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Improvements in the Washing Operation of Coffee Harvested with Plastic Nets¹

*L. E. Cancel, I. Hernández-Torres, E. R. de Hernández,
and J. A. Rosario-Hernández²*

INTRODUCTION

The washing operation in the preparation of parchment coffee is very important due to its influence on the economic aspects (quality and price) of the final product.

Coffee harvested in plastic nets is associated with large amounts of extraneous matter. Leaves constitute the bulk of the material collected and most of these are removed by means of a blower.³ The remaining material consisting mostly of coffee beans and a large amount of twigs with attached berries, together with lesser amounts of decayed leaves, dirt, seeds and other types of decomposed organic matter, is fed into a horizontal washing machine⁴ which pulps the coffee berries and washes the parchment coffee to a commercially acceptable level. The drawbacks in this washing operation are the large number of small twigs mixed with the washed parchment coffee that remain and the large amount of hulled coffee produced.

The results of a study conducted for the purpose of determining how best to eliminate the twigs and reduce the excessive coffee hulling in the washed coffee are presented herein.

MATERIALS AND METHODS

THE WASHING MACHINE

The washing unit (fig. 1) consists of a holding bin, a feeding hopper, a scrubbing or washing cylinder, and a shaker screen. The holding bin can

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² Food Scientist and Research Assistants, respectively, Food Technology Laboratory, Agricultural Experiment Station, Mayagüez Campus, University of Puerto Rico, Río Piedras, P.R.

³ Cancel, L. E., Rivera-Ortiz, J. M., and García-Rivera, F., Machine for separating coffee beans and berries from detritus, U.S. Patent No. 3,647,062, March 7, 1972.

⁴ Cancel, L. E., Rivera-Ortiz, J. M., and Ruiz de Montalvo, M. C., Separating and washing coffee harvested with plastic nets, *J. Agr. Univ. P.R.* 56(1): 11-7, 1972.

be of a size desired to accommodate the amount of coffee to be processed. Our bin holds 300 pounds of air-blown coffee. Coffee from the bin is fed by gravity into the feeding hopper and into the washing cylinder. The washing cylinder is composed of a partially perforated casing and a revolving spoked axle. The perforated casing consists of a solid upper half and a staggered slotted lower half (fig. 2). Perforations in the lower half of the cylinder are $\frac{1}{8}$ inch- \times $\frac{3}{4}$ inch-slots, side staggered, and length of slots parallel to the

