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EXPLOSION PUFFED DEHYDRATED CARROTS. III. ESTIMATED COST OF COMMERCIAL PRODUCTION USING SHORTENED CYCLE

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ABSTRACT

A shortened cycle is described for explosive puffing of carrot pieces with superheated steam, increasing gun capacity by about 73 percent over that previously reported. A means for increasing bulk density of puffed pieces from 18 pounds per cubic foot to 24 pounds per cubic foot is given.

A complete cost estimate is made for commercial operation employing these advances. This shows that the cost to make and package in fiber drums varies from 37 cents per pound in Texas where raw material is available at $16 per ton for 7 months annually to 42 cents per pound in California where raw material is $25 per ton.

EXPLOSION PUFFED DEHYDRATED CARROTS. III. ESTIMATED COST OF COMMERCIAL PRODUCTION USING SHORTENED CYCLE

V. A. Turkot, R. K. Eskew, J. F. Sullivan, J. Cording, Jr., and W. K. Heiland [1]

INTRODUCTION

A process for the explosive puffing of fruit and vegetable pieces to yield quick-cooking dehydrated products has been developed at the Eastern Utilization Research and Development Division near Philadelphia. The process has received extensive publicity (1-8)[2]. It has evoked widespread interest from potential producers as well as consumers of these new products.

The most recent publication on the process (8) describes a new gun for explosive puffing designed at the Eastern Division. Superheated steam supplements external heating. Increased experience with this gun has enabled shortening the time per charge from about 6 minutes (including 2 minutes to discharge and recharge) to less than 4 minutes, at the same time slightly increasing the charge size. The net result has been an increase in output per gun from 200 pounds per hour of 3/8" carrot dice to 345 pounds per hour (at 25 percent moisture), corresponding, respectively, to 156 and 258 pounds per hour of finished product (at 4 percent moisture).

Moreover, it has been found that 3/8" carrot dice can be squeezed between rolls after puffing and before final drying, thereby increasing the bulk density of the finished product from about 18 pounds to 24 or more pounds per cubic foot. This effects a reduction in packaging and shipping costs; container cost alone is reduced by 25 percent. The compressed pieces rehydrate just as rapidly and completely as the uncompressed material.

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2/ Underscored numbers in parentheses refer to References at end of the report.

