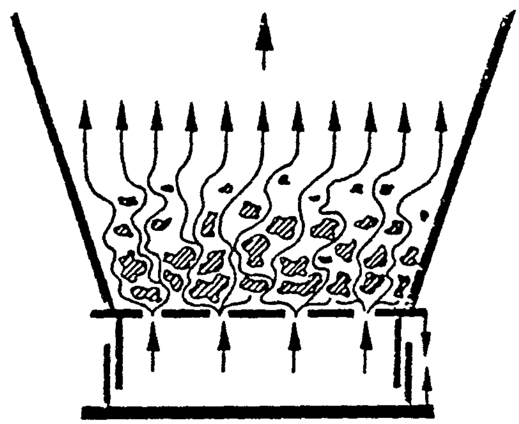

FIGURE 23: SCHEMATIC DIAGRAM OF A FLUIDIZED BED

In 1978 R&D tested a fluidized bed type dryer (made by Wolverine Corporation called a JETZONE Dryer). It utilizes vibrating trough conveyors with tube bundles suspended over the troughs. Heated air is blown down through the tubes and directed at the conveyor bottom. The impinging air creates a cushion of air and thereby suspends the conveyed material.

Result: From a drying standpoint, the Jetzone dryer successfully dried Burley strip to target. There were no mechanical problems with the Jetzone equipment during the tests.

For a taste comparison, Burley strips dried by an apron dryer, a rotary dryer and the Jetzone dryer were made into 100% Burley cigarettes and subjectively screened by members of the Flavor Department. The results said that in general the cigarettes were judged to be subjectively similar.

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b. Rotary Dryer

Rotary dryers offer a second alternative for drying Burley; they have been used in several Latin American affiliates and were also used in the 20th Street plant in the past.

Rotary strip dryers are usually gas heated dryers and as such have no steam coils that come directly in contact with the tobacco, as is the case in cut filler dryers.

The importance of this lies in both the mechanism of heat transfer as well as in a more practical consideration--buildup of casings in the dryer dictated the periodic use of chains run through the dryers to knock off the casings buildup.

In an evaluation of the 20th Street Adt burley dryer (circulating hot air) with the P&S dryer which ran side by side, it was concluded that:

(1) the Adt has less longs (3/4 mesh) in its products,

(2) the P&S had greater yield losses (0.6 vs. 0.1%),

(3) the P&S product had a less uniform moisture (standard deviation of 3.5 vs. 1.%),

(4) no differences in maker dust or filler sieves was seen, and

(5) no difference in filling power was seen.

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An economic comparison was made between the P&S burley dryer and the rotary Adt dryer which indicated that the operating costs would be roughly 30% cheaper for Adt dryers.

The overall conclusion was that no major disadvantage existed with the Adt dryer compared to the P&S dryer.

c. Multiple Conveyor Dryer

This dryer has not been installed yet in a production environment.

Principle: A multiple conveyor dryer is a one zone heating unit containing two or more conveyors staged vertically with alternating directions of travel. This configuration allows several passes of the sprayed Burley strip through the same zone with a bed turnover between each pair of conveyors.

A P&S prototype multiconveyor dryer has recently been evaluated for capacity, product uniformity and product quality.

Results: Tobacco processed in this prototype multiconveyor dryer, dried to target with no reordering, was essentially the same as that processed in the P&S apron control dryer. The exit OV variation was the same as the semiworks control but more uniform than production dryers.

This prototype dryer was not designed specifically for tobacco drying and has some obvious deficiencies. However, these deficiencies notwithstanding, the multiconveyor dryer, because

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of its narrower width and two tobacco drops within the dryer, provides a more uniform exit OV than the wider production dryers.