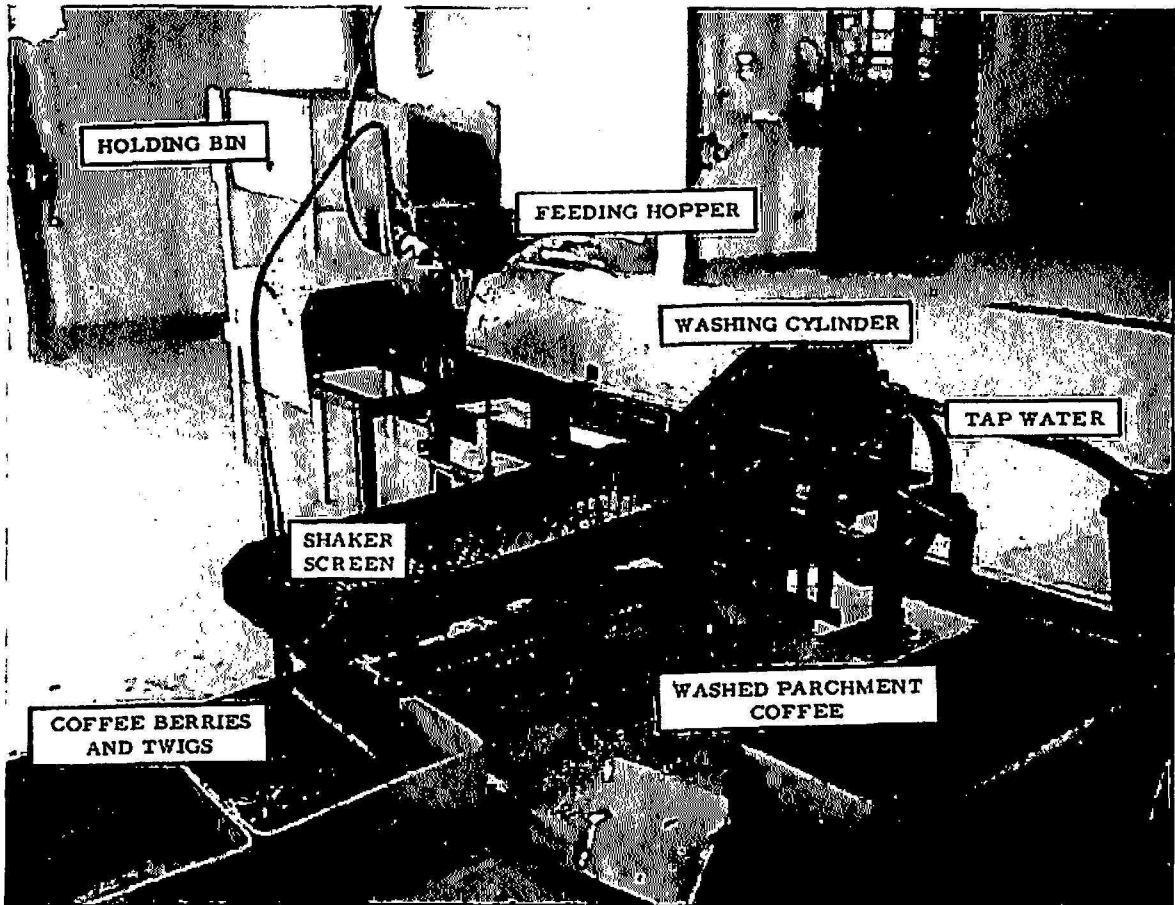


FIG. 1.—Original coffee washing machine.

length of the cylinder. The open area of the perforated surface is 43 percent.⁵ The revolving spoked-axle has three sections. The section below the feeding hopper is a one and one half flight screw which forces the material into the cylinder. Following is the spoked section of the axle which does

⁵ National Standard Company, Cross Perforated Metal Plant, Catalog C1-601, Carbondale, Penna., p. 17, 1962.

Trade names are used in this publication solely for the purpose of providing specific information. Mention of a trade name does not constitute a guarantee or warranty of equipment or materials by the Agricultural Experiment Station of the University of Puerto Rico or an endorsement over other equipment or materials not mentioned.

the braking, rubbing, and washing of the coffee. At the end of the axle—the discharging section of the cylinder—there are two diametrically opposed paddles which force the washed coffee out of the cylinder and onto the shaker-screen.

The shaker-screen is made up of a perforated metal sheet, slots $\frac{5}{16}$ inch \times 1 inch side staggered, length of slots perpendicular to the length of the

