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A NEW GUN FOR EXPLOSIVE PUFFING OF FRUITS AND VEGETABLES

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ABSTRACT

A new gun designed in the Engineering and Development Laboratory for the explosive puffing of partially dried fruits and vegetables is described. Improved design and the injection of superheated steam to supplement external heating have increased capacity, shortened the cycle and improved product quality. This pilot plant model is considered also suitable for commercial use. Construction drawings are available.

This is a report of work done at the

Eastern Utilization Research and Development Division

Philadelphia, Pennsylvania 19118

A NEW GUN FOR EXPLOSIVE PUFFING OF FRUITS AND VEGETABLES

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A new gun designed expressly for explosive puffing of partially dehydrated fruits and vegetables has now been successfully developed at the U.S. Department of Agriculture's Eastern Utilization Research and Development Division near Philadelphia, Pa. The process for preparing quick-cooking dehydrated fruits and vegetables in which an explosive puffing step is used has been widely publicized (references 1-8; see Literature Cited, at end of this report). The development of this process has become recognized as a significant advance in dehydration. The products are unique and possess some of the desirable attributes of freeze-dried materials, yet can be made at a cost only slightly higher than that for products dried by conventional hot-air processes. The explosive puffing process has thus far been successfully applied to apples, blueberries, white potatoes, sweetpotatoes, carrots, beets, and rutabagas. Other fruits and vegetables are being tested.

Work is in progress at the Eastern Utilization Research and Development Division on the development of apparatus for continuous puffing. However, the demonstrated practicability, relative low cost, and flexibility of batch guns such as the one described here make them well suited for small-scale operation; for example, in a plant that has a daily output of 10 tons or less.

DESCRIPTION OF GUN

The gun was originally designed for external heating only, but has been modified for internal heating also, by employing superheated steam or other gas. The heating cycle has been greatly shortened by introducing superheated steam, after the charge has been forewarmed by tumbling in the preheated gun to avoid steam condensation. The pieces are exposed to heat on all surfaces instead of by fortuitous contact with the heated wall alone.

The gun (fig. 1) incorporates a number of features designed for product improvement and operating ease. These include a thin-wall, stainless steel puffing chamber 10 inches in diameter and 30 inches long (1)* with integral fins for better heat transfer and a single-piece, light-weight, stainless steel lid (2) with a positive acting locking mechanism (3). This achieves fast, explosive product discharge, which in turn means good puffing. There

* Numbers in parentheses refer to the numbers shown on figs. 1 and 3 denoting features of the gun.

is a low inertia lid arrester (4) for smooth absorbing of the lid impact; a pushbutton control station (5) and a foot pedal (6) for easy control of the tilting mechanism. Figure 2 shows the gun in processing position.

The system for supplying superheated steam to the gun (fig. 3) consists of the following main components: A flow control valve (21) at the input side to the electric superheat - er (22); an indicating control thermostat (23) for selecting and maintaining a desired steam temperature; a swivel joint (24) and a rotary joint (25) for introducing steam into the gun; a quick opening valve (26) just ahead of the rotary joint; a bypass line just ahead of the swivel joint leading to an adjustable pressure regulating valve (27) to an expansion chamber (28) and out through a steam trap (29) or vented to the atmosphere (30).

