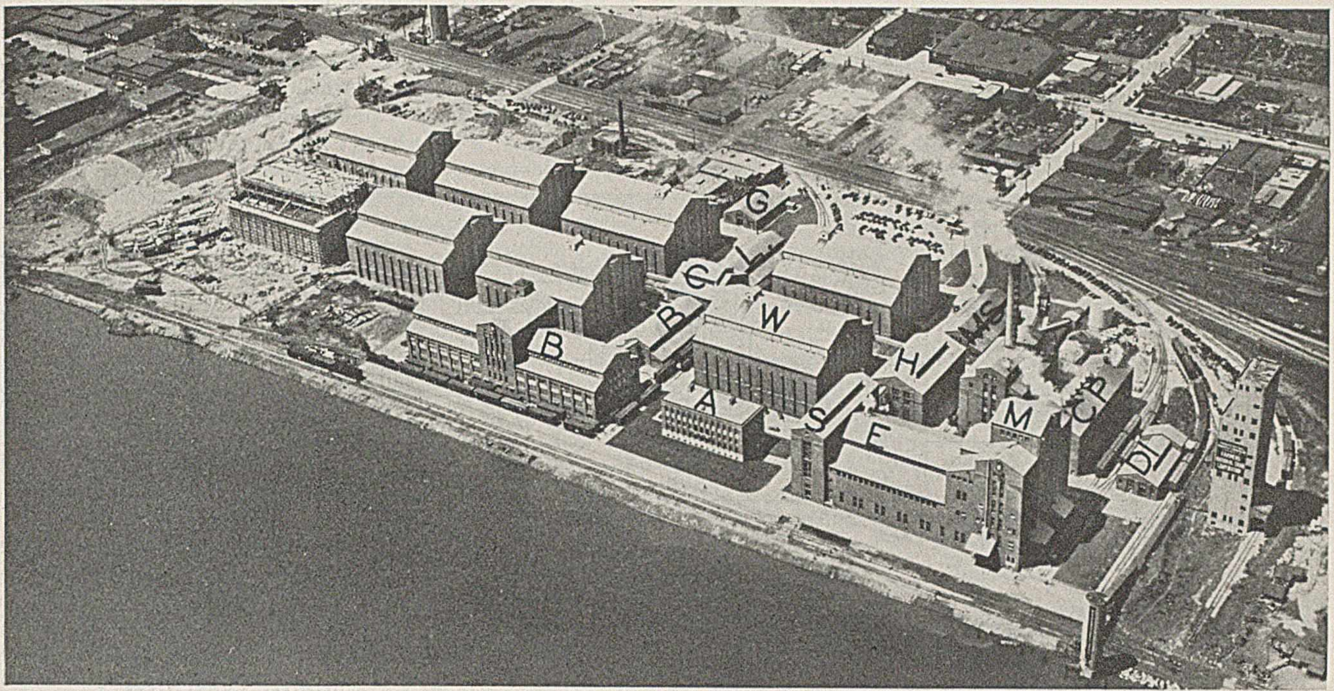


Figure 1. Distillery of Hiram Walker & Sons, Inc., Peoria, Ill.

M. Mill
E. Fermenters
S. Stills
A. Administration
B. Bottling
DI. Solid carbon dioxide
CP. Cereal by-products
H. High wines
W. Warehouses, eight in two rows
C. Cistern and shipping
BL. Barreling
MS. Machine shop
G. Garage

DISTILLERY BY-PRODUCTS

L. C. COOLEY
7438 Kingston Avenue, Chicago, Ill.

DISTILLERY by-products from a grain distillery are carbon dioxide, which will be reserved for separate treatment, and stock food or distillers' dried grains. The importance of the latter can be judged by the output and value. The output of the plant to be described here is approximately 150 tons daily. To produce such a quantity calls for an investment in buildings and machinery of almost $2,-000,000, a steam consumption of nearly 4,500,000 pounds daily, and a water consumption of around 5,500,000 gallons. The amount of raw material (corn, rye, and malt) required in a distillery producing 150 tons of feed daily is 20,000 bushels or 560 tons, and the alcohol yield is from 100,000 to 104,000 gallons of 100-proof alcohol (*1*, *2*). The value of distillers' dried grains varies from $17.00 to $30.00 per ton.

Historical Review

Prior to prohibition the methods of recovering values from grain distillery wastes were, in principle, much like the methods used today except that the machinery now has a greater capacity per unit, takes a little less steam and water, and requires less labor. In order to remove alcohol from the fermented grain mash, dealcoholizing columns or beer stills were and are now used, with open steam jets in the bottoms and condensers at the tops for alcohol and water vapors. The condensed steam, spent grain, and most of the mashing water came out of the bottom of each beer still at a concentration of about 4.8 to 6.0 per cent total solids (suspended and dissolved) and ran to the sewer or was treated in one of three ways. The waste, called "distillery slop" or "spent mash," was often screened, and the screenings were sold wet or dry for stock feed, or the liquid from the screenings was evaporated to a sirup and added to the partially dried grains for further drying. Thirdly, and as practiced in many distilleries, the water and spent grains were run down through troughs to which were chained thousands of head of cattle being fattened on the trip from the western ranges to the market.

The objection to dumping spent mash in a stream is that it seriously depletes the oxygen there and thus destroys fish. Where the waste material becomes deposited on the banks or on a sand bar, decay sets in and the odor is objectionable.