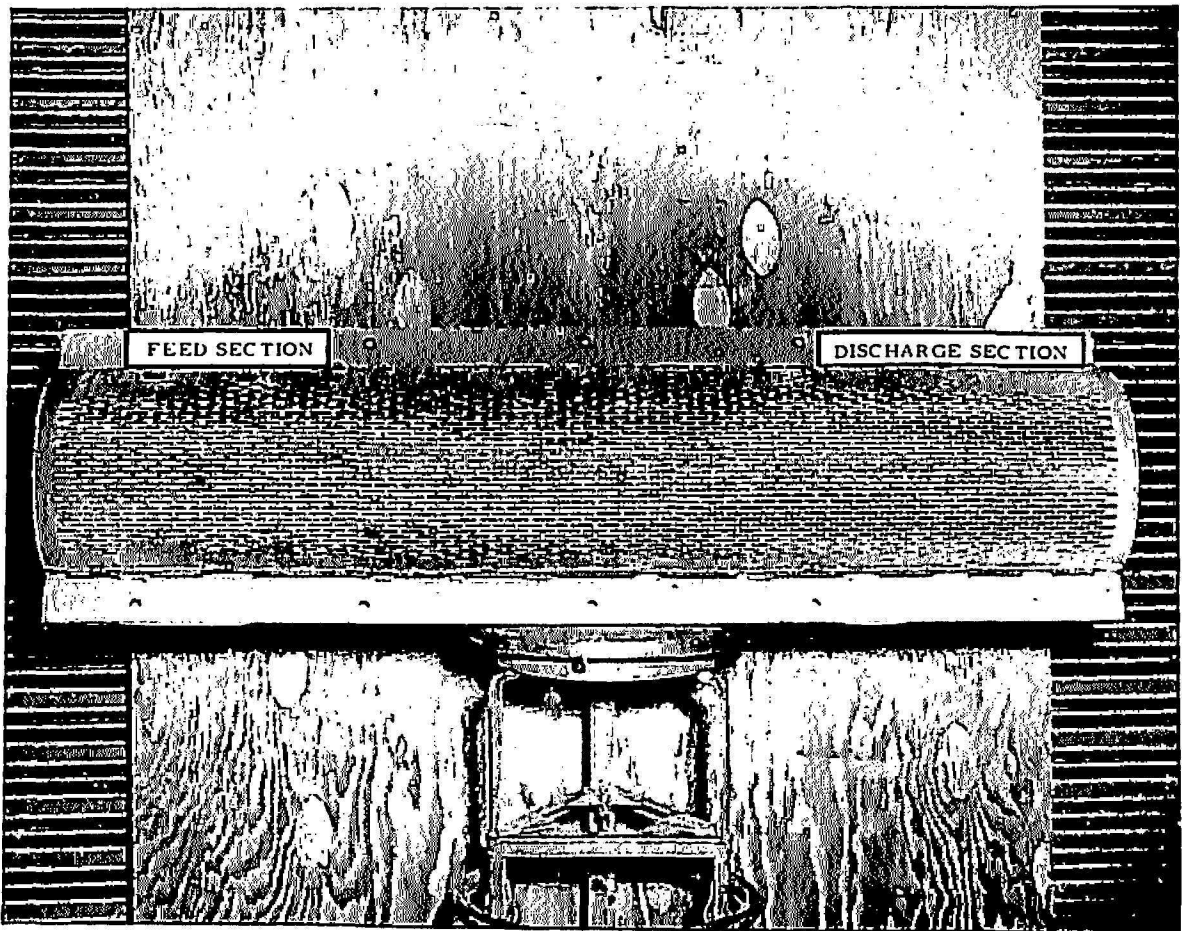


FIG. 2.—Lower half of perforated cylinder of washing machine, showing damage caused by some materials.

screen. The vibrating motion is 650 v/m decreasing with the load placed on the washing machine. The inclination of the screen is 0.5 inch per foot, with a recommended size of 5 feet long by 14 inches wide for a 36-inch washing machine. The coffee from the shaker screen drops into the flotation tank together with the small twigs that go through the perforations.

THE FLOTATION TANK

The flotation tank is placed just beneath the shaker screen of the washing machine (fig. 3). Its size depends on the size and type of opera-

tion. The flotation tank consists of a rectangular tank 66 inches long, 28 inches wide, and 22 inches deep. One of the sides is recessed 3 inches to permit the overflow of water in that direction. Opposite the recessed side there are water jets located 3.5 inches from the top of the tank and equally spaced along the length of the tank. These jets are fan shaped to spread the incoming water, thereby causing a side-wise movement of the water directed toward the recessed wall of the tank. This surface current carries