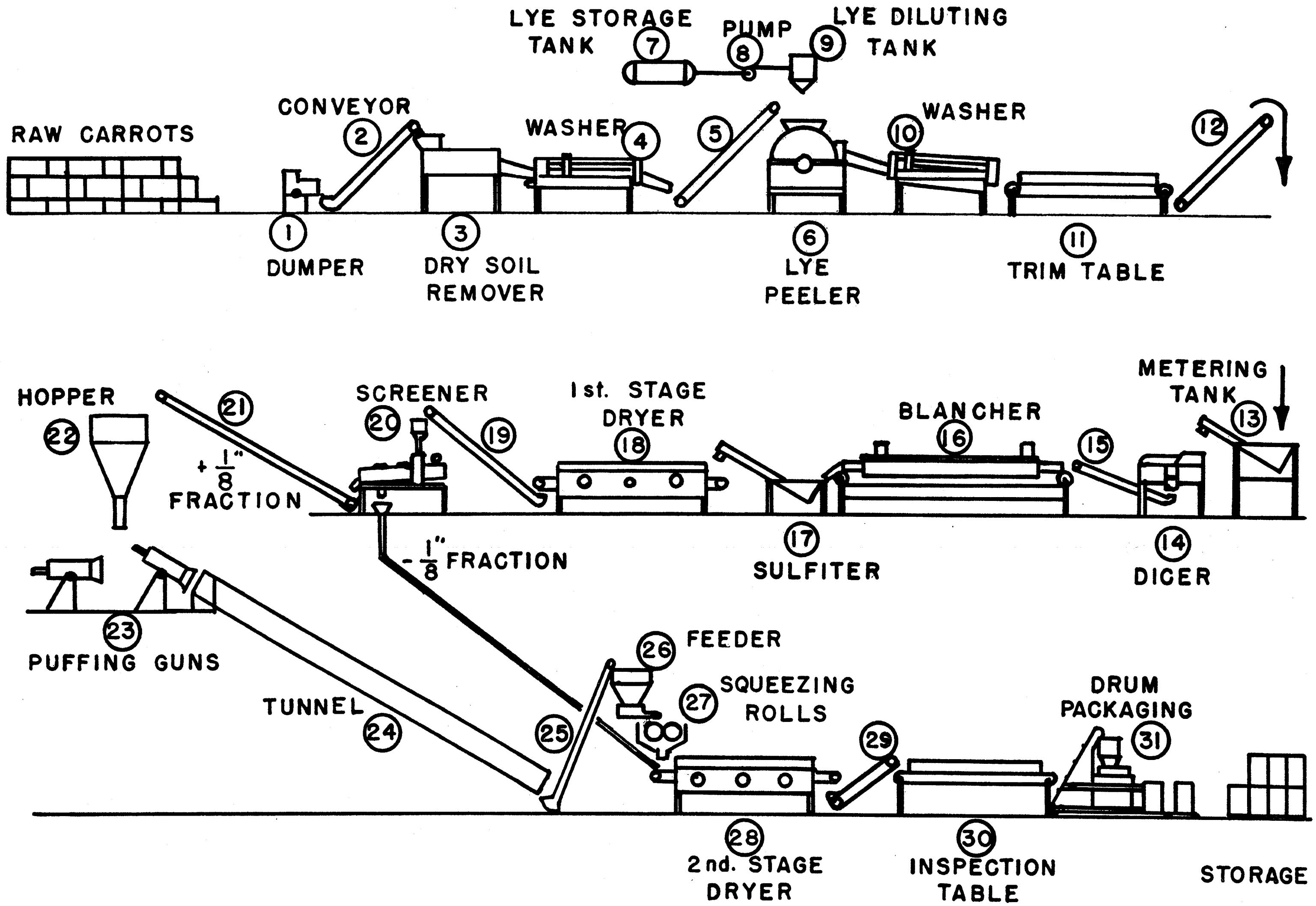

Figure 1. Flow Sheet for Explosion Puffed Dehydrated Carrots

The purpose of this publication is to report details of the new operating procedures with superheated steam and to present an estimate of the cost of commercial operations with carrots using these new procedures and compressing the puffed material.

DESCRIPTION OF PROCESS

The flow sheet (fig. 1) depicts the sequence of processing steps and the equipment. Raw carrots, in bulk boxes, are dumped onto a conveyor and elevated to a dry soil remover having a rotating cylinder. They next pass through a water spray washer and into a lye peeler. They are then washed to remove the loosened skins, trimmed by hand, and conveyed to a metering holding tank which feeds the dicer. The dicer is normally set for a 3/8" x 3/8" x 3/8" cut. The dice are steam-blanched for 4 minutes, dipped in a solution containing about 1/2 percent each of sodium bisulfite and citric acid, and fed to the first-stage dryer. This is a conventional continuous belt, steam-heated, hot-air dryer, which reduces moisture content of the dice to approximately 25 percent. The partially dried dice are next screened to separate small pieces, which are sent directly to the final dryer. These small pieces will rehydrate quickly enough so that they need not be explosive puffed. The overs from the screen are conveyed to the feed hopper of the puffing guns. The guns discharge puffed dice into a sloping discharge tunnel from which they are conveyed to the hopper of the feeder for the squeezing rolls. After squeezing, the dice are fed along with the screen unders into the second-stage dryer, which discharges product at about 4 percent moisture. Following manual inspection for removal of defective pieces, the dice are weighed into fiber drums and taken to storage.

OPERATION OF PUFFING GUN

The relatively slow operating cycles previously suggested for the gun (8) were found to be the consequence of loss of superheat in the steam between the point of temperature measurement and actual entrance into the gun. The installation of a thermocouple through the rotary joint to the entrance of the gun, as shown in figure 2, revealed that although steam at 35 pounds per square inch gage and 500° F. was introduced to the system, heat loss in the connecting lines and through the 1/2" bore of the gun shaft resulted in only saturated steam at the point of entrance into the barrel. Five changes were required to rectify this and to improve steam distribution inside the gun. These were:

1. The point of venting steam prior to introducing it into the system was relocated as near as possible to the rotary joint; in this case, within 3 inches of it.