The advantages of this type of dryer over a single pass unit are more uniform drying, reduced energy requirements, and less floor space. The more uniform moistures because of the bed turnover exposing more surface area and the fan arrangement which pushes air over and under each conveyor from both sides. This increase in uniformity eliminates the need for overdrying and reordering as is experienced with the present Burley strip dryers. The several passes should also reduce the overall drying temperature. The staging of conveyors allows a capacity increase of bed depth decrease without increasing floor space requirements. The independent belts may also offer bed depth variations at different stages of drying.

Figure 24 depicts the schematic side elevation of the multiconveyor dryer.

d. <u>P&S Apron Dryer</u>

Currently, cased Burley strip dryers in Philip Morris U.S.A. are of the apron type made by Proctor & Schwartz. Typically, residence times are relatively long (15-20 minutes) in this type of dryer.

These dryers are the largest piece of process equipment in a primary. At the Manufacturing Center these dryers have an overall length of approximately 90 ft, an overall width of

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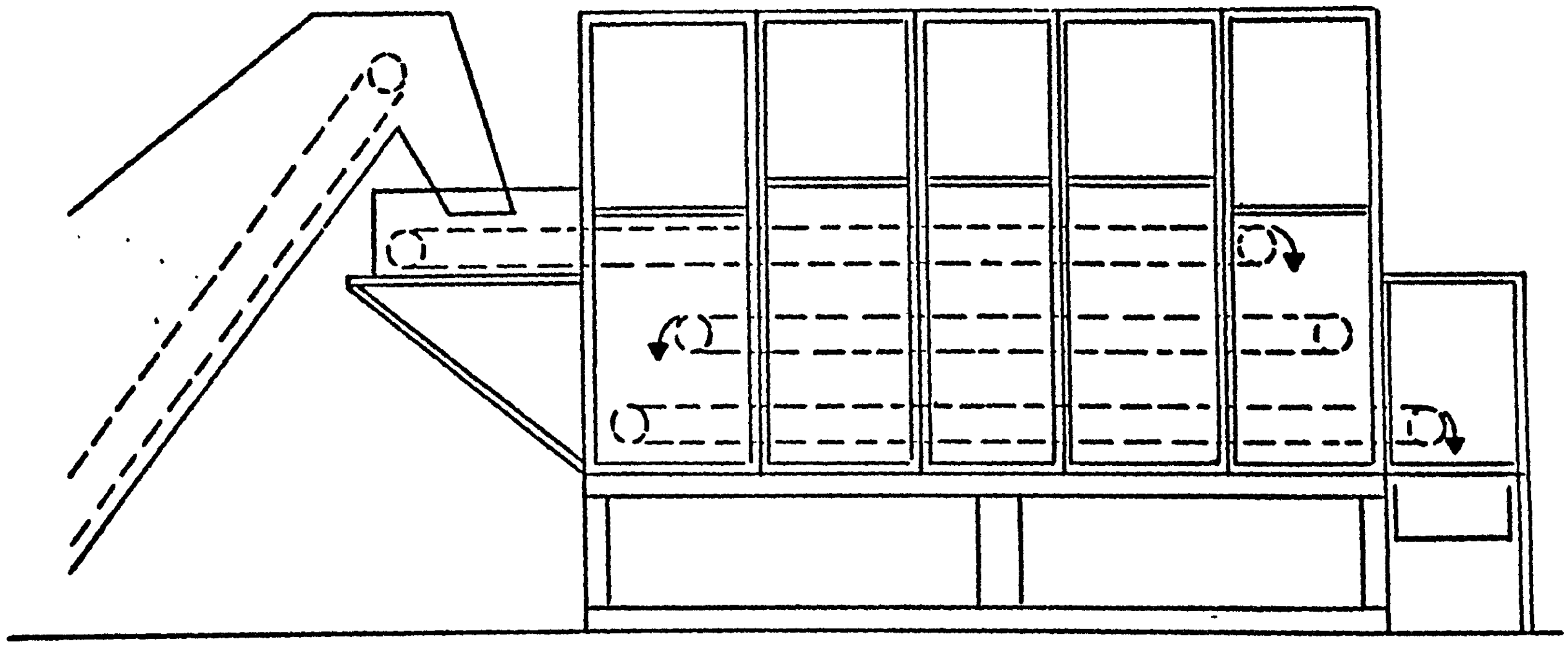