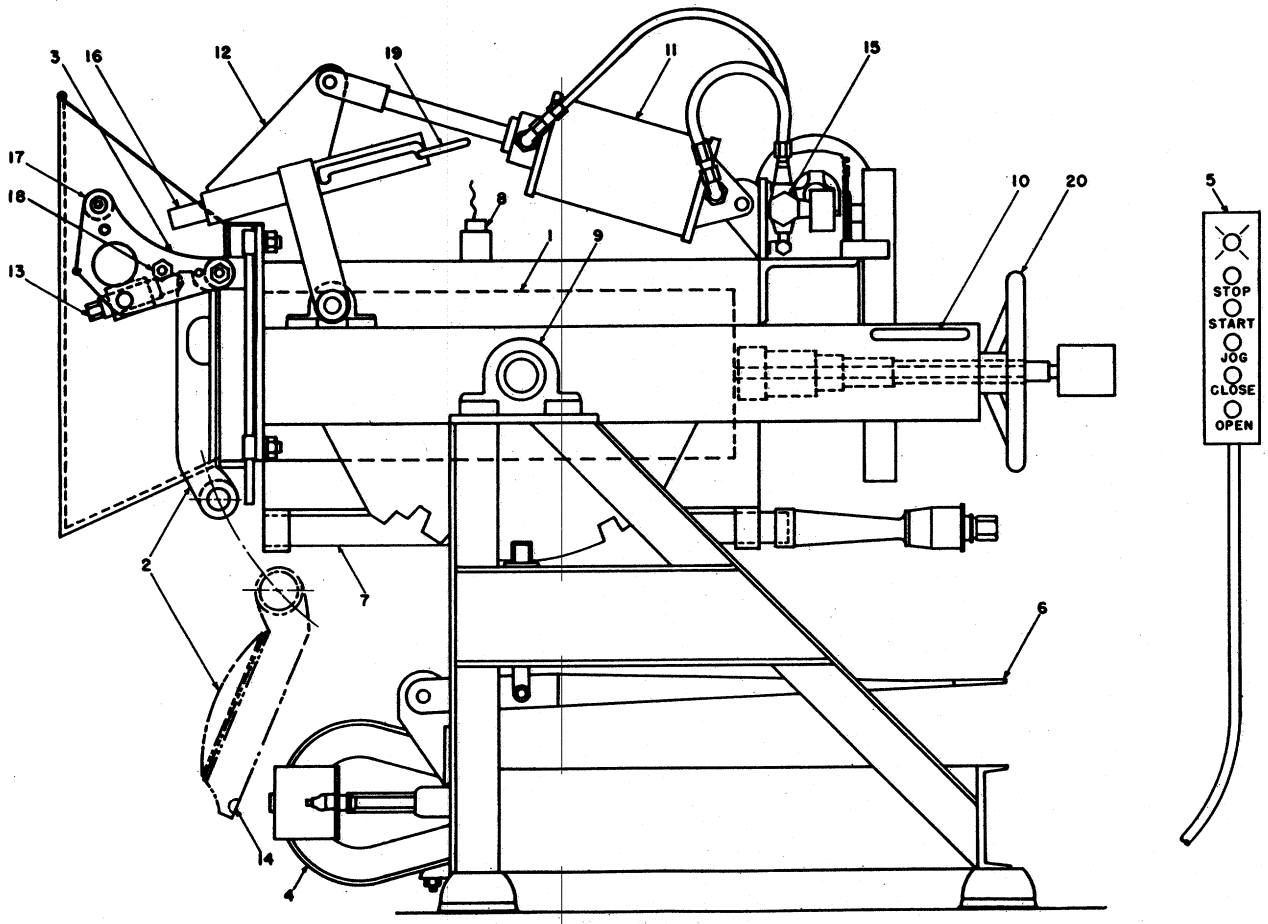

Figure 1. Side elevation of gun.

1. Puffing chamber
2. Lid
3. Locking mechanism
4. Lid arrester
5. Pushbutton control station
6. Food pedal
7. Gas burners
8. Thermocouple
9. Pivot center bearing
10. Handle
11. Air cylinder, double acting
12. Opening-and-closing mechanism
13. Locking bolt
14. Detent of Lid
15. Dual solenoid
16. Rod
17. Roller
18. Stop
19. Handle
20. Handwheel