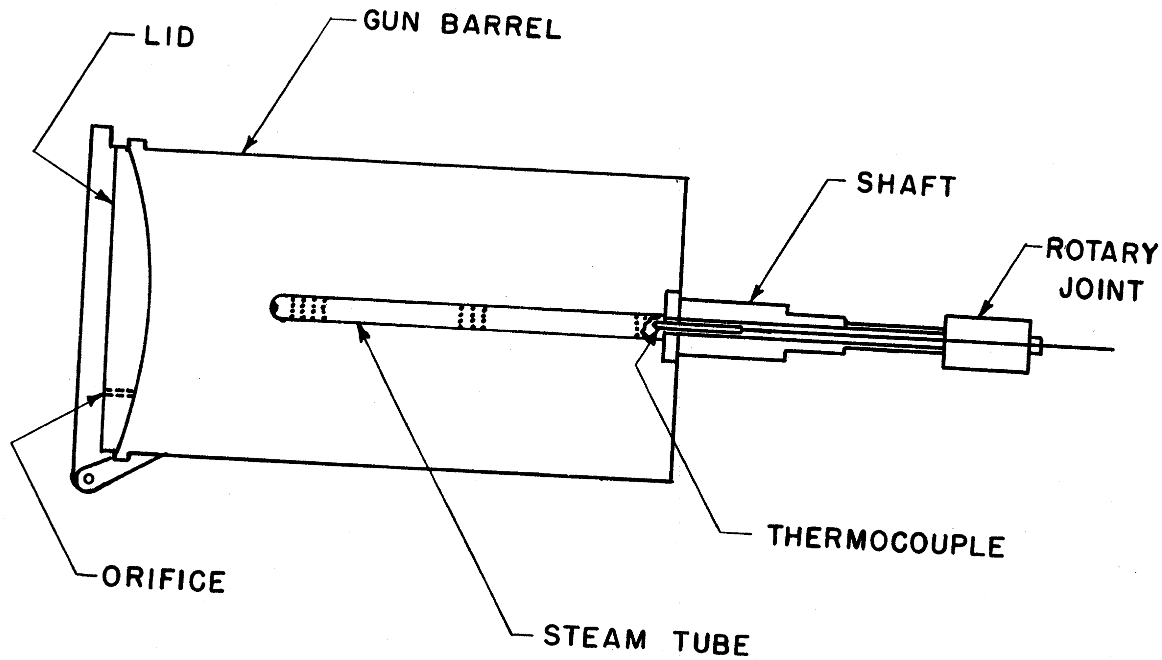

Figure 2. Location of Thermocouple at Entrance to Gun Barrel

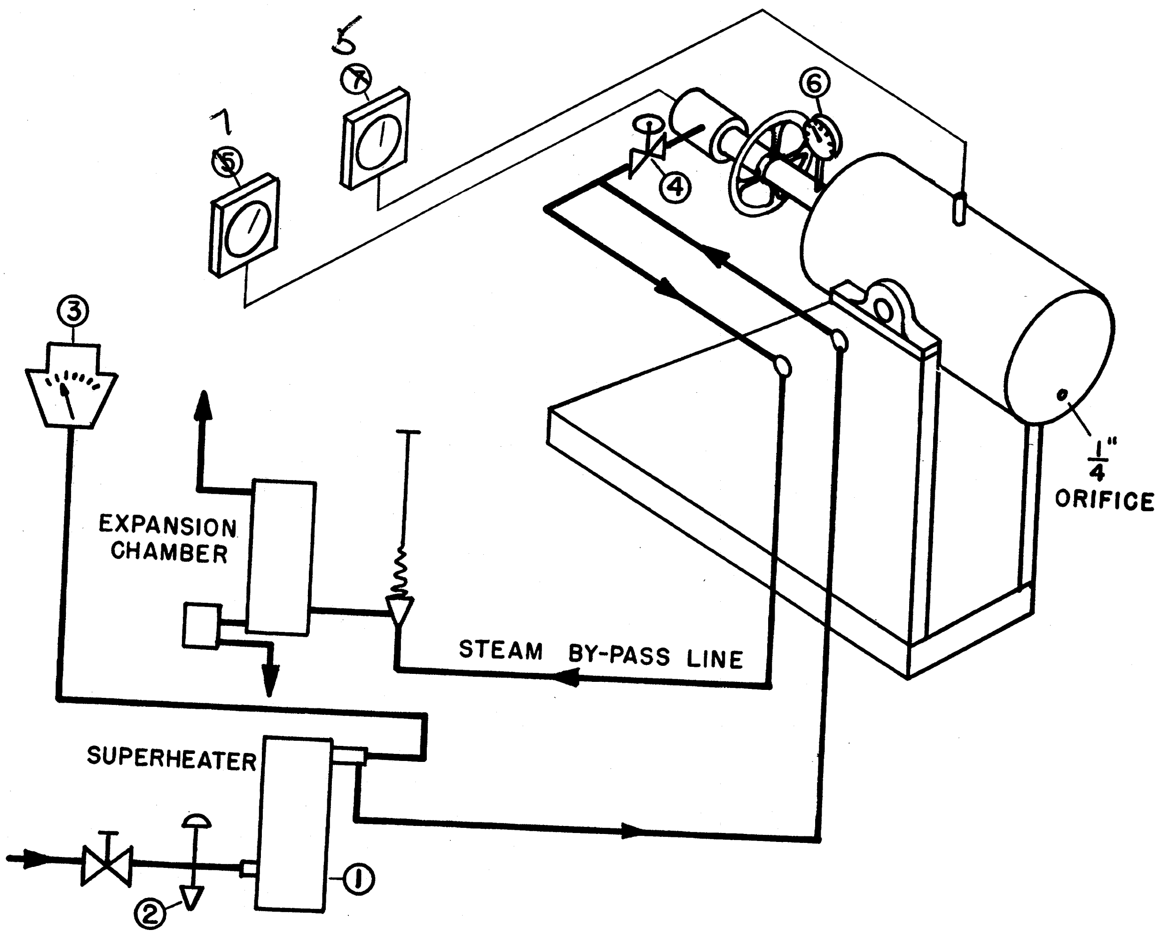

Figure 3. Controls for Gun Operation

2. The bore of the gun shaft was increased to 1 inch and a ceramic insulating sleeve was inserted between the rotary joint and the gun barrel. This was 3/4" inside diameter.