In cases where it was permissible to dump the liquid from the screenings into the sewer or where the sanitary authorities attempted to stop all dumping, the arguments which followed involved the question of what it cost to evaporate and dry the residue in the liquid.

If the liquid could be dumped into the sewer, leaving the screenings to be dried, nearly 85 per cent of the steam cost could be saved and practically all of the water cost. The investment for building and equipment would be cut in half, the labor saving would be about 70 per cent, and the amount of feed produced would be approximately half.

Since repeal local boards of health often prohibit the feeding of dairy cattle with spent mash by the old methods so that distillers are forced to assume the expense of recovering all the solids. Except in very small distilleries or where the laws do permit dumping into streams or large bodies of water, it is necessary to screen, evaporate, and dry the solids in the spent mash.

der of the screen length the baffles scrape the partially drained grain over the screen so that it finishes draining as much as possible before it falls off the end of the screen into a deep copper hopper. Each screen is nearly 8 feet wide and 25 or 30 feet long, and is made of stainless-steel plate with 1-mm. holes

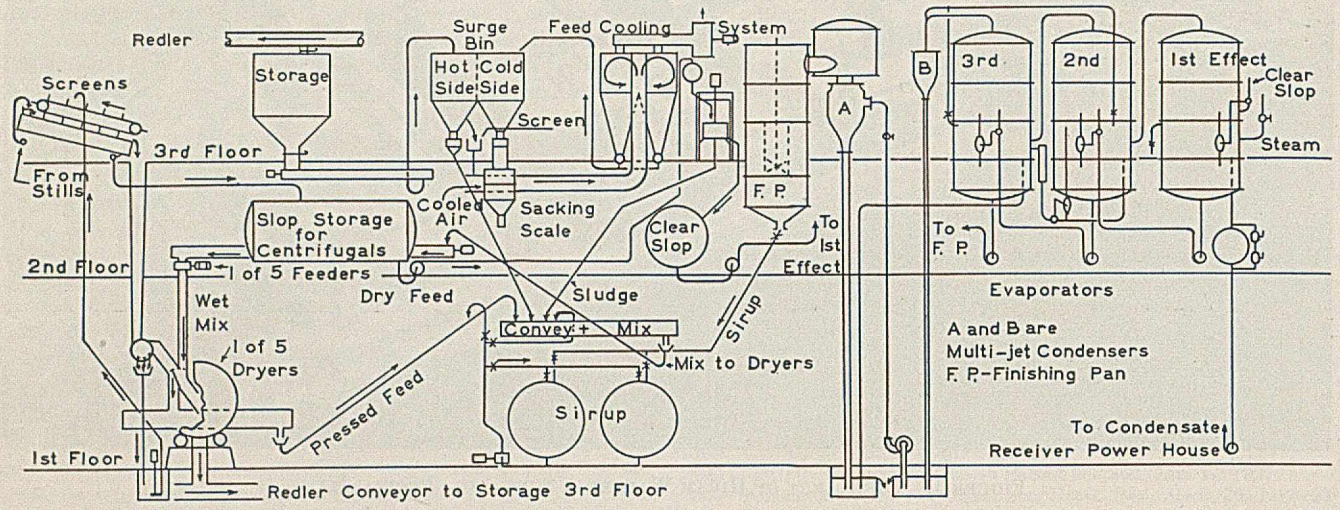


Figure 2. Flow Sheet of Equipment in Cereal Products Division

Modern Practice

One of the most modern and best equipped plants for the recovery of by-products from grain distillery waste is the Cereal Products Division of Hiram Walker & Sons, Inc., at Peoria, Ill. (Figure 1). The building is three stories high, built of steel, concrete, and brick and consistent in architecture with the design of the whole distillery. The equipment is arranged at elevations and in the sequence indicated by the flow sheet (Figure 2). The spent mash enters the system by a pipe shown in the upper left-hand corner of Figure 1.

The stillhouse where the spent mash originates has four beer stills and a three-chamber periodic still. Each still is equipped with a walking-beam pump with variable stroke. The cylinders are arranged in pairs, each pair having a motor and speed reducer. One cylinder of a pair is used to pump beer feed to the top of the column; the other, possibly with a slightly different length of stroke, removes the spent mash from the bottom section of the still and forces it through two copper pipe lines approximately 400 feet long to the top floor of the cereal products building.

Screens

On the top floor of the cereal products building are five sloping screens set in boxes which are provided with a distributing weir at the top or head end into which the mixed liquid and solid spent mash is fed by a pipe from a three-way bronze cock; there is one of these cocks in each of the two mains. In this way feed can be taken from either main to one screen. The spent mash overflows the weir and passes down the screen; it is restrained from rushing down too fast by moving baffles which impede the flow during the first 5 or 6 feet of its passage and form small pools back of each moving baffle so that the liquid has time to drain through. Over the remainder of the screen length the baffles scrape the partially drained grain over the screen so that it finishes draining as much as possible before it falls off the end of the screen into a deep copper hopper. Each screen is nearly 8 feet wide and 25 or 30 feet long, and is made of stainless-steel plate with 1-mm. holes throughout its length. The liquid which passes through the screens runs down the bottom of the sloping box on which each screen is supported and passes out at the end through a copper drain to a storage tank on the second floor.