Schematic Side Elevation

FIGURE 24: PROCTOR AND SCHWARTZ MULTICONVEYOR DRYER

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over 15 feet, and a height not including ductwork of over 9 ft. Included in these dimensions are a feed section, three drying zones, a cooling zone, and two ordering sections. Figure 25 shows a schematic of the P&S dryer.

In the following a typical P&S dryer is described:

(1) Feeding

The purpose of the feeder attached at the infeed end of the dryer is to spread the leaves of Burley smoothly across and along the dryer apron. The amount of Burley in the feeder depends on the weigh belt output and the incline speed. The amount of Burley on the horizontal conveyor depends on the speed of the horizontal and weigh belt output. The amount of dwell time on the horizontal, tends to permit natural penetration of the Burley flavor into the leaf. The Burley load on the horizontal belt must be uniform in depth, otherwise the "roll" on the incline belt would be uneven on one side causing thin spots on one side and a heavy load on the other. If proper flavor penetration and a low moisture deviation is fed into the feeder, a small roll should be kept on the incline belt and the depth on the horizontal should be kept at a minimum because a deep bed of Burley at high moisture causes the leaves to compress and uneven drying occurs. The doffer on the incline should be adjusted evenly across the width of the incline, and its purpose is to distribute the Burley evenly the width of the

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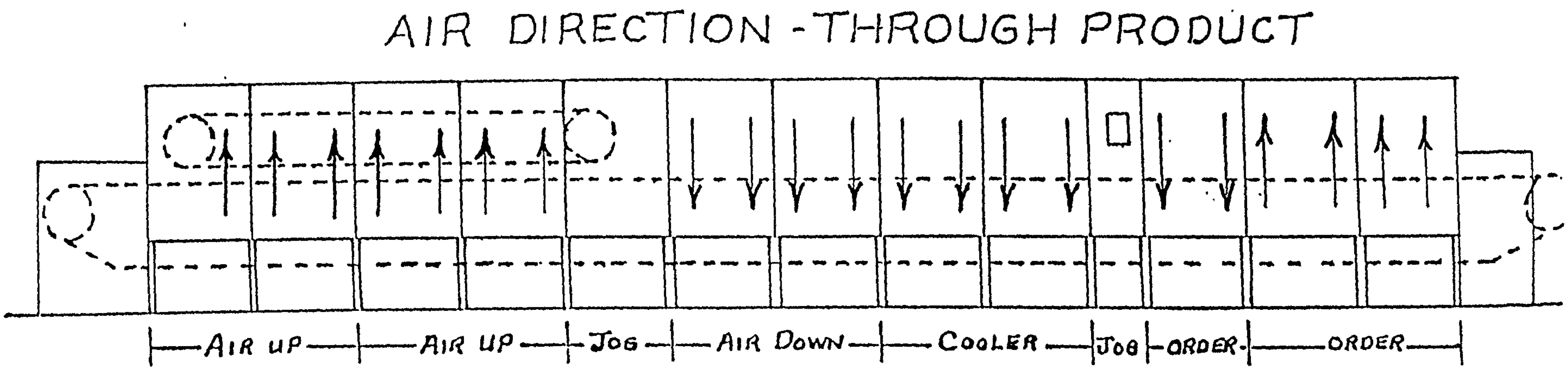
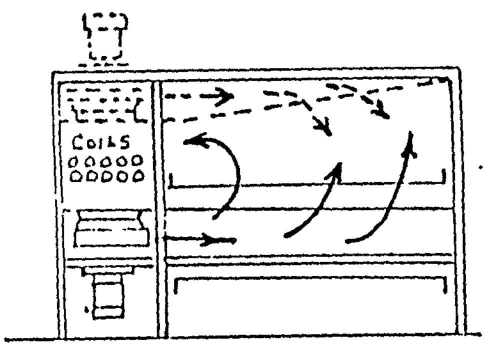
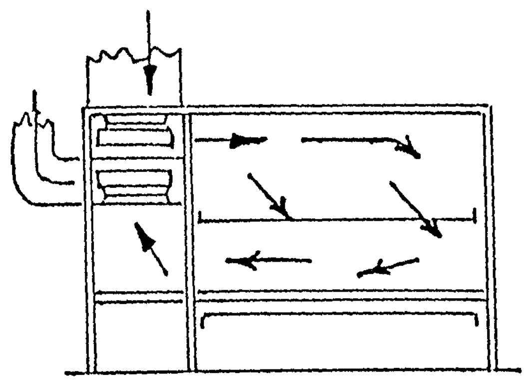
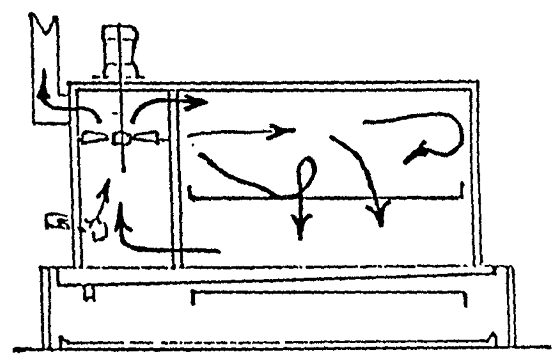