3. The orifice vent in the lid of the gun was increased from 1/16" to 1/4" diameter to increase steam flow.

4. A thermocouple was installed with instrument to indicate and record the actual temperature of the steam entering the gun proper (fig. 2).

5. To improve steam distribution, especially important with large charges and shortened time in the gun, a 3/4" outside diameter stainless steel tube running approximately 3/4 of the barrel's axis was connected to the point where steam enters the barrel. This had 1/16" perforations.

The net result of these changes assured superheated steam entering the gun thereby enabling the elimination of the 2 minute forewarming of the charge before admitting steam and the 3/4 minute holding time after reaching pressure (8). Actual time in the gun was reduced from about 4 minutes to less than 2 minutes.

The following sequential steps (fig. 3) are suggested for initiating operations:

1. Admit steam to the superheaters (1) by opening valve (2).

2. Turn on electric power to the superheaters and set thermostat (3) (temporarily) to give 340° F. steam.

3. Close gun lid and start rotation.

4. Light gas burners and admit steam to gun through quick-opening valve (4).

5. Adjust gas rate to give a gun surface temperature of 340° to 350° F., as indicated by recorder (5). This is actuated by a sliding thermocouple on the outside of the gun barrel.

6. Adjust steam pressure by means of valve (2) to 35 p.s.i. as indicated by gage (6) on gun shaft.

7. Shut off gas to gun and shunt steam to the bypass by closing valve (4).

8. Charge the gun with carrot pieces, for example 23 pounds of 3/8" dice, and start rotation. Re-light gas, maintaining gun surface temperature between 340° and 350° F.

9. Open valve (4) admitting steam to the gun.

10. Observe the temperature of superheated steam entering the gun as indicated on recorder (7). Re-adjust thermostat (3) if necessary to maintain steam at 305° to 310° F. (which corresponds to 24° to 29° superheat) entering the gun. It may be necessary in initiating operations to process several charges until the proper settings of (2) and (3) are achieved. Thereafter, the settings are left the same.

Having carried out the foregoing preparations, it is now possible to process charges in rapid succession as follows: Charge the gun with about 23 pounds of dice containing between 20 and 30 percent moisture, close the lid, start rotation, light the gas burners keeping the gun surface temperature at 340° to 350° F., and admit steam through valve (4). When gage (6) reads 35 p.s.i. (in about 2 minutes) shut off the gas, tilt the gun, fire it, shut off the steam. The gun is now ready for reloading and continued operation.

BASIC ASSUMPTIONS FOR COST ESTIMATE

The plant is assumed to be located in the lower Rio Grande Valley of Texas, near Weslaco, where carrot prices are favorable and the harvest season is long. The plant would be operated from December 1 through June 30 (7 months) on carrots. Processing of other commodities, such as beets or potatoes, if available, could be done during the remaining months. This would spread the fixed costs over additional production and lower the cost to make dehydrated carrots.

The plant would operate for 6 days a week, 175 operating days a year. Twenty-three (23) hours of production per day with 1 hour downtime for cleanup and maintenance is assumed.

Capacity of the plant is taken as 5,200 pounds of raw carrots per hour, or 59.8 tons per day. Product rate of 473 pounds per hour is based on an overall "shrinkage ratio" of 11:1; that is, 11 pounds of fresh carrots yield 1 pound of dried product containing 4 percent moisture. Output is thus 10,879 pounds per day, totaling 1,903,825 pounds a season.

The plant is assumed to use "field run" carrots at $16.00 per ton delivered. These would arrive in wooden bins furnished by the processor and of suitable size for handling with a forklift truck.

An additional source of raw material could be sound culls obtained from packinghouses where oversize, misshapen, or broken roots are removed before shipping the first grade carrots. These culls are sold mainly for livestock feed at about $6 a ton. If used as a part of the raw material supply, they could reduce the average cost for raw carrots appreciably. However, this potential saving has not been included in the cost figures because the exact proportion of culls that might be used is unknown. For an example, use of 50 percent culls at $8 a ton would save about $40, 000 a season in raw material costs.

The plant is also assumed to be built as a "grass roots" plant, that is, complete from the ground up. Actually, the dehydration plant would probably be built as an addition to an existing processing or packing plant. In that case both initial capital costs and fixed operating costs would be lower because certain existing facilities could be shared, such as roads and parking areas, warehouse space, boilers, and office equipment. Thus, the costs shown here are conservative for expansion of an existing enterprise.

