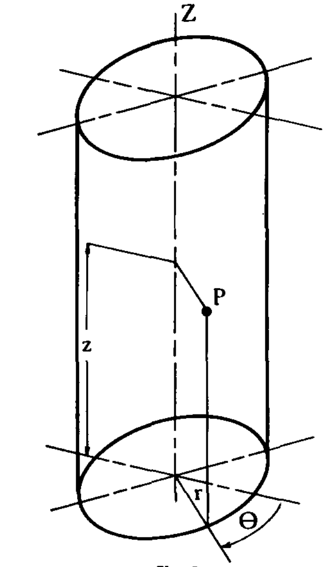


Fig. 1

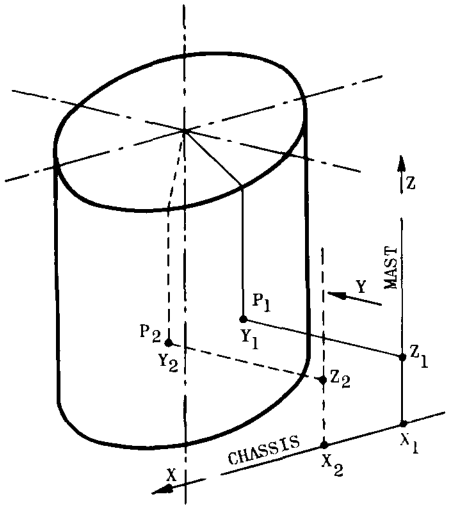


Fig. 1a

Fig. 1. Any point on a cylindrical coordinate system can be defined by three variables: r, Θ, and Z. Fig. 1a. Relationship of cylindrical coordinate system to movements of mast, chassis, and boom as used in a man-positioner for picking fruit.

Fig. 2. Standing positions shown in sketches A, B, and C offer much greater range of picking than sitting position shown in sketch D. Lateral reach shown in sketch E remains the same for either position.

CITRUS HARVEST

. . . b

JOSEPH MOLITORISZ

CERTAIN PARAMETERS must be established if citrus harvesting devices are to be designed and used effectively. For this reason the relationships between a citrus tree and a man-positioning device were analyzed in this study in terms of the tree shape, the motions of the machine, and the motions of the operator of the machine. For this discussion, the tree is considered a cylindrical body (when ideally pruned) and the position of any point on its surface or within its boundaries is determined by the "cylindrical curvilinear coordinate system." The coordinates are defined as follows: r = the length of the radius; Θ = the angular direction of the radial coordinate relative to an arbitrarily selected radial line. The height above ground is the third coordinate, which is designated by Z, and it determines the position of the point relative to the base of the cylinder (fig. 1).

For trees (not in hedgerows) that are described by cylindrical coordinates, the simplest picking-pattern and motion-coordinate relationship is provided with superimposed cylindrical coordinates, if the patterns shown in figures 6 and 7 are followed. In both cases there are only two variables involved: vertical and horizontal. Other body-motion variables are not considered part of the coordinates of the machine.

In designing a vehicle to support the man-positioning device, available space, soil conditions, and irrigation practices must be considered. Ideally, the motion of the ground-supported vehicle should be parallel to the rows and should not intersect the irrigation furrows. Such motion should not cause damage to either the tree that is being served, or those adjacent to it.