UP/DOWN CIRCULATION



COOLER



ORDER

FIGURE 25: SCHEMATIC OF THE P&S APRON DRYER

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incline. After the Burley drops off the incline, another doffer travelling in the opposite direction puts the Burley on the apron "plate". The function of this "plate" is to eliminate light spots or holes going into the apron. The apron pulls the Burley off the plate evenly across the width of the apron. If there are "holes" going onto the apron then, either the plate is too narrow, at the incorrect angle, the Burley is not falling on the plate, the infeed is incorrect, or the apron is travelling too fast. If the apron is travelling too slow, the tobacco will "pile-up" on the plate, then roll onto the apron on top of Burley already on the apron causing high spots.

(2) Dryer Circulation - Air Up and Down

The dryer is designed so that the circulating fans in each drying section recirculate a large part of the total air handled through the heating coils. The dryer is sealed as much as possible so static pressure builds up under the distributing plate or perforated plate. Then it spreads the air across the dryer apron and then through the bed of Burley on the apron.

The source of air into the dryer comes from the cooling section. Outside RM air is brought into the dryer and circulated through the tobacco, which heats the air, and is exhausted into the supply air duct for the circulating

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fans in the drying sections by using two fans on one shaft. This makes the efficiency of the steam being used to dry the Burley greatly increased.

As this warm air is pulled towards the fan it passes through the heating coils and it is heated up. This dry hot air picks up the moisture from the Burley as it is exhausted. Both the intake warm air and the discharge of exhaust from each drying section keeps the moisture level in this air low enough to permit drying and prevent condensation inside. As the hot air passes through the bed of tobacco and picks up moisture from the tobacco, the air is cooled. The amount of cooling depends upon the amount of moisture being picked up. This, in turn, depends upon the amount of moisture in the tobacco in that drying section, on the temperature and volume of the circulating air, and on the ability of the tobacco to release moisture.

The temperature of the air entering the bed of tobacco will always be higher than the temperature of the air leaving the bed of tobacco unless the tobacco is completely dry. Also, the temperature difference will be greater when the tobacco is wetter at the entrance end of the dryer. This cooling effect is caused by the heat that is absorbed from the air by the moisture when it is converted from water in the leaf to water vapor in the air. "THE LATENT HEAT OF VAPORIZATION". This is the major use of the heat in the steam.