The output of the plant, although referred to as dice, consists actually of the total output of Urschel Model B cutters 3/ set for 3/8" cubes, and includes imperfect cubes and smaller pieces. Approximately 10 percent of the output of the cutter will pass through a 1/8" screen.

It is assumed that the dried carrot dice will be sold for remanufacturing use, such as for inclusion in dehydrated soup mixes, or for institutional use. Therefore, they will be bulk-packaged in fiber drums having lever-closed, gasketed lids and a built-in 4-mil polyethylene liner as a moisture barrier. Drums are 20 inches in diameter by 30 inches in height and hold 125 pounds of dried carrots having a bulk density of 24 pounds per cubic foot.

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

EQUIPMENT SUMMARY

Item No. [4/]	Description	Estimated Price Dollars
1	Dumper -- to dump boxes of carrots into feed hopper of conveyor. 1-1/2 hp. motor.	600
2	Conveyor-elevator -- to lift 5,200 pounds per hour of raw carrots to dry soil remover. All steel construction, feed hopper, draper of steel slats on side chains. 1 hp. motor.	1,800
3	Dry soil remover -- to remove loose dirt and debris without the use of water; 36-inch diameter, 8-foot long rotary rod reel. 2 hp.	3,300
4	Washer -- to wash dirt from carrots; 36-inch diameter, 12-foot long rotary rod washer; steel construction, with centrally located water pipe. 2 hp. splashproof motor.	3,600
5	Elevator -- to lift carrots from washer into lye peeler. All steel construction. 1 hp. motor.	1,800
6	Lye peeler -- rotating drum with pockets, with drive speed variable from 4 to 12 minutes per revolution and with steam heating coils. Steel construction. 1 hp. motor.	4,000
7	Lye storage tank -- to store 50 percent caustic soda solution; 4,000-gallon plain steel tank.	800
8	Pump -- to transfer 50 percent caustic from item No. 7 to overhead lye dilution tank. Approximately 15 gallons per minute at 45-foot head. All steel construction. 1 hp. motor.	400

[4/] The numbers refer to Figure 1.

9	Dilution tank -- for diluting 50 percent caustic to about 25 percent before feeding to lye peeler, 500-gallon plain steel tank with clamp-on propeller agitator. 1/4 hp.	400
10	Rotary rod washer -- to wash loosened skins from carrots with high-velocity water sprays, 36-inch diameter by 12-foot long. All steel construction. 2 hp. motor.	3,600
11	Trim table -- for hand trimming and inspection of about 4,150 pounds per hour of peeled carrots. Three belts each about 25 foot long -- one for peeled carrots, one for trimmed carrots, and one for trimmings. 2 hp. motor.	4,800
12	Elevator -- to raise trimmed carrots to holding-metering tank. Steel construction. 1 hp. motor.	1,800
13	Metering tank -- to hold a reserve 1/2 hour-supply of trimmed carrots and to set feed rate to following operations; belt-type conveyor in a stainless steel tank. 3/4 hp. motor with variable speed drive.	4,800
14	Dicer -- to cut carrots into cubes 3/8" x 3/8" x 3/8". 2 hp. motor.	3,200
15	Elevator -- to convey dice from cutter to blancher. Belt-type with 3/4 hp. motor.	1,200
16	Blancher -- to blanch dice for approximately 4 minutes in atmospheric steam, with mesh stainless steel belt and 3 hp. motor with variable speed drive.	6,300
17	Sulfiter -- to immerse dice for approximately 1 minute in a solution containing 1/2 percent sodium bisulfite and 1/2 percent citric acid to prevent darkening during drying. Parts contacted by liquid made of stainless steel. 3/4 hp. motor with variable speed drive.	4,300

18	First-stage dryer [5] -- to dry approximately 3,700 pounds per hour of dice from 89 percent to 25 percent moisture. Apron-type conveyor dryer about 30 to 40 feet long with through circulation of air heated by steam coils. Total power load of about 62 hp.; complete with feeder.	42,000
19	Elevator -- to lift partly dried dice to screener. Belt-type with 1 hp. motor.	1,800
20	Screener -- to separate small pieces from larger dice. 1/8" mesh slotted screen. 1 hp. motor.	2,000
21	Elevator -- to lift material retained on the screen to gun platform. Belt-type with 1-1/2 hp. motor.	2,200
22	Hopper -- to hold supply of dice for puffing guns, with slide-type bottom gate.	400
23	Puffing guns -- three guns, one of these to serve as a spare. Includes two recorder-controllers for outer surface temperature of gun barrels; two recorders for steam temperature entering guns; a semi-automatic feeder to charge guns; and a steam superheating system. Gun equipped with 1/4 hp. motor.	39,600
24	Discharge tunnel -- to receive dice shot from guns. Inclined at 22-1/2° to the floor and swiveled so that it can serve each of the guns. About 40 feet long. Aluminum and stainless steel construction.	4,200
25	Conveyor -- to take dice from bottom of tunnel and convey to feeder of squeezing rolls. Belt-type with 1 hp. motor.	2,300

[5] Alternatively a belt-trough dryer could be used.