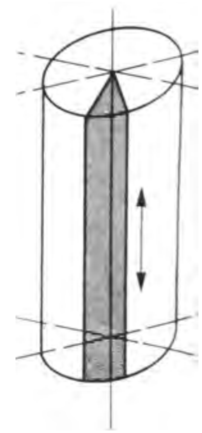


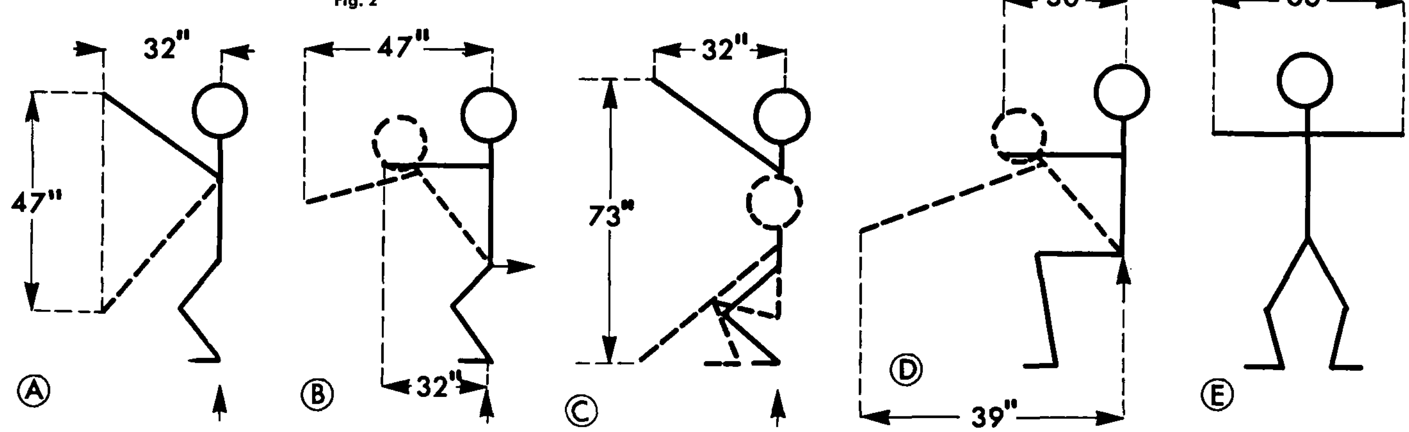
Fig. 3

Fig. 3. Reaching range along the Z coordinate. Fig. 4. Reaching range along the Θ coordinate. Fig. 5. Reaching range along the radial (r) coordinate.

Until very recently, the most common man-positioning device for citrus-picking was the ladder, which offers only two alternatives: up or down. But when mechanical devices with three possibilities of motion are considered, a critical look should be taken at picking patterns. When the fruit-filled bag is not a burden on the picker's shoulder and lateral movements are not limited, picking becomes an uninterrupted process without "non-productive" motions.

Another question now arises: does a predetermined programmed motion pattern have any advantage over the "free choice" motion of a picker when he is the driver of a device? A ladder is, in fact,

Fig. 2



MECHANIZATION

sic parameters and the man-positioner

RUSSELL PERRY

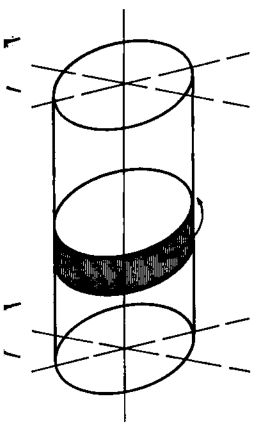


Fig. 4

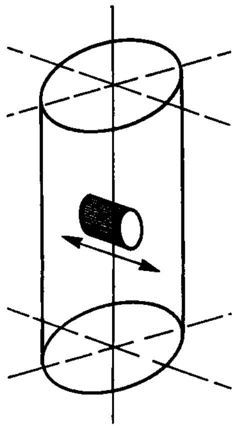


Fig. 5

a "programmed" picking aid that limits at least one motion (not considering the body motions). A picking platform also is "programmed."

In a previous report, a picker performed as many as 670 operating motions in one hour. Each change in position was preceded by fruit searching and mental decision-making. If each movement required 2 seconds, then 670 × 2 = 1,370 seconds, or about 22 minutes, or approximately 30% of the hour.

At this time, data are not available that would indicate a reduction of time losses by moving the man on a pattern of continuous motion; but with little imagination, improvement may be foreseen in this area.

The deficiency of a mechanical positioning device with three degrees of freedom with motion coordinates other than that of the tree, becomes quite obvious if it is considered that a motion along any one coordinate results in a position change relative to one other coordinate.