The feed to the screens may be a maximum of 43,000 gallons per hour, equivalent to 1070 bushels of grain. The normal load is about 30,000 gallons hourly. The total solids in the spent mash vary in amount with the method of preparing the mash. Ground grain is mashed with warm water after cooking and cooling (*2*), or a portion of the warm water may be replaced with cooled screen effluent from the screen effluent storage tank up to 30 per cent of the volume of a fermenter. Using screen effluent increases the proportion of solids in spent mash up to possibly 6 per cent. Effluent from water mash may have as little as 4.5 per cent. The solids retained on the screen are grain hulls, proteins, unfermentable substances, and some dead yeast cells. The temperature of the spent mash leaving the stills is approximately 220° F. so that it flashes as it is discharged from the feed pipe into the screen weir box and gives off a large amount of vapor during its passage down the screen. For this reason, above each screen is a transite hood connected to a fan-exhausted ventilator. The liquid leaving the screens cools to 196° or 190° F. and contains about 3.6 per cent total solids.

The original screens were made of thin Muntz metal plate but were replaced by stainless steel.

Presses

After the drained grain, with about 80 per cent water, has fallen into one of five copper hoppers, it feeds directly into one of five rotary presses erected on a balcony just under the second floor. The presses are built of a special alloy with stainless-steel perforated plates and rotate at about 5 r. p. m. although the speed range is from 1 to 7 r. p. m. A 10-horsepower motor is used. The capacity varies with the dryness of the output. At 80 per cent water these presses take 9000 pounds each per hour and put out 6300 pounds containing 65 per cent water. Capacity is controlled by the dryer operator who changes the speed reducer to as many points as are required to keep the hoppers nearly full without flowing over on the floor. The feed to the screens and hence the amount of solids to the presses is not necessarily uniform in solid content because of shutting down or starting some of the stills during the operation of the others. Each point on the press speed reducer is equivalent to an output of nearly 900 pounds of wet grain. The liquid effluent contains about 2.8 to 3.1 per cent solids at 180° F. and is run into a tank and mixed with recovered grain from the dryer dust collectors into a slurry and pumped over the screens again.

Centrifugals

If the process were conducted without evaporators but merely with screens and dryers, the next step would be for the pressed feed to fall through a chute into a dryer. However, the need for complete recovery of all the solids in the spent mash calls for evaporation of the effluent from the screens. During the building of the new distillery, development work on waste recovery was carried on at a temporary distillery in Peoria where methods of waste disposal were studied by the research department. It was finally discovered that by passing the screen effluent through centrifugals, a small percentage of material could be removed which would leave a clarified effluent in such condition that its viscosity when evaporated to about 50 per cent solids was not greatly different from that of screen effluent evaporated to 25 per cent solids but without centrifuging. The use of centrifugals is one of the most progressive steps which has been taken in the recovery of distillery wastes. Instead of sending sirup to the dryers with 25 to 27 per cent solids and the balance water, sirup is mixed with wet grain starting with 42 and as high as 60 per cent solids. The steam required to evaporate a pound of water in the dryers is about 1.3 pounds. In the evaporators about 0.26 pound of steam is required to remove a pound of water under the most favorable conditions, and 0.4 pound at other times; therefore it pays to concentrate the sirup as highly as possible in the evaporators and leave less work to be done in the dryers. This ideal is accomplished by centrifuging the screen effluent before evaporating it.

There are twelve centrifugals. Eight of them operate at 800 r. p. m. with 20-horsepower motors, and four operate at 900 r. p. m. with 25-horsepower motors.

The centrifugals are constructed with 40-inch-diameter bronze baskets without perforations and with stainless-steel shells (Figure 3). The bulged head of the overhead constant-level feed tank can be seen near the top center. In Figure 4, on top of the centrifugal a horizontal shaft is shown at the right with two pairs of lock nuts and a handwheel. This is the skimmer which removes the thin layer of fluid from the sludge cake after a batch is spun. The large handwheel at the left raises or lowers the discharging plow which is swung into or out of the cake by the short lever. Feed to the centrifugal is controlled by the valve and long handle shown near the center of Figure 4. As a safety measure all the centrifugal driving shafts were surrounded by sheet brass sleeves supported from the feed pipe as shown. The brake drum and lever appear near the top of Figure 4.

Two men operate the centrifugals, working 8-hour shifts. The screen effluent is stored in a copper tank on the second floor and is pumped to the constant-level feed tank by one of two bronze centrifugal pumps. If the level begins to rise as indicated by gages on the centrifuge platform, additional machines are put into service or the operating cycles are

