressures and forces required.

Field tests indicated that the unit is comparable to boom shakers with respect to harvest rate and fruit removal but pointed out the advantages:

Close-up of C-type clamp engaged on limb.

1. A separate propelling vehicle is not required, thus reducing the cost.

2. Provided the incline of the shaker is not great, the mounting effectively isolates the vibration from the catching frame, reducing maintenance.

3. The C-type clamp, together with the flexible mounting, reduces bark damage.

Further work is needed toward optimizing shaker design, considering both power consumption and reactive loads. For example, the rotating-mass design that was used requires less power than the piston-crankshaft design that was used. Also, the reactive load is a function of the weights and the electricity.

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