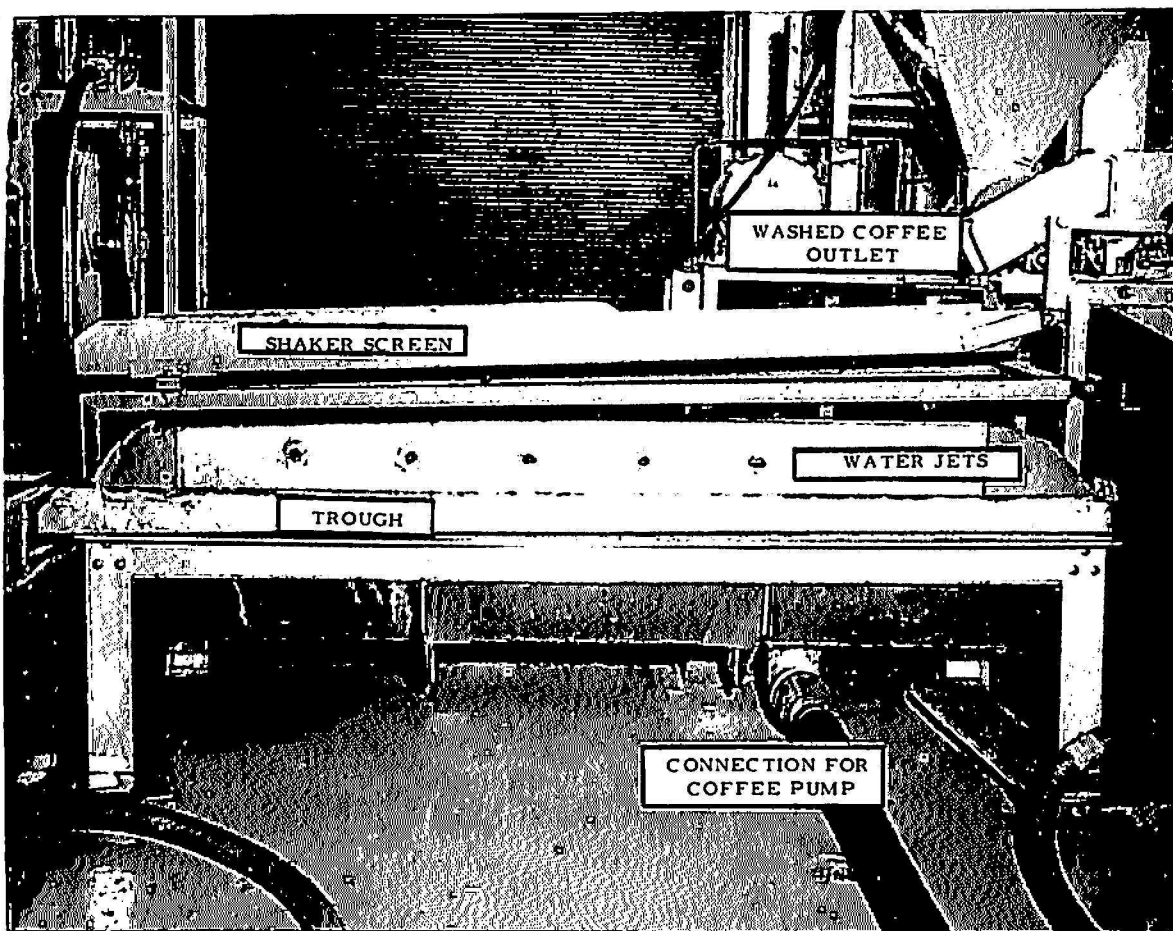


FIG. 3.—Position and construction details of flotation tank.

the floating material into a trough located on this side of the tank. The trough is 3 inches wide, the depth varies from 1.5 inches in the shallow part to 3 inches in the deepest part, and the slope is 0.18 inches per foot.

The floating material carried by the water through the trough drops into a screening tank. The screening tank is composed of a holding tank and a removable perforated container. The perforated container is made of aluminum angles and mesh to facilitate removal of twigs coming from the washed coffee. The holding tank serves as a reservoir to hold the overflow water. The water-holding tank is connected to the washing machine by a

water line so that overflow water is returned to the coffee washing operation (fig. 4).

RESULTS AND DISCUSSION

Several problems were encountered immediately in our studies with the washing machine available in the market. This machine was designed to