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(3) Cooling Section

In order that the recondensing of water vapor on the tobacco in the ordering section can be done, the heat must first be removed from the tobacco leaf. This is done in the cooling section of the dryer. Cool ambient room air is blown down and/or pulled through the hot dried tobacco on the apron wihtout disturbing the tobacco. The cool air cools the tobacco. (The cooler has one right hand and one left hand fan on the same shaft.) The balanced cooler provides a means to adjust the static pressure of the air above the bed of tobacco in the cooling zone relative to the pressures in the adjacent drying and ordering zones.

The static air pressure in the last drying zone relative to factory room pressure is always higher than the static air pressure in the first ordering zone because the fans are moving much more air in the drying zone. The static air pressure over the tobacco in the cooling zone should be high enough to reduce leakage from the last air-down circulation drying zone to the cooling zone to a minimum. This can be done by partially closing the slide gate in the cooling zone discharge duct until the hinged air seal curtain in the partition between the drying zone and the cooling zone rests lightly on top of the tobacco bed.

Maintain as low a static pressure over the bed of tobacco in the cooling zone as possible while controlling the

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leakage from the last drying zone to a reasonable amount. Too much static pressure over the tobacco in the cooling zone, while it will reduce leakage from the last drying zone to even lower amounts, will cause excessive leakage from the cooling zone to the first ordering section. Ideally, the cooling zone static pressure and volume should be adjusted so that leakage from the drying zone is minimized and leakage to the ordering section is also maintained. Too much leakage into the ordering zone from the cooler will dilute the humid ordering atmosphere with fresh air and reduce ordering effectiveness. This means that the cooling zone pressure relative to the factory room pressure will be lower than the drying zone pressure and higher than the ordering zone. The total volume of air circulated through the tobacco in the cooling zone can be reduced by partially closing both cooling zone intake and discharge duct slide gates a small amount to suit. Doors in the jog between the cooling zone and the first ordering zone is for taking tobacco samples. Proper adjustment of the cooling zone air pressure and it won't "BLOW-OUT" through these doors.

(4) Ordering Section

The ordering section is designed to gently circulate warm moist air through the cool tobacco. For the same reason that the dryer has air-up and air-down circulation of air through the tobacco, the ordering section has air-down

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and than air-up circulation. Changes of air direction through the bed of tobacco always tends to produce air movement from areas of higher pressure to areas of lower pressure. For this reason, the dryer has only one air direction change in the dryer and one in the ordering section. The compartments next to the cooler are all air-down circulation. Steam and water are mixed to create a warm tropical condition inside the ordering section. The fan circulates this tropical condition and static pressure of warm moist air builds up until it's exhausted out onto the roof. The exhaust duct and intake fan are located beside each other so the damper on the exhaust must be set to allow the correct amount of static pressure build up before allowing it to exhaust. The intake air for the fan is adjusted by moving the sheet metal covers over the steam and water nozzles. The more moisture needed in the tobacco, the higher the steam pressure.

The more steam pressure the drying man sets, the more heat is released by the condensation of the steam. This tends to raise the temperature of the steam/water/air circulating through the tobacco in the ordering section. As the temperature of the steam/air mix rises more and more water vapor is required in the air to maintain the same relative humidity in the mix to which the tobacco is exposed for reordering. (The higher the R.H. in the mix, the faster the tobacco will absorb the moisture.)

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From this relationship, a higher relative humidity in the ordering section at lower temperatures is better and easier.

The atomizing nozzles are equipped with water holes as well as steam. These can be used to help control the ordering temperature. Increasing the water flow adds water droplets to the steam and air circulating through the tobacco and has some effect toward reducing temperature.