26	<u>Feeder</u> -- to feed dice evenly into squeezing rolls. Vibrating type, with feed hopper, gate, stainless steel feeding chute.	500
27	<u>Squeezing rolls</u> -- pair of rolls of stainless steel, 6-inch diameter by 16-inch long, to squeeze dice through 1/16 inch gap to increase bulk density. 1/2 hp. motor with variable speed drive, discharge chute, doctor knives, adjustable gap.	2,900
28	<u>Second-stage dryer</u> -- similar to item No. 18 but smaller. To dry puffed dice and undersize fraction from screener down to 4 percent moisture. Connected motor load 46 hp. complete with feeder.	34,000
29	<u>Elevator</u> -- to convey dice from dryer to inspection table. Belt-type, 1 hp. motor.	1,600
30	<u>Inspection table</u> -- for final inspection of dice and manual removal of defects. Rubber belt conveyor approximately 10 foot long. 1/2 hp. motor.	1,400
31	<u>Packaging</u> -- elevator, hopper, and scale for filling fiber drums to 125 pounds net weight.	2,200
32	<u>Portable wooden bins</u> -- for handling raw carrots.	2,500
	TOTAL EQUIPMENT COST	$186,300

CAPITAL COSTS

		Dollars
1	Land and site preparation	4,500
2	Roads and parking areas	15,600
3	Buildings - combination processing, office, storage building. 125' x 125', includes lighting and heating . .	250,000
4	Boilers - 8,600 lb. steam per hr. at 125 p.s.i.g.	18,000
5	Equipment - manuf. (details in section on Equipment Summary).	186,300

6	Erection of equipment - manuf. 13 percent of (5).	24,200
7	Instrumentation	4,000
8	Piping and ductwork -- 6 percent of (5)	11,200
9	Erection of piping and ductwork -- 5 percent of (5)	9,300
10	Power - installed - 148 kw.	20,000
11	Transportation facilities - forklift truck	6,500
12	Insulation of steam lines	3,500
13	Freight on equipment -- 2 percent of (5).	3,700
14	Office furniture and fixtures	4,000
15	Contingencies -- 10 percent of total.	75,400
16	Engineering fees -- 12 percent of total	90,400
17	Contractor's fee	25,000
18	Fire protection and safety	2,000
19	Total fixed capital	753,600
20	Working capital	190,000
21	Total capital	943,600

OPERATING COSTS

(23 hours production per day, 6 days per week, 175 days per year, 473 lb. product per hour at 4 percent moisture; 10,879 lb. per day)

	Cost per day Dollars	Cost per lb. of product cents
I. Factory Manufacturing Costs		
(A) Direct Production Costs		
1. Raw materials:		
Carrots-field run, 59.8 tons per day at $16 per ton	956.80	8.79
Lye-for peeling, 2,400 lb. per day of 50 percent caustic.	42.00	.39
Sodium bisulfite, 26 lb. at $8.50 per 100.	2.21	.02
Citric acid, 18 lb. at 35 cents per lb.	6.30	.06
Total raw materials	1,007.31	9.26

2. Packaging materials:		
Fiber drums, 20" diam. x 30" high, polyethylene-lined, 125 lb. net, 87 per day at $3.30	287.20	2.64
Total packaging materials	287.20	2.64
3. Operating labor, 25 per shift, 3 shifts a day	1,238.40	11.38
4. Indirect labor:		
Supervision foremen, one per shift	79.20	.73
Mechanic, one, year-round	29.71	.27
Office help, two, year-round, two, seasonal	104.68	.96
Total indirect labor	213.59	1.96
5. Maintenance and repairs, 4 percent of fixed capital per year	172.25	1.58
6. Operating supplies, 10 percent of (5)	17.23	.16
7. Utilities:		
Steam, 165,000 lb. per day at 85 cents per 1,000	140.25	1.29
Electricity, 3,650 kw.-hr. per day at 1.2 cents	43.80	.40
Fuel gas for puffing guns, 1.6 M ft.^{3} at 50 cents	.80	.01
Water, 185,000 gallons per day at 20 cents per M	37.00	.34
Total Utilities	221.85	2.04
Total direct production costs (A) (sum of 1 to 7)	3,157.83	29.03
(B) Fixed Charges		
8. Insurance, 1 percent of fixed capital per year	43.06	.40
9. Taxes (real estate), 1.5 percent of fixed capital per year	64.59	.59
10. Depreciation St. Line, 45-yr. bldgs., 12 yr. equipment	227.65	2.09
Total fixed charges (B) (sum of 8 to 10)	335.30	3.08