FIGURE 3 (*Above*). CENTRIFUGALS

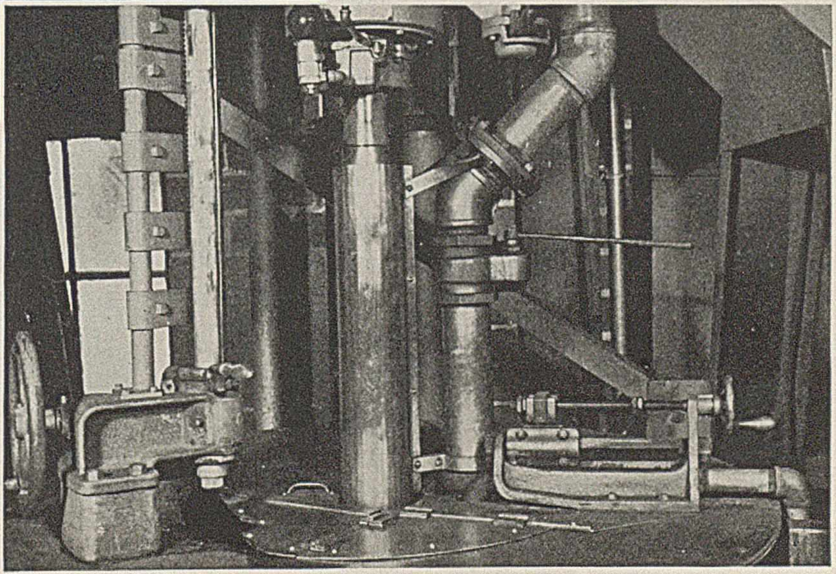


FIGURE 4 (*Right*). CENTRIFUGAL DETAILS

lengthened slightly. Normally a centrifuge is run about 60 minutes, including time for bringing it up to running speed, braking down after filling, and then dumping. The cake of sludge accumulates on the horizontal ring baffles and against the wall of the basket. After the feed is shut off a few minutes, running brings a layer of thin slop to the surface which is siphoned off by a pipe. Then the speed is reduced by push-button control to about 50 r. p. m. for unloading. In fact, the momentum of the load is used to keep the basket revolving during the unloading period so that the operator merely jogs the switch occasionally to keep the basket turning at the right speed while he manipulates the unloading plow which reaches into the cake and removes the sludge to the open center of the basket. The sludge, which contains about 80 per cent water, falls to a brass conveyor and is later mixed with dry feed and sirup. The effluent from the centrifugals, having changed in solid content from 3.7 per cent (screen effluent) down to about 3.2 per cent, has also cooled to about 150° or 160° F. and is stored in a copper tank on the second floor, which is provided with a remote level-reading gage.

Evaporators

The evaporator plant consists of six cast-iron bodies with copper tubes, tube sheets, and central downtakes, and is erected on the third floor. Final concentration is accomplished in a cast-iron finishing pan equipped with a mechanical circulator in the central downtake, and with copper tubes and tube sheets. The vapor piping is so arranged that the six bodies can be operated as two triple effects, the finishing pan being heated by direct low-pressure steam or by vapor from either first effect or by both. When the load from the stills is light enough, the bodies can be operated as a quintuple effect, using one or both first effects to heat the second effect. The finishing pan is heated in the same manner as when operating with two triple effects. Another advantage of the quintuple effect is that it saves water as well as steam, since only one condenser needs to be operated. Condenser water from the two third effects at about 90° F. is pumped to the finishing-pan condenser, the great quantity (about 3000 gallons per minute) overcoming the disadvantage of the high injection temperature. The temperature rise is about 20° to 25° F. The two condensers on the triple effects have steam-jet air ejectors which use about 400 pounds per hour of 250-pound pressure steam in two stages. No jets are used on the finishing-pan condenser. The use of air ejectors saves a total of about 1500 gallons of water per minute.

Four technically trained operators work in three shifts, so arranged that one man works 6 days and is off 56 hours. In this manner the evaporators are always being operated or cleaned throughout a 7-day week.

Operating control is made positive and simple by indicating and recording thermometers, and by effluent and steam flowmeters arranged on a panel board standing near the first effects (Figure 5).

On the vertical center line below the clock is a two-pen chart which records the temperature of the water into and out of the condenser on the finishing pan. At each side are liquid-level gages showing the level of screen effluent and of clarified screen effluent. On each side of and between the liquid level gages are ten small panels with starting and stopping buttons and indicator lights for the feed, condensate, and transfer pumps. In the two outside glass-covered circles are the integrators showing total pounds of condenser water to each triple-effect evaporator, known as the north side and south side. Above in the next horizontal row are four charts. The two nearer the center show the rate of flow of water to each condenser. No rate is shown to the finishing-pan condenser; the amount of water is controlled by a 10-inch gate valve and is varied only enough to maintain as high or low a vacuum and consequently as high or low a temperature in the finishing pan as is required to keep the viscosity of the sirup from increasing too much for the evaporative capacity of the pan. One of the water rate charts has a pressure-recording pen. The two outside charts are three-pen charts. One pen shows the steam temperature in each first-effect steam chest, one pen shows the rate of flow of steam, and the third pen shows the rate of flow of liquid to each first effect. In the name plate above each outside chart is a small dial showing the reading of the integrator of the feed meter. Nearly on a level with the clock are two charts with two pens each. One pen gives the temperature of the vapor to the third-effect condenser and the other the temperature of the condenser leg pipe.

Figure 6 shows the finishing pan, condenser, and panel board. On the vertical center line and near the bottom of the panel is a recording ammeter by which the operators accurately judge the condition of the sirup. The six switch panels and lights above the ammeter control the operation of two cleaning-fluid pumps, the main agitator motor for the finishing pan, the water supply to the finishing-pan condenser, and two pumps for transferring 25 to 30 per cent sirup from either third effect to the finishing pan. Mounted on the finishing pan is a large Bourdon gage indicating vapor pressure in the finishing-pan steam chest, and near the ladder is a mercury U-tube for indicating vacuum or pressure. This gage is piped to several parts of the finishing pan, catch-all, condenser, and third effects in order to study pressure conditions when leaks or other troubles are suspected.