5.4 Drying Operation

a. Air Flow

One fairly major problem with the P&S dryer is the non-uniform air flow across the apron. The air exiting the recirculating fans tends to continue its horizontal travel until it hits the wall opposite the fan. This results is a high air flow through the tobacco on the side away from the fan and a low air flow through the tobacco on the side nearest the fan. Figure 26 shows the air profile of the P&S dryer in ML; these data were gathered with no tobacco or heat in the dryer. The air flow is ratioed to the overall average velocity, which is 691 ft/min.

This non-uniform air distribution results in overdried tobacco on the side farthest away from the fan and too wet tobacco near the fan. Test data has demonstrated that exit OV varies from 25% (fan side) to 15% (access door side). The overdried material is brittle and suffers more degradation through blending, cutting and drying.

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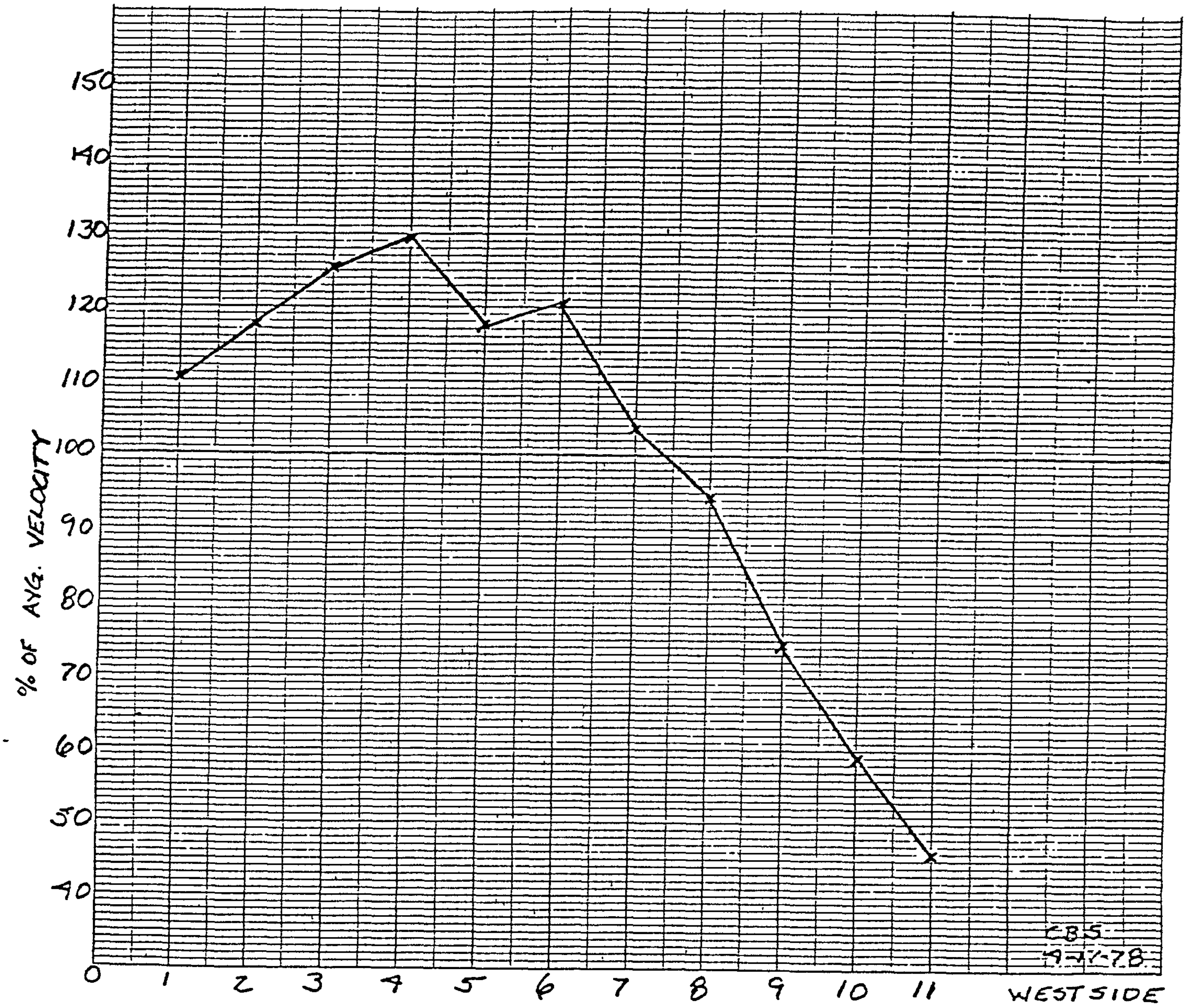