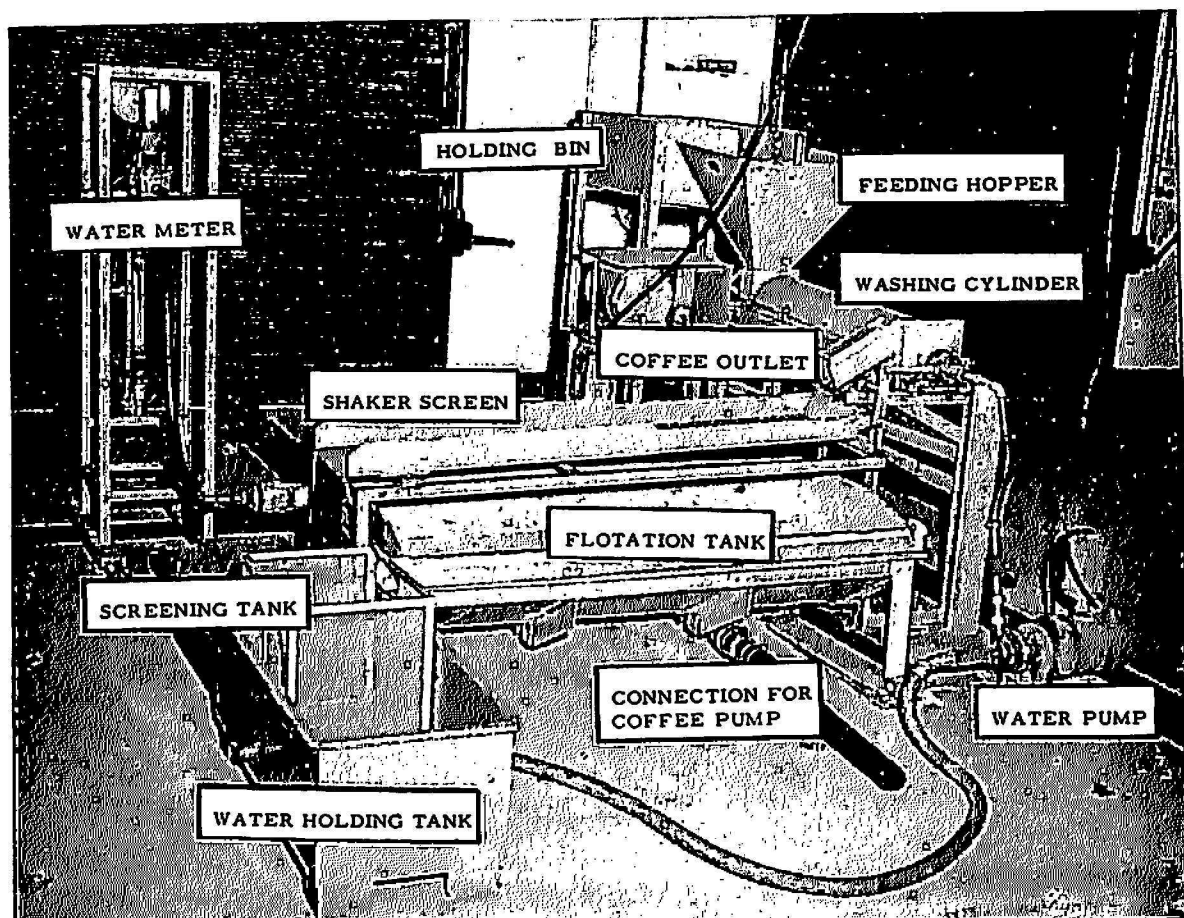


FIG. 4.—Arrangement of developed coffee washing system.

operate coupled directly to a coffee pulper to wash freshly pulped coffee beans.

The first problem was the small size of the feeding opening (3.5 inches \times 3.5 inches), which did not permit free flow of coffee beans, berries, some decayed leaves, and twigs of different sizes. To correct this problem the feeding opening was enlarged to 3.5 inches long by 6.5 inches wide. The enlarged opening permits a more satisfactory flow. Our experience now shows the opening should be as wide as the washing cylinder, that is, 10 inches wide by 3.5 inches long. The intake was not modified to the latter dimensions because the construction of the machine did not allow it. Such alteration would require total reconstruction of the washing cylinder.

As our studies progressed, it became apparent that the axle slats at the feeding end of the cylinder were hammering against the material which led to a large amount of coffee hulling at this point. To correct this problem the slats were removed and a one-and-one-half flight length of screw conveyor was constructed at that end of the axle. With this modification, hammering of coffee stopped and the material fed was forced immediately into the washing section of the cylinder, thus reducing coffee hulling.

The spokes of the cylinder, consisting of $\frac{3}{4}$ -inch iron rods, were covered with canvassed rubber tubing to cushion the impact of the spokes against the coffee beans. This modification also reduced the coffee-hulling action but increased the load on the electric motor.