The feed entering the triple effects has about 3 or 3.2 per cent solids, and the concentration in each body is about 4.5, 8.0, and 25 per cent, respectively. The operating temperatures are first-effect steam 250° F., vapor 225°, second-effect vapor 195°, third-effect vapor 125°. The maximum steam consumption when running both triple effects and

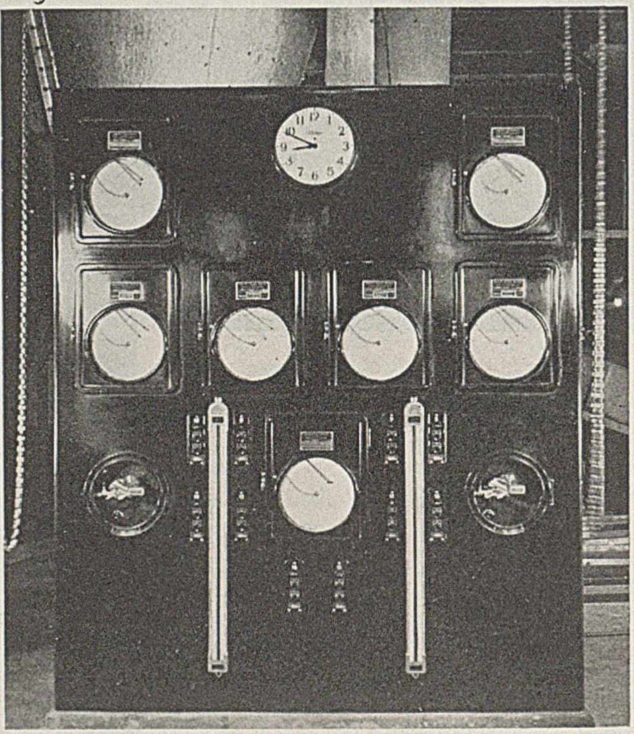


FIGURE 5. EVAPORATOR GAGE BOARD

finishing pan is 132,000 pounds of steam per hour, and the evaporation per pound of steam is about 2.3 pounds, feeding clarified screen effluent at 140° F. When running quintuple effect, the evaporation per pound of steam is about 3.5 pounds, and the amount of steam used is 60,000 pounds per hour. These figures apply when evaporating clarified screen effluent from bourbon mashes which are mostly of corn with but little rye. On all-rye mash, which is seldom run, the operation is much more difficult; the screens have less capacity and the viscosity rises in the evaporators with small increases in concentration. Occasionally mixtures of corn and rye are used with rye slightly in excess, and then the operation of the equipment is not badly upset, although reduced in capacity.

The operating conditions when running as a quintuple effect are steam 244° F., first-effect vapor 226°, second-effect 216°, third-effect 194°, fourth-effect 176°, fifth-effect 128°. Vapor is being taken from the first effect to the finishing pan at this time, and the temperature of the steam side of the finishing pan is 222° F., vapor side, 132°. The injection water to the quintuple-effect condenser has a temperature of about 55°, and the down-leg temperature is 90° to 95° F. The finishing-pan condenser has a water inlet temperature of 90° and a leg temperature of 110° F.

Low-pressure steam (20 pounds per square inch pressure) is provided either by reducing valves from the boiler main or by the exhaust from the turbines, and is carried through a 20-inch main to the evaporators. The condensed steam from each first effect is pumped back to the powerhouse from a condensate receiver, 4 feet in diameter and 6 feet long, with a steel diaphragm in the middle vertically so that each first effect is served by its individual receiver, one in each end of the tank. Each end is provided with two floats actuating electric switches which stop or start the pump motors as required for maintaining a minimum volume of condensate in the receiver and consequently a nearly constant head on each pump. The pumps are located on the first floor, 20 feet below the receiver.

The condensate in each second effect passes through a float-controlled valve to a flash pot which admits the mixture of vapor and hot condensate to the steam chest of the third effect from which a barometric leg removes the condensate to a hot well below the first floor. A float chamber connected to the second-effect steam chest controls the valve which admits condensate to the flash pot. As the flow of condensate from the second effect increases, the level in the float chamber rises and opens the valve enough to take care of the increased flow, or vice versa.

Feed to either first effect is controlled by a float chamber which operates according to the change in level of the liquid in the first effect. A rod from the float chamber operates a 4-inch globe-type valve in the feed line. Feed from body to body is regulated by float-controlled valves, but, instead of relying on the difference in pressure which exists between each body and the next one, a pump is used to transfer the feed. If a larger pipe were installed, it might be possible to transfer the feed without pumps, but then fluctuations in body pressure would be added to other variables and would oppose smooth regulation. The feed flows parallel with the heat from the first effect to the last on account of the character of the material being handled.

The flow of steam is controlled to each first effect by a 12-inch globe valve, around which is piped a smaller globe valve used to control the pressure closely and which is also used during cleaning periods when only a small amount of steam is required and damage to the 12-inch valve from wire drawing can be avoided. The original installation using an 18-inch gate valve with chain wheel and chains was too laborious to handle and not adaptable to throttling conditions.

The finishing pan has to be operated in batches because the coefficient of heat transfer at 42 to 60 per cent solids is so low that the pan cannot carry the required load when operated continuously at such a high density. Feed is pumped into the finishing pan from either of the last effects as nearly as possible in a steady stream, keeping a constant level. At a certain ammeter reading indicated by practice, the feed is reduced or shut off completely, and the pan is boiled down, the vacuum is broken, and the sirup is sampled and dumped quickly through a large gate valve out of the cone bottom into one of two heavy sirup tanks on the first floor. The heavy sirup tanks are of steel, provided with coils which are supplied with low-pressure steam (3–10 inch vacuum) in order to keep the sirup at a fluid temperature. As another precaution, the sirup is circulated constantly by pumping with a heavy bronze steam magma pump from the bottom of a tank back into the top of it. In order to keep track of the amount of sirup made and used, one tank is used for receiving sirup from the finishing pan and the other to supply the mixing system with sirup. When one tank is filled, the other is empty; then the valves are switched and the roles reversed.