(C) Plant Overhead Costs		
11. Non-wage payments:		
Social Security, 3-5/8 percent of first $4,800 per year	51.85	.48
Workmens Compensation, 1-1/4 percent labor, 1/2 percent office	17.36	.16
Unemployment Insurance, 3 percent of total payroll	43.56	.40
Total non-wage payment	112.77	1.04
12. Waste disposal	15.00	.14
Total plant overhead (C) (sum of 11 and 12)	127.77	1.18
TOTAL FACTORY MANUFACTURING EXPENSE (I) (sum of A, B. and C)	3,620.90	33.29
II. General Expense		
(D) Interest on working capital, $190,000 at 6 percent per year	65.14	.60
(E) Research and Development, 2 percent of gross sales	107.51	.99
(F) Administration and general, 15 percent of operating labor, supervision, maintenance and repair, and supplies	226.06	2.08
TOTAL GENERAL EXPENSES (II), (sum of D to F)	398.71	3.67
TOTAL COST TO MAKE (sum of I and II)	4,019.61	36.96

SUMMARY AND CONCLUSIONS

Detailed instructions are given for initiating operation of a puffing gun employing superheated steam to produce quick-cooking dehydrated carrot pieces. The shortened cycle increases hourly gun capacity from about 156 pounds per hour to 270 pounds per hour of product at 4 percent moisture.

A cost estimate is presented for the manufacture of explosive-puffed dehydrated carrot dice (nominal 3/8" cubes) in a hypothetical all-new plant located in the lower Rio Grande Valley of Texas, with a daily input of 59.8 tons of raw carrots and an operating season of 7 months. Product at 4 percent moisture is bulk-packed in air in polyethylene-lined fiber drums holding 125 pounds. With a typical price of $16 per ton for raw material and a "shrinkage ratio" of 11 pounds of carrots per pound of product, the cost to make is 37 cents per pound of dice. Selling costs, profits, and taxes on net income would be added to arrive at the manufacturer's selling price.

The investment required comprises approximately $750,000 in fixed capital (plant and equipment) and $190,000 in working capital.

The cost to make could be lowered by any one or any combination of three likely circumstances:

1. Building of the plant as an addition to an existing packing or processing plant, when sharing of existing facilities would reduce costs.

2. Use of sound cull carrots at a lower price as part of the raw material supply.

3. Operation of the plant during its idle season to produce other dehydrated products, thus spreading fixed costs over a larger output.

An attractive alternative location for the plant would be in California, where the processing season could be longer since carrots are harvested almost year-round. However, raw material prices are higher; processing carrots cost about $25 a ton. The cost to make dice for the plant presented here if using raw carrots at $25 a ton would be about 42 cents per pound, as compared to 37 cents with carrots at $16. The longer processing season in California would compensate to some extent for the higher cost of carrots.

Previous calculations by the authors and associates have shown that the cost to make explosion puffed carrot dice exceeds that for conventional air-dried dice by 10 to 15 percent. In view of the superior properties of the explosive-puffed product, the widespread interest shown in it, and the cost to make given here, manufacture of this product on a commercial scale offers an attractive potential for success.

PARTIAL LIST OF MANUFACTURERS OF EQUIPMENT

The companies listed below supply equipment which can be used in some of the steps in making explosion puffed carrot dice. The item numbers refer to the flow sheet, Figure 1, and the Equipment Summary. Reference to these companies does not imply endorsement of them by the Department of Agriculture over other companies not mentioned, and failure to list other companies is not intentional.

1. Dumper:

Allied Mfg. and Sales Co., 4701 W. Grand Ave., Chicago, Ill. 60639
Essex Conveyors, Inc., Dumpers Division FP, 101 Colden St., Newark, N. J. 07103
Gifford-Wood Co., 1 Hudson Avenue, Hudson, N. Y.
Mercury Industries, Conveyor and Dumper Division, 107 Hawthorne Ave., Park Ridge, N. J.

2, 5, 12, 15, 19, 21, 25, 29, 31. Conveyors and Elevators:

American Machinery Corporation, Subsidiary of Wallace and Tiernan, Inc., P. O. Box 3228, Orlando, Fla. 32802
Blaw-Knox Co., Food and Chemical Equipment Div., 1543 Fillmore Ave., Buffalo, N. Y. 14211
Continental Conveyor and Equipment Co., P. O. Box 398, Winfield, Ala. 35594
F. H. Langsenkamp Co., 229 E. South St., Indianapolis, Ind. 46225
A. K. Robins and Co., Inc., 713 E. Lombard St., Baltimore Md. 21202

3. Dry Soil Remover:

FMC Corporation, Packing Equipment Div., 3075 Twelfth St., Box 552, Riverside, Calif. 92502
A. K. Robins and Co., Inc. (SEE item 2 for address)
Wilcox Mfg. Co., 4610 Waterloo Rd., Stockton, Calif. 95201

4. Washer:

Same suppliers as for Item 3.

