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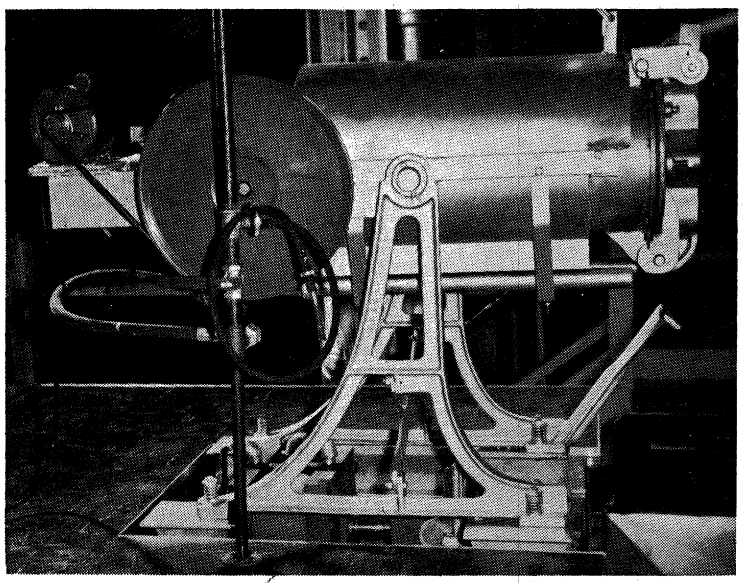

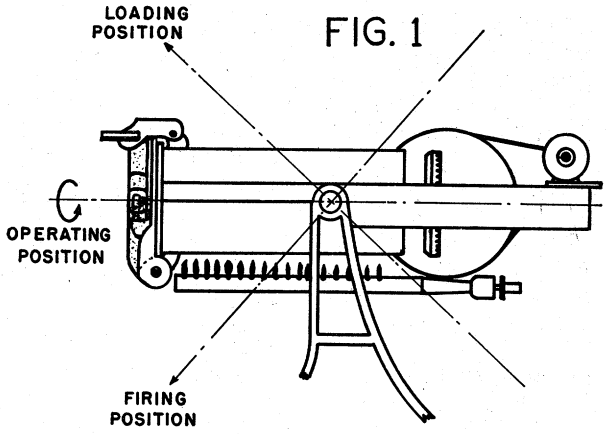

FIG. 1

PUFFING GUN is shown in operating position at left. Assembly can be tilted with a locking lever to three positions: loading, operating, and firing (Fig. 1).

Process prepares quick-cook dehydrateds by means of a gun designed for...

Explosive Puffing

A PROCESS for preparing quick-cooking dehydrated fruits and vegetables was developed by engineers at the Dept. of Agriculture's Eastern Utilization Research and Development Div., Wyndmoor, Pa. It has generated much interest among food dehydrators (see references).

In some cases, products can be rehydrated in one-tenth the time required for conventionally dried pieces of the same size. Yet the cost is only an estimated 10-15% more.

How Drying Is Done

Pieces of vegetable, for example ⅜-in. dice or larger, are dried conventionally at atmospheric pressure using hot air. The drying is interrupted when the moisture is reduced to approximately 25-45%, depending on the vegetable. The pieces are then subjected to explosive-puffing by heating in a rotating closed cylinder and then suddenly releasing the pressure to the atmosphere.

A small fraction of the superheated moisture instantly vaporizes creating a capillary structure. Final drying can then be done by conventional means. However, the drying rate will be about twice as fast as that of pieces which have not been explosion-puffed.

Commercial adoption of the process has been retarded only by the lack of a suitable puffing gun. The apparatus employed in developing the process was a small cast iron unit designed for puffing relatively dry cereal grains at pressures of 200 psig or higher. Sticking of the moist pieces of fruits and vegetables to the rough interior frequently caused scorching. Further, the apparatus was otherwise ill-suited to the relatively low pressures used in the process, about 65 psig maximum.

Sand-blasting the interior, nickel-plating it and the use of a silicone spray-release agent reduced scorching. But it was still obvious that a unit would have to be designed specifically for the process, if results were to be extrapolated to full scale.

The pilot plant unit described here was specified by the Wyndmoor Laboratory and constructed by McEwen Manufacturing Co., Portland, Ore. It was later modified at the laboratory as a result of experience.

The present unit is not necessarily a prototype of what would be used commercially. Improvements may well result from further experience. However, it is described at this time since it operates satisfactorily and since there is an active interest in sources of pilot plant puffing equipment for immediate use. Meanwhile a number of other equipment manufacturers are also developing designs for commercial units.

Gun's Design Modified

Above photo shows the gun in operating position. Gun consists of an 18-8 stainless steel cylinder, 5/16-in. wall, 12-in. inside dia., and 30 in. long. One end is closed and affixed to it is a shaft operating in a single bearing and having an at-

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tached gear. This is driven by a motor, belt, sheave and spur gear. Beneath the cylinder is a gas burner. The entire assembly is mounted on A-frames on which it can be tilted to three positions with a locking lever: nearly vertical for loading, horizontal for heating (Fig. 1), and 45 degrees below the horizontal for discharging. The interior of the cylinder has a polished finish and ribs about 1½ in. high. Their function is to increase the heating surface and to increase turbulence during rotation.