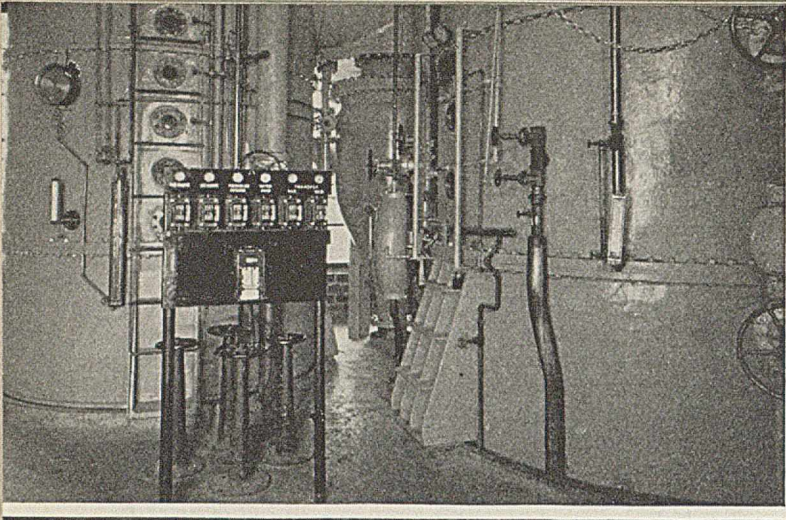
It takes about 5 minutes to empty the finishing pan. Then the bottom valve is closed, the water pump to the condenser is started which exhausts the air from the pan, and the pan is filled from the third effects.

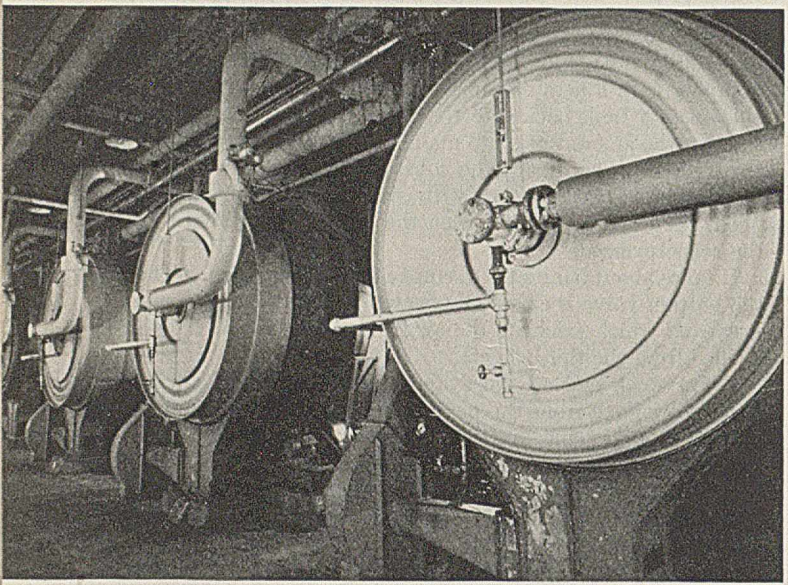
Every week end all the evaporator bodies are cleaned in order to remove from the heating surfaces the small amount of scale and organic matter which accumulates during the week and which seriously reduces the capacity during the following 4 days if not completely removed. A regular cleaning schedule has been developed which calls for a hot water rinse and short boiling period, then a boiling period of 3 hours with a chemical solution, followed by a water rinse. The amount of alkali is surprising which can remain on the heating surface and neutralize some of the descaling acid bath which follows. The acid solution is about 0.5 per cent hydrochloric. In order to avoid handling too great a volume of chemical solution, the bodies are washed consecutively, the two first effects being pumped out into the two second effects, etc., and finally the solutions are pumped into the finishing pan. The concentration of the cleaning solutions is maintained by adding more chemical when need is shown by titrating a sample with a pH indicator. In order to remove the scale completely, it is essential to keep up the chemical concentrations.