No modifications were made to the discharge section of the cylinder and cylinder axle, although our 3 years of observation show the advisability of conducting additional studies to determine the proper size and shape of the slats that force the coffee out of the cylinder.

While working with this machine, several experiments were conducted with both the lower and upper half of the washing cylinder totally perforated. The results were not satisfactory as the extruded material was deposited and eventually caked on top of the cylinder. Another disadvantage was that the amount of water retained in the cylinder was insufficient and the washing action was diminished unless the water flow was increased.

An evaluation of the slotted metal used for the construction of the washing cylinder showed its deterioration at the intake section (fig. 2). This is caused by large stones and thick pieces of wood that come with the coffee material and are not removed by the coffee blower. Such deterioration will be eliminated by a new blower design recently developed,⁶ which removes all stones and pieces of wood larger than a coffee berry.

The washed coffee coming out of the washing cylinder flows into the shaker screen where the coffee berries and large twigs are separated and flow into a tank. The coffee beans and small twigs drop into the flotation tank. The motion of the shaker screen results in a dispersing action allowing the beans and twigs to fall separately into the water. This dispersing action eliminates the occlusion or dragging of the light material and twigs by the heavier coffee beans.

The flotation tank system was tested in two ways. Each system arrangement adapts to different farming situations in relation to size and availability of water.

In the batch system (fig. 5, without accessories 10, 11, 12, and 13), the flotation tank is large enough to hold a predetermined amount of washed

⁶ Cancel, L. E., New design for a machine to separate coffee beans and berries when harvesting with plastic nets, patent application under preparation, March 1973.

coffee which is removed periodically by the operator. In this system the overflow water carrying the floating material runs into a screening tank from which the water is pumped into the washing machine at the same rate it is fed into the floating tank. Using this system we washed from 800 to 1,100 pounds of wet parchment coffee per hour. The water consumption ranged from 600 to 700 gallons per hour (table 1). Variations in the ca-