To the open end of the cylinder is attached a hinged cover held in place during operation by a heavy iron "strong back." This hinged cover reinforcement is shown shaded in Fig. 1. Closure is by an eccentric lock. As originally designed the cover was grooved to hold a lead seal for tightness.

Experience suggested the following simple changes:

(1) The lead seal was replaced with a ¼-in. Melrath #150 gasket made by the Melrath Supply and Gasket Co., Philadelphia. This overcame leaks experienced at low pressures.

(2) A shock absorber was installed to take the recoil from the lid and "strong back." This is shown in Fig. 2 with the open lid and "strong back" impinging upon it.

The shock absorber consists of a compressed air cylinder with pressure maintained at about 10 psig. To the piston is attached a face plate contoured to receive the lid and "strong back." The face plate should be covered with some shock-absorbing material such as leather or rubber, backed with felt. The force of recoil would be lessened if the gun barrel were constructed with a slight taper at the opening. This would permit the use of a lid of smaller diameter than that of the cylinder.

The time to reach operating pressure is important, not only for reasons of output, but because prolonged heating may cause scorching or mushiness in the product. And too rapid heating may not achieve the desired temperature at the center of the piece. After the system is preheated, not more than 10 min. should be required to reach 35 lb. pressure, with for example, a 16-lb. charge. If the gas supply is inadequate for fast pressure rise, a second burner may be required.

With the foregoing changes the gun has thus far been operated satisfactorily on carrots, ~~potatoes~~, ~~beets~~ and apples.

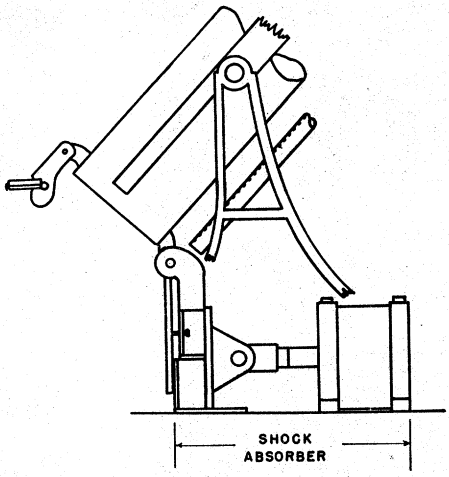

FIG. 2—Shock absorber was installed to take the recoil from lid and "strong back" which are shown here impinging on it.

Typical Operation

A typical operating procedure would be as follows: The gun is first heated by charging it with approximately 1 qt. of water, closing the lid, starting rotation and lighting the burner. When the pressure has reached about 40 psig, the burner is shut off and the gun is tilted to discharge position. At this point the latch is automatically tripped and the contents discharged. It is generally desirable to follow this with a small charge, for example, 6 lb. of the material to be puffed. This assures that the gun is adequately preheated and that the desired pressure will be quickly achieved when operating with a full charge.

If ⅜-in. carrot dice, for example, are being used, about 16 lb. previously dried to 40% moisture will be charged. The gun will then be put in operation as before until a pressure of 35 psig is reached. The product is discharged into a chute and hopper located below a wire cage. The discharge hopper should be constructed so that material does not impinge directly against a surface but strikes it obliquely to avoid collapsing the product. Since only a small amount of water is removed in puffing, the product must be dried to a proper moisture for storage. This can be done conventionally in hot air and the rate will be quite rapid as a consequence of the porosity created by explosion puffing.

Theoretically, the degree of puff (lb. water vaporized per lb. of dry solids) will always be the same for a given product moisture and chamber pressure, regardless of charge size. However, there are practical limits as to the minimum and maximum charge. The maximum will be governed by the internal surface of the gun (area of heat transfer) with respect to gun volume.

Another factor limiting charge size is desirability of free contact of all pieces with the inner heated surface while tumbling. The lower charge limit is governed by the water removed from the pieces in developing the desired vapor pressure in the gun. If the charge is too small, so much will be evolved in attaining the pressure that piece moisture will be too low. Then scorching or inadequate puffing will result.

Gun Size Limits

There are practical limits to gun size. Increasing the length of the gun to increase surface area is limited. Reason: the gun becomes too ponderous to move into the three positions required for loading, heating and discharging. Although the present gun was procured as a pilot model, it appears from the above considerations that its size may be adequate for some commercial uses.

For a gun of the dimensions described, the optimum charge in the case of ⅜-in. carrot dice will be about 16 lb., which occupies a little less than one-third of the gun volume. Charges as large as 18 lb. have been successfully puffed, but this is probably marginal.

Research is continuing at the Wyndmoor Laboratory to apply explosion puffing to other fruits and vegetables and to accumulate engineering data to permit industrial design of guns specifically for the process.

NOTE: Reference to certain products or companies does not imply an endorsement by the Department over others not mentioned.

REFERENCES

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* Viton A, Specification Grade made by Delaware Asbestos & Rubber Co., 245 North Front St., Philadelphia, Pa., has been found superior for this use.