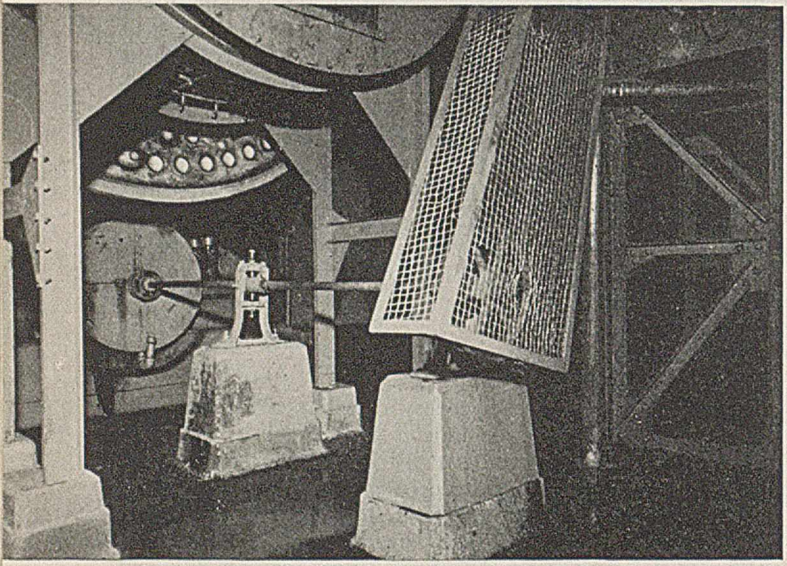
Conveyors

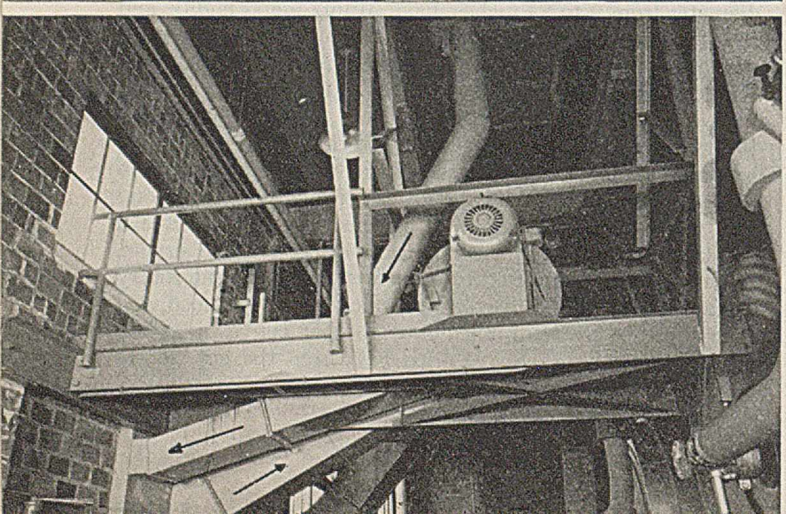
Involved in complete recovery of solids is the need for drying the sirup, which is difficult to accomplish; the sirup should be spread out thin on dry feed while being carried through the dryers. This process requires a long and expensive conveying and mixing system. In all, there are 500 feet of Muntz metal conveyors. The conveyors vary in diameter from 9 to 24 inches, have Muntz metal flights, and are driven by a total connected load of 300 horsepower, using gear-head motors. Muntz metal is used to withstand the corrosion of the moist feed. In order to preserve good sanitary conditions, the entire recovery system from screens to dryers is carefully cleaned every week end. The cleaning job takes about 12 or 14 hours, and eight men are required to scrape the conveyors and flights, sweep and hose the floors, and wash the centrifuges and screens. Two men have a regular Sunday job of cleaning and inspecting the dryers.

The conveyors are used to carry wet feed from the rotary presses up a sloping conveyor into which sirup is pumped, and then the mixture is dropped into another conveyor at the second floor which receives dried feed from the hot side of









(Reading from top to bottom)

FIGURE 6. FINISHING PAN, GAGE BOARD, THIRD EFFECT

FIGURE 7. FEED OUTLET—STEAM INLET ENDS OF DRYERS

FIGURE 8. FEED INLET END OF DRYER

FIGURE 9. BULK FEED LOADING FAN

the surge bin (Figure 2), and also sludge from the centrifugals. The combined load is then carried to a stationary stainless-steel mixer just above the first floor which is provided with paddles and cut flights mounted on two shafts. From the mixers the load of wet and dry feed, sludge, and sirup is carried back to the second floor to another conveyor which distributes a portion for each dryer through bronze vane feeders operated by variable-speed drives to Muntz metal chutes down to the dryers on the first floor. If at some time the vane feeders do not take from the distributing conveyor all of the mixture, then the excess is carried back to the head end by additional conveying equipment until the operator in his regular rounds discovers the condition and alters the drives on enough vane feeders to redistribute the excess. All the conveyor motors are wired to operate in sequence with one another and with the presses and feeders, so that if any one unit is obstructed with foreign material, the conveyors leading up to it "kick out" and a Klaxon sounds an alarm.

Dryers

Steam for the dryers is taken directly from the 250-pound main at 100° F. superheat through a reducing valve at 125 pounds per square inch to a header in the dryer house for distribution to each dryer after desuperheating.

There are five steam-tube rotary dryers (Figures 7 and 8). Each dryer has a steel shell which is 8 feet 6 inches in diameter and 26 feet 8 inches long, and is lined with large boiler tubes. Through the center of each dryer is built a steel mandrel which is steam-jacketed and which heats the grain falling on it and also the air blown through it. The dryers rotate at about 6 r. p. m. and are driven by 20-horsepower motors through back gears. Heat is supplied by 125-pound steam through rotary joints (Figure 7), and the condensate passing through traps, flashes to the 80-pound steam supply. At maximum load one dryer can remove 6000 pounds of moisture per hour. Air is blown through the dryers by forced and induced draft fans, the former blowing through steam-heated coils and the latter taking the moisture-laden air through a large transite duct near the roof. There are two induced-draft fans, one at each end of the duct, and each has a capacity of 80,000 cubic feet per minute. To withstand the corrosive vapors, they are built of special materials. Vapors reach the duct from the dryers through five rectangular stacks which carry air and dust to large dust-catching chambers, each of which is connected to the duct. The air to the dryers at about 294° F. passes through the mandrel to the end of the dryer and then back over the grain and tubes to the stack, issuing at about 160° F. and saturated. Feed falls out of the dryer at about 180° F. to a Redler conveyor which runs at about 94 feet per minute in a pit under the first floor and which carries the feed up above the third floor over the feed storage bins.