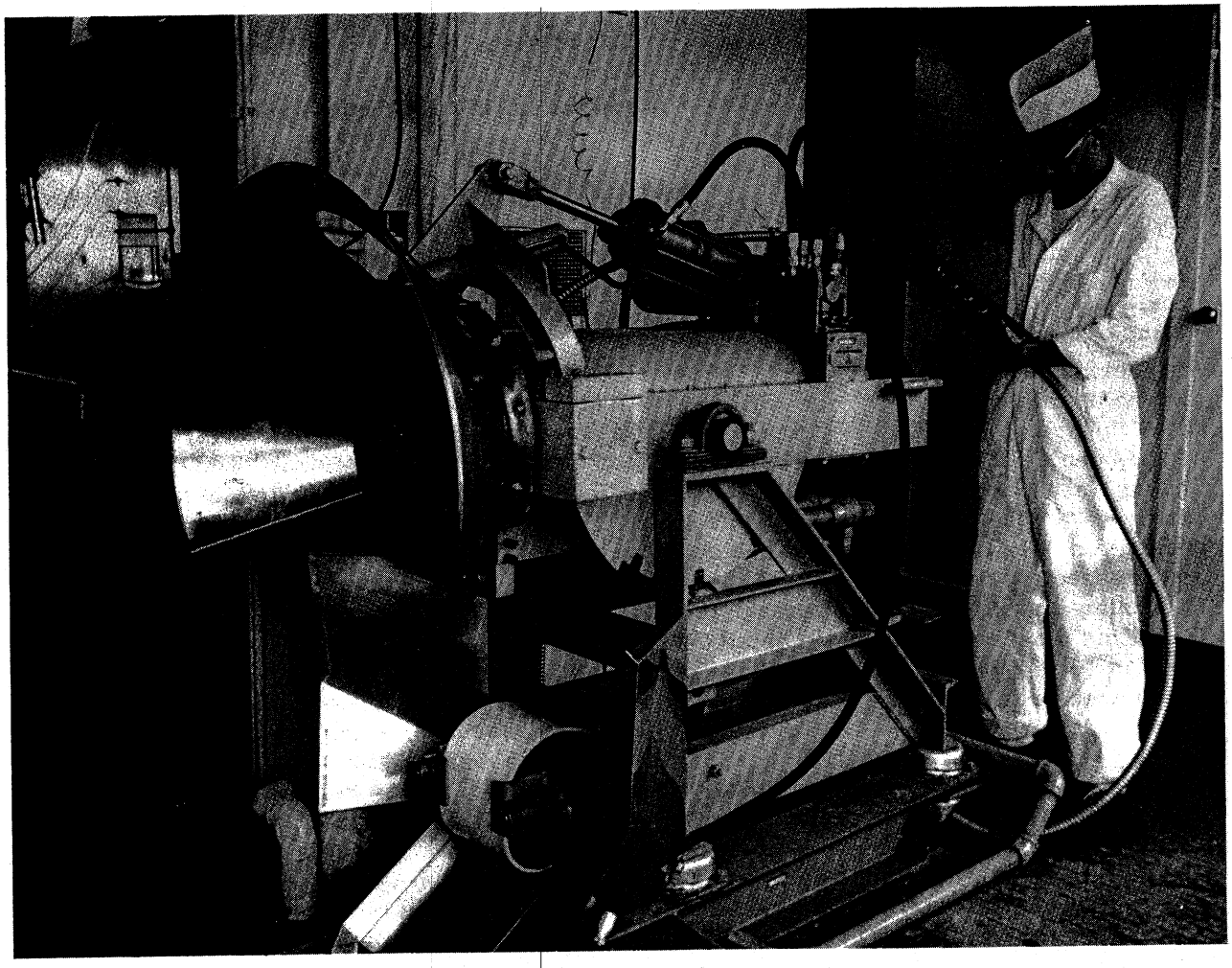

Figure 2. Gun rotating in operating position.

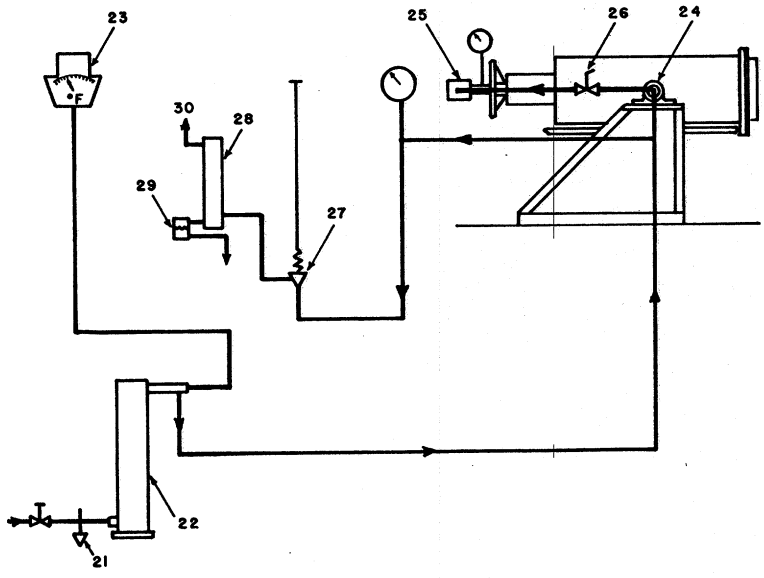

Figure 3.
Piping and controls
for superheated steam system.

21. Flow control valve
22. Electric superheater
23. Thermostat
24. Swivel joint
25. Rotary joint
26. Quick opening valve
27. Pressure regulating valve
28. Expansion chamber
29. Steam trap
30. Vent

OPERATION OF GUN

The operation of the gun may vary somewhat with the commodity being processed bu in general, consists of the following steps.