FIGURE 26: AIR PROFILE OF THE P&S DRYER ACROSS THE APRON

Although there is not a lot of potential for improvement with these dryers due to inherent design problems, a modified perforated baffle plate can improve the dryer performance to a

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certain extent: As depicted in Figure 25 this plate can be installed on an angle across the apron both in the air up and down drying zone.

b. Overdrying vs. Drying to Target

In the P&S dryer, historically the Burley leaf is dried below target OV to the 6-8% OV range, cooled and then remoisturized to the desired 19-20% range. From an energy standpoint, it would be more prudent to dry directly to a target OV without overdrying providing, however, that uniformity and subjectives can be maintained. As higher production rates were required, the target exiting the drying zones was raised and now the Manufacturing Center dries down to only about 16% and then reorders back to the desired 19-20% range.

Philip Morris tests show, that cigarettes made from Burley dried straight to target and from overdried, cooled and remoisturized Burley were judged to be subjectively similar. However, the tobacco dried straight to 20% OV was found to be heavier, have more body and more impact than the tobacco that was overdried and then reordered.

What the physical properties (sieves and CVs) concerns, tests show that overdried conditions had a reduction in "longs" (3/4 mesh) and both the cylinder volumes and sieves were better for the Burley dried to target.

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CV AND SIEVE DATA FROM BURLEY DRYING STUDIES

Data taken from 100% cut burley after primary drying.

Proctor & Schwartz	CV/OV	CCV @ 12.5% OV	Longs	Meds	Shorts	Smalls	Fines
Over dried & reordered	36.5/13.0	38.0	44.5	47.4	6.5	1.0	0.6
Dried to target	39.4/12.7	40.0	50.3	42.1	6.1	0.8	0.7
		+2.0	+5.8				

c. Temperatures

The temperatures of the circulating heating air are determined by

- The quantity of Burley that has to be dried
- The desired overdrying range (10-12%)
- The maximum possible temperature (275°F)
- The desired formation of reaction flavors during drying.

While the cased Burley strips are dried, there is a change in the sugar content resulting in so-called reaction flavors (or sucrose inversion) which give the Burley its special fragrance and taste. These flavors develop below caramelization, i.e., the melting point of sugar (160-180°C/320-366°F).

The temperature in the air-up drying sections should be set to dry the underside of the tobacco to "Target" without driving the moisture into the stem of the leaves. Temperatures should be set in relation to air movement through the tobacco and relative humidity out the exhaust. Higher temperature in the first air-up section is desirable up to 250°F because the moisture of evaporation from the wetter leaf will keep it cool

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and the static pressure under the bed should be lower than the air-down section. Because of this temperature--wetter relationship, the temperature in this second air-up section can be lower, 225°F because of the moisture removal that occurred in the first seciton. The temperature in the third air-down section should be set to achieve uniform drying on top of the bed to match the drying that has already taken place. This temperature should be set to the higher air movement through the product and moisture to be removed.

If an excessive air pressure drop is observed in the air-down drying section, it may be due to the fact that the bed is compressed by the air-down pressure. The tobacco is either not sufficiently dried in the air-up drying zones, in which case the remedy is to turn up the temperature in the air-up zones, then turn down the heat in the air-down drying zone, as required to hold the correct moisture in the tobacco at the cooling zone. Or the bed of tobacco may be too deep, the air cannot properly penetrate it in the air-up drying zone, so when the tobacco reaches the air-down drying zone, the still moist, soft tobacco is compressed into a dense mass. The air pressure will become excessive, and the tobacco will not be uniformly dried. Although the natural tendency in this situation will be to increase the drying time, the remedy is the reverse. Increase the speed of the apron which will decrease the depth of loading. This will make the bed thinner, and less resistant to air flow.