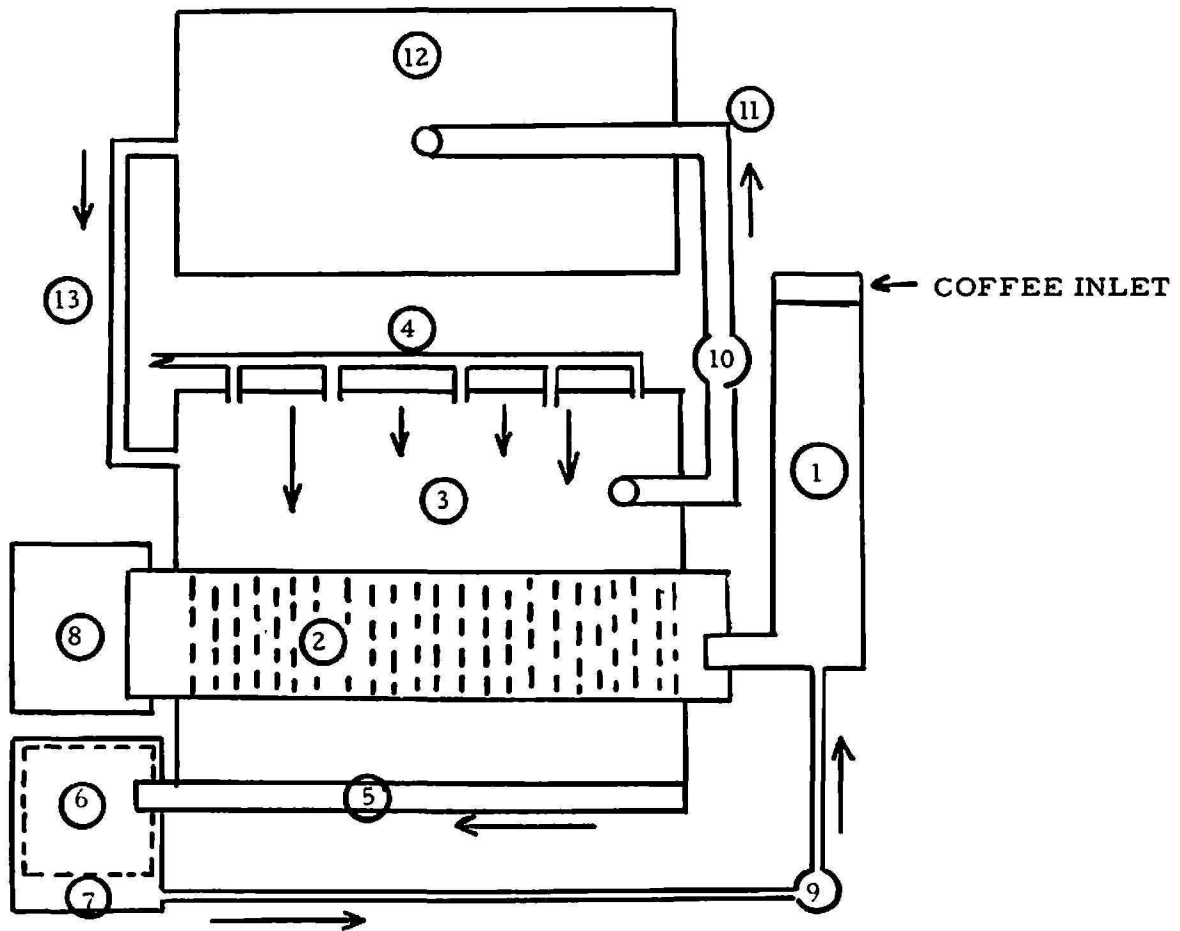


FIG. 5.—Diagram of coffee washing system with coffee draining platform. 1, Coffee washing machine; 2, shaker screen; 3, flotation tank; 4, manifold pipe with water jets; 5, collecting trough for overflow water and twigs; 6, screening tank; 7, water holding tank; 8, tank for coffee berries and large twigs; 9, water pump; 10, coffee transfer pump; 11, coffee transfer pipe; 12, coffee draining platform; 13, drained water return.

capacity of the washing system arise from the unavailability of a constant feeding accessory for the washing machine.

The compounded or continuous system (fig. 5) provides for continuous removal of washed coffee from the flotation tank and its deposition on a draining platform located well above the coffee dryers.

In this system the bottom of the flotation tank should be pyramidal or cone shaped with enough slope in the bottom to force the coffee beans into the tank outlet. The coffee is drawn off with a 3-inch pump to a draining

platform. The water from the draining platform is collected and piped back into the flotation tank to save water.

Results of experiments made to analyze the performance of this system are presented in table 1.

Observations made in the experiments undertaken during the last two coffee harvesting seasons show that coffee hulling during the washing operation is influenced by weather. Coffee material harvested during dry weather produces more hulled coffee during washing. This is due to the drying of the parchment and the bean inside. On drying, the bean inside shrinks and the parchment gets brittle, thus weakening the structure and increasing the probabilities of breakage on impact. Dried coffee beans also

TABLE 1.—*Evaluation of the flotation tank as a method for removing twigs from washed coffee*

Item	Experiment 1	Experiment 2	Experiment 3
Capacity: parchment coffee/hr.	850 lb	1,150 lb	800 lb
Water used	600 gal	680 gal	620 gal
Twigs floated out	4 lb 3½ oz	5 lb 4 oz	9 lb 6 oz
Twigs in washed coffee	4 oz	1½ oz	7 oz
Coffee in floated twigs	7½ oz	5½ oz	10 oz
Efficiency of flotation method ¹	94.4 pct	98.2 pct	95.5 pct
Coffee lost in flotation	0.39 pct	0.15 pct	0.27 pct
Parchment coffee (dry) ²	66 lb 8 oz	63 lb 5 oz	162 lb 4 oz

¹ (Twigs separated by flotation × 100)/(Twigs separated by flotation + twigs picked from dry parchment coffee) = Efficiency.

² Dry parchment coffee corresponding to sample used in analysis.

present a problem in the removal of small twigs by flotation. As dry parchment coffee has air pockets inside, it floats and is carried away with the twigs by the overflow water. Experiments show this dry condition can be eliminated by soaking the coffee material in water prior to passing it through the washing system. To avoid this problem the coffee material obtained from the blower was soaked overnight before washing. This reduced floated coffee to less than 1 percent as shown in table 1.