For example, consider a man-positioner which consisted of a chassis to be moved along the road between the rows of trees (the X direction), fig. 1a. The chassis carried a vertical mast on which a horizontal boom was mounted, at right angles to the chassis. The boom, which carried the picker's support, could be extended toward the trees (in the Y direction) and moved up the mast (the Z direction). With this mechanism, movement from position P_1 to P_2 required the operator to accomplish two coordinated movements; advancing the chassis to move the mast from X_1 just to X_2, and extending the boom from Y_1 just to Y_2. Until the operator develops good skill and judgment, he may have to make several moves of each control to arrive at the desired position.

Efficiency is one product of systematic work, but how systematic is a citrus picker? If he is a good picker, he is systematic, and if he trades the ladder for a mechanical device, he will remain systematic—and his rate of pick probably will not show remarkable improvement.

The first attempt to investigate experimentally the functional relationships between a tree and the motion coordinates of a positioning device was made by the construction of the "Power Ladder." Structurally and functionally it is a mast, equipped with a wheel-supported frame and with a power unit. The picker's support is self-propelled, both on the ground and up or down in space. It is steerable to perform linear or curvilinear movements on the ground. (See photo.)

Maximum height of the mast is 15 ft; maximum length of the basic frame is 10 ft. The minimum turning radius is about 3 ft. The electric controls are operated by foot pedals with the operator either standing or sitting. The power plant consists of a 6 hp gasoline engine driving a 12-volt, 58-amp automotive alternator that transmits power to electric clutches to control the reversible ground drive, and to electric motors for the reversible up-down drive, and the steering mechanism.

The variables for the human operation of the machine are based on three possibilities of motion with various degrees of restriction: sitting, standing or moving (such as on a catwalk-type platform or reaching for fruit). Figure 2 indicates that much greater reaching range is possible from a standing position than a sitting position. If the operator can move along the cylindrical coordinates of the tree (fig. 1a), the number of radial movements may be reduced by the increased reaching depth. By extending the reaching range of the picker with mechanical aids along any of the selected coordinates, several patterns of picking strips can be obtained (see figs. 3, 4, and 5).

Principles of cylindrical coordinate system were used at Riverside in development of research prototype of commercial power ladder now in production.

Several picking-strip patterns are possible using cylindrical coordinate system. Fig. 6. Vertical patterns. Fig. 7. Horizontal patterns.

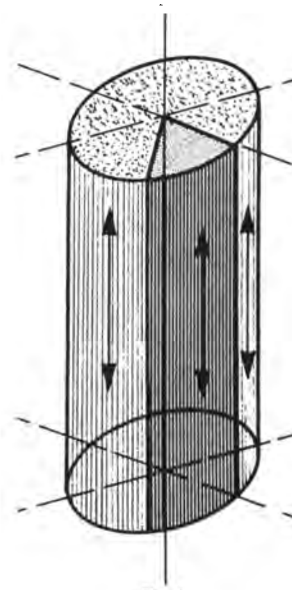


Fig. 6

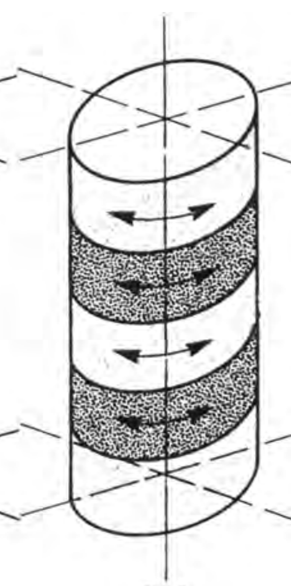


Fig. 7

Joseph Molitorisz is Research Engineer, USDA Agricultural Engineering Research Division, and Russell Perry is Agricultural Engineer, University of California, Riverside. This is a report from the research project on citrus harvest mechanization being conducted in cooperation with the University of California.