Before the Redler conveyor was installed, the feed from each dryer was blown by a fan up to a storage bin. This system required 110 horsepower more than the Redler conveyor and was subject to rapid deterioration in fans and piping, due to the sandblasting effect of the feed.

The dust collectors are chambers about 15 feet long, 8 feet wide, and 8 feet high, built with transite walls sheathed with copper and with copper floors. Water-flooded copper eliminator plates are built opposite the vapor and dust inlet; in the rest of the space the reduction in velocity allows practically all the dust to settle. A constant stream of water is sprayed on the floor of each dust collector to wash out the dust. The washings are run over a vibrating screen which drops the feed into the slurry tank previously mentioned. The continuous washing system is estimated to save 15 dryer hours daily in addition to reducing an appreciable amount of water which went to the evaporators with the former system of washing out the dust collectors several times daily with a hose. Under the latter system the opening of a dust collector for cleaning cut down the draft through the dryer and thus reduced its capacity.

The five storage bins are built of sheet steel with sloping bottoms to permit the feed to slide out to vane feeders for passage to the conveyor just under the third floor, which carries the feed to the shipping system. In order to reach the shipping system, the feed is carried to a high-speed bucket elevator which raises it to a surge bin on the third floor. The surge bin is divided into a hot and a cool compartment. The hot compartment supplies part of the feed which is needed as a "carrier" for the sludge and sirup through the dryers. Some carrier feed is also taken directly from the Redler conveyor before it goes to the storage bins. Feed which is to be shipped passes out of the hot compartment over a shaking screen to separate flaky feed from balls which are damp and dry out to hard pills. The balls are crushed or rolled flat so that they will dry easily and are sent on with the carrier feed; the flakes are dropped into a cooled air stream which is drawn up into two deep cyclone separators, the feed being cooled during this passage until it is suitable for sacking without danger of spontaneous combustion. The air from the cyclone separators goes to a fan and then out through a water-spray dust scrubber. From the bottom of the deep cyclones the cooled feed is conveyed to the cool compartment which supplies two weighing and sacking stations.

Sacking

The dried feed (distillers' dried grains) can be shipped in bulk in boxcars or can be sacked and shipped in cars or trucks from either one of the two weighing and sacking stations through automatic scales. Each scale has a capacity of 240 sacks per hour of 100 pounds each. The sacks are hung on the scale hopper by one man, filled when the automatic scale dumps, guided through the sewing machine by the second man, dropped through the square hole in the floor to a chute, and conveyed to a boxcar where a man stows them according to the requirements of the American Railway Association in order to prevent shifting. Figure 9 shows the sack chute in the rear (the third).

Shipments in bulk are loaded as shown in Figure 9 by the use of a blower. From the scale the feed falls through the pipe into a rectangular duct which connects the blower discharge to the metal box set in the wall. The feed and air pass through the box and are spouted into the car. Just inside the car door the spout has a head on it with two 90° elbows so that the feed is blown to each end of the car. The air would escape through cracks in the car and through the doorway, carrying much dust, except for a canvas hood over the door and except for a duct which connects the car to the suction side of the blower.

The percentage analysis of the feed from bourbon mashes is:

Crude protein (minimum)	28
Crude fat (minimum)	6
Carbohydrates, N-free extract (minimum)	35
Fiber (maximum)	13
Moisture	6–9

Ventilation

Usually a ventilation system is installed in a plant to benefit the health or comfort of the workers, to remove fumes, etc. In this plant a ventilation system is needed not only to remove heat and humidity for the comfort of the employees but because in winter the entrance of cold air into the building through doors or windows causes enough fog to interfere with operations.

Part of the ventilation is accomplished on the first floor by the forced-draft fans in removing 30,000 cubic feet of air per minute from near the ceiling over the dryers. On the second floor a sheet copper duct extends along the powerhouse wall over the mixed-feed conveyor where vapor accumulates. Hot air and vapor come up from the press balcony through openings around the copper hoppers spaced at intervals in the floor along this wall. From this long duct a connection is made to a fan on the third floor which discharges through the wall near by. In winter when heating is required, this same fan with a capacity of 50,000 cubic feet per minute (20 horsepower) takes dry cold air from out of doors over heating coils, and blows it into the second-floor duct to displace the warm moist air near the powerhouse wall on the second floor. Heated air is also blown to two places above the third floor to displace moist air which passes out of the hoods over the screens in part but mostly out of three roof ventilators which handle 3000 cubic feet per minute each with 3-horsepower motors. The hoods over the screens are provided with Bifurcators at about 2000 cubic feet per minute each. If needed, warm air can be blown down to the first floor.

Acknowledgment

Grateful acknowledgment is made to the staff of Hiram Walker & Sons, Inc., for assistance in preparing this article—namely, to E. R. Luney, L. P. Weiner, C. S. Boruff, W. F. Biggs, B. L. Bailie, C. H. Rogers, and S. D. Bullock.

Literature Cited

(1) Boruff, C. S., Ind. Eng. Chem., News Ed., 15, 307–9 (1937).
(2) Cooley, L. C., *Chem. & Met. Eng.*, 41, 183–6 (1934).

Received January 25, 1938.