SUMMARY

Coffee harvested with plastic nets presents a new processing problem during the cleaning and washing operations. Leaves and light extraneous matter are removed during the processing by a blower leaving a manageable material containing coffee beans and berries in different stages of decomposition. To wash the coffee with a minimum amount of hulling and also reduce the amount of foreign materials to an acceptable level, a series of modifications were made to the commercially available coffee washer. The

washer was complemented with a flotation tank to make the washing system satisfactory.

The modifications consisted of enlarging the feeding opening, adding a one-and-one-half flight screw conveyor to the cylinder axle in the feeding end, and covering the axle spokes with canvassed rubber. The enlargement of the feeding opening permits continuous flow of coffee material into the washing cylinder. The screw conveyor section forces the material into the washing cylinder without hammering the coffee beans and reduces the coffee hulling action. Covering the axle-spokes with canvassed rubber diminishes the hammering action during the washing operation and also reduces coffee hulling.

A flotation tank under the shaker-screen of the washer separates twigs and light material not eliminated during the washing operation. The overflow water used in the flotation tank is recovered in a screening tank and pumped back into the washing machine thereby saving water. In a more elaborate system a draining platform is added. Coffee is pumped from the flotation tank to the draining platform. The water drained is collected and piped back into the flotation tank.

This washing system handles from 800 to 1,100 pounds of wet parchment coffee in 1 hour. The amount of water required varies from 600 to 700 gallons per hour. The removal of twigs is performed with 96-percent efficiency. When the flotation operation is conducted as suggested, the coffee that floats out is less than 1-percent.

RESUMEN

El café recogido en mallas plásticas presenta un problema nuevo en la fase del lavado durante el proceso del beneficiado. El material que se recoge en las mallas se pasa por un separador a base de aire, el cual remueve las hojas y otros objetos livianos dejando una mezcla de café pergamino y café uva en diferentes estados de descomposición. Para reducir la cantidad de café pilado y eliminar la materia extraña en el café lavado fue necesario modificar la lavadora comercial disponible en el mercado local. Para llevar a cabo la operación del lavado en forma satisfactoria se añadió un tanque de flotación al sistema.

Las modificaciones que se hicieron con resultados satisfactorios fueron: la ampliación de la apertura para la alimentación, la incorporación de una sección de tornillo alimentador al eje central del cilindro y la colocación de tubos de goma reforzada en los rayos del eje central. La ampliación de la entrada para la alimentación permite el flujo continuo del material. Para que opere mejor ésta debe ser del ancho del cilindro del lavado. La sección del tornillo alimentador colocado a la entrada elimina el martilleo del café y reduce la cantidad de café pilado. Este sistema de alimentación per-

mite también una alimentación forzada y continua al cilindro del lavado. Al forrar con goma reforzada los rayos del eje central se reduce el efecto del martilleo sobre el café pergamino y por consiguiente la cantidad de café pilado.

El tanque de flotación añadido al sistema fue colocado debajo del cedazo de la lavadora. La dispersión que lleva a cabo el cedazo al vaciar el café lavado en el tanque de flotación facilita la separación de los palitos y el material liviano, ya que elimina su arrastre. El material flotante que cae al agua es arrastrado hacia el lado por una corriente superficial de agua desbordante. Esta y el material arrastrado caen a una chorrera que conduce a un tanque separador. El agua separada en este tanque se bombea a la máquina lavadora, permitiendo su uso de nuevo para el lavado. En un sistema de lavado más elaborado se añade una plataforma para escurrir el café. El café lavado que se sedimenta en el tanque de flotación se bombea a la plataforma que sirve de escurridero y el agua separada se devuelve por medio de una tubería al tanque de flotación.

Mediante este sencillo sistema arriba descrito pueden lavarse de 800 a 1,100 libras de café pergamino húmedo por hora. El consumo de agua en estas pruebas varió de 600 a 700 galones de agua por hora. La remoción de palitos se llevó a cabo con un 96 por ciento de eficiencia. Cuando la operación del lavado se llevó a cabo en la forma indicada las pérdidas ocasionadas por la flotación fueron menos del 1 por ciento.