6. Lye Peeler:

FMC Corporation, Canning Machinery Div., 333 W. Julian St., Box 1120, San Jose, Calif. 95108
A. K. Robins and Co., Inc., (SEE item 2 for address)

7. Lye Storage Tank:

Any local supplier.

8. Pump:

Allis-Chalmers Mfg. Co., Milwaukee, Wisc. 53201
Goulds Pumps, Inc., 164 Fall St., Seneca Falls, N. Y. 13148
De Laval Turbine Inc., Nottingham Way, Trenton, N. J. 08602

9. Lye Dilution Tank:

Any local supplier.

10. Rotary Rod Washer:

Same suppliers as for Item 3.

11. Trim Table:

Chisholm-Ryder Co., Inc., Drawer F, Bridge Station, Niagara Falls, N. Y. 14305
A. K. Robins and Co., Inc. (SEE item 2 for address)
FMC Corporation, Canning Machinery Division (SEE item 6 for address)

13. Metering Tank:

A. K. Robins and Co., Inc. (SEE item 2 for address)
FMC Corporation, Canning Machinery Division (SEE item 6 for address)

14. Dicer:

Urschel Laboratories, Inc., Valparaiso, Ind. 46383
FMC Corporation, Canning Machinery Division (SEE item 6 for address)
A. K. Robins and Co., Inc. (SEE item 2 for address)

16. Blancher:

FMC Corporation, Canning Michinery Division (SEE item 6 for address)
Chisholm-Ryder Co., Inc. (SEE item 11 for address)
A. K. Robins and Co., Inc. (SEE item 2 for address)

17. Sulfiter:

FMC Corporation, Canning Machinery Division (SEE item 6 for address)
Overton Machine, Co., 407 South Front St., Dowagiac, Mich.
Idaho Falls Steel Products Co., 255 East Anderson St., Idaho Falls, Idahc
A. K. Robins and Co., Inc. (SEE item 2 for address)

18. Dryers:

Belt Dryer

Proctor and Schwartz, Inc., Div. of Proctor-Silex Corp., 7th and Tabor Rd., Philadelphia, Pa. 19120
National Drying Machinery Co., Lehigh and Hancock, Philadelphia, Pa. 19133
C. G. Sargent's Sons Corp., Graniteville, Mass. 01829

Belt Trough Dryer

Diamond Manufacturing Co., 1763 Timothy Drive, San Leandro, Calif.

20. Screener:

Sprout Waldron and Co., Inc., Muncy, Pa. 17756
Syntron Company, 111 Lexington Ave., Homer City, Pa. 15748
Blaw-Knox Co., Food and Chemical Equipment Division (SEE item 2 for address)
J. H. Day Company, 4932 Beech St., Cincinnati, Ohio 45212

22. Hopper:

Any local supplier.

23. Puffing Guns:

Wilmot Fleming Engineering Co.,[6/] Hasbrook below Cottman St., Philadelphia, Pa. 19111

6/ This is the only company known to have manufactured puffing guns of our design, upon which this publication is based.

24. Discharge Tunnel:

Blueprints for fabrication may be obtained from USDA, ARS, EU, Engineering and Development Laboratory, 600 East Mermaid Lane, Philadelphia, Pa. 19118

26. Feeder:

Syntron Company (SEE item 20 for address)
The Exact Weight Scale Co., Division of National Industrial Products Corp., 556 E. Town St., Columbus, Ohio 43215
Jeffrey Mfg. Co., 856 N. Fourth St., Columbus, Ohio 43216
Vibra Screw Feeders, Inc., 156 Hurron Av., Clifton, N. J.

27. Squeezing Rolls:

F. J. Stokes Co., A Division of Pennsalt Chemicals Corp., 5500 Tabor Rd., Philadelphia, Pa. 19120
Blaw-Knox Co., Food and Chemical Equipment Division (SEE item 2 for address)

28. Dryer:

Same suppliers as for item 18.

30. Inspection Table:

Same suppliers as for item 11.

31. Scale:

Toledo Scale, Div. of Toledo Scale Corp., 5225 Telegraph Rd., Toledo, Ohio 43612
Colt Industries, Inc., Fairbanks Morse Weighing Systems Division, 19-01 Route 208, Fair Lawn, N. J.
The Exact Weight Scale Co., Div. of National Industrial Products Corp. (SEE item 26 for address)

32. Wooden Bins:

American Box Co., P. O. Box 248, Fernwood, Miss. 39635
Clinch-Tite Corp., 807-P Old Lancaster Rd., Berwyn, Pa.
Hoerner Boxes, Inc., 600 Morgan St., Keokuk, Iowa 52632

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