These will be more easily understood if it is kept in mind that the axis of the puffir chamber (1) can be in any one of four positions. These positions are: 35° upward or loac ing position; horizontal or processing position; 35° down, or product accumulation positic (for use with small charges only); and a 22-1/2° down or firing position. After the empt horizontally rotating puffing chamber is preheated by means of two gas burners (7), to th desired wall temperature, as indicated by a suitable instrument and picked up with a sli ing thermocouple (8), gas is shut off, rotation is stopped, lid is opened, and the gun pivoted upward about center (9) with aid of foot pedal (6) and handle (10). The gun is loa ed in this position. At this moment, the retracted piston of air cylinder (11) has positior ed the opening-and-closing mechanism (12) in closing (back) position. Lid (2) is close locking mechanism (3) is swung down, and locking bolt (13) is started in semispheric detent (14) of the lid. All this is done manually and requires only about 10 seconds. Whe pushbutton "CLOSE" is pressed, one coil of a dual solenoid (15) is energized, which admit compressed air to the blank end of air cylinder (11). This causes forward extended rod (16 of opening-and-closing-mechanism (12) to press down on roller (17) of locking mechanis (3). This movement is stopped by stop (18), and the lid is closed tightly and locked togeth er with locking mechanism (3), which is clearly indicated by a strong, snapping soun Subsequent pressing of pushbutton "OPEN" returns the air cylinder piston (11) and opening and-closing mechanism (12) in order to remove pressure from the extended rod (16). Th manual retraction of handle (19) and rod (16) and the pressing of pushbutton "CLOSE" retur the opening-and-closing mechanism (12) into forward or opening position and clear an elec trical lockout; then the puffing chamber may be rotated. This is done by pressing pushbutt "START." The puffing chamber (1) is rotated at a constant speed of 40 r.p.m. by means an electric gear head reduction motor and a chain drive. Not more than 30 seconds shou elapse between start of charging and start of rotation. The gun is now returned to the hor zontal position and the burners are lighted. Gas flow is controlled to maintain a previous selected wall temperature.

The charge, after being tumbled in the heated gun for about 2 minutes, will have becom heated to the point where condensation will not take place to any significant degree whe superheated steam is admitted. Superheated steam, for example at 500°F. and 55 p.s.i.g is admitted to the puffing chamber by opening quick-opening valve (26).
Before the steam is admitted, a small amount should have been venting to the atmosphe through bypass (30) to rid the system of condensate and to keep the lines hot. Approximat ly 1 minute will be required for the pressure in the gun to reach that of the steam from th superheater. Meanwhile, entrapped air and a small amount of steam are permitted to escap through a 1/16 inch diameter orifice in the lid. Experience has shown that approximate 45 seconds at the equilibrium pressure is generally sufficient to superheat the containe water in 3/8 inch dice to the point where good puffing will result on exploding from the gu

When the gun is ready for firing, rotation is stopped by pressing pushbutton "STOP By the turning of the handwheel (20), the puffing chamber (1) is lined up for firing. The g is pivoted into a 22-1/2° downward or firing position, in which a pressure lockout of the a cylinder solenoids is bypassed. While the gun is under pressure, this lockout prevent accidental firing in all other positions. The rod (16) with handle (19) is now brought forwa below roller (17) of locking mechanism (3). and the gun is fired by pressing pushbutt "OPEN."

When less than the normal 20-pound charge is being processed, it may be desirable before firing (to assure complete discharge of the contents) to tilt the gun downward to the 35° position and rotate for a few seconds. This causes the charge to accumulate at the muzzle end. Rotation is then stopped, the gun is raised to the 22-1/2° firing position and then fired as already described.

An experienced operator can puff from 9 to 10 charges per hour, depending on the commodity and conditions being used.

Although the gun was designed for pilot plant research, its capacity has proven so much greater than anticipated that it appears practicable for commercial use. One gun equipped for both external heating and steam injection can handle approximately nine 20-pound charges per hour of 3/8 inch vegetable dice containing 22 percent moisture. This amounts to about 1-1/2 tons per day of finished product. Four guns and two collection chutes installed with instrumentation should cost about $45,000. This capital investment would be largely offset by saving in the drier capacity, for explosive puffed materials dry approximately twice as fast as nonexploded pieces.

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