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Most of the air is recirculated but a portion (about 15%) is exhausted to prevent excessive moisture build up in the air. The average air velocity through the tobacco bed in the drying zones is in the 200-255 ft/min range. The exhaust air temperature is about 170°F.

Exiting the drying zones the tobacco passes through a cooler. This cooler pulls room air through the tobacco. To conserve energy at the Manufacturing Center, the exhaust from the cooler is used to provide make up air to the drying zones to replace the 15% of the air that is exhausted.

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6. Total Strip Blend

6.1 Quality Goals

In the total blend area the strip components are blended together and stored up to the required blend quantity. Both Burley and Bright strips get cased in different cylinders, while sheet products are added to the line just prior to the total blend silos without being cased. The following goals should be achieved in this area:

- Efficient Blending: All three leaf components (Burley, Bright/Turkish, homogenized product) must be blended over the entire length of the silo, especially comparatively small components.

  The different components must be included in all layers of the silo, i.e., over the entire height of storage. This can only be achieved by a common infeed time of all components.

- In order to get a straight surface profile over the entire length of silo, the speed ratio of traverse shuttle/longitudinal carriage must be adjusted to the individual silo dimensions (see 6.3d).

- The combined average moisture content after the silos should come close to the optimal cutting OV. Due to the casing of only a part of the blend (Bright and Burley, not sheet products) this could lead to difficulties. Humidity transfer is, of course, only possible if leaves of different conditions lay side by side.

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- When the silo is discharged, the strip flow must be even. The lamina is to be well mixed, fluffy, flexible and open, no compressed or sticky pads and clumps should exit the silo.

- In order to avoid fermentation, molding or developing of a "cheesy" taste, cased strips shouldn't stay too long in the blending silo: It may stay filled over night (maximum: 12 hours), but it should be emptied before long interruptions.

- The casings applied on Bright and Burley must be sprayed on the total surface of the strips. The solution should penetrate into the leaf and should be absorbed by the tobacco.

- The strips exiting the silo must not have wet or dry spots, no casing droplets should be on the tobacco.

6.2 Bright Casing/Burley Top Flavor

A vast amount of tobacco additives are being used, not only to improve the smoking quality of the tobacco employed but also to improve its hygroscopic properties and to develop the required flavor impressions. The preparation and exact quantities of such materials are generally considered confidential. In fact, setting up a "formula" containing the necessary additives is an art which, because of the extreme sensitivity of the human sensory organs, requires extraordinary skill and precision.

After determining the exact amount of sugar to be added (to restore the sugar deficit to the blend) the amount of "sweetening agent" to be used can be calculated.

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As mentioned, the Burley casing contains a high percentage of sugar already (11.1% by weight), so there is no need of putting sugar into the Burley top casing. Bright casing on the other hand contains very little sugar (2% by weight).

a. Humectants

There are certain chemicals, i.e., glycerin, glycol, etc., which have the important function of keeping the cigarette tobacco at its optimum moisture content by reducing the influence of relative humidity on tobacco to a minor degree. In addition to hygroscopic properties humectants function also as lubricants, producing effects similar to those to be expected from the addition of oils. The use of glycol is being applied, in addition to some other chemicals which have been found to be useful as humectants.

Many experiments have been carried out with the idea of finding out how different grades of tobacco react towards atmospheric humidity. It has been proved that if the humidity and temperature are kept at a constant figure and samples of tobacco left in contact with such conditioned air, the lower grades of Virginia and Burley will reach a lower equilibrium moisture content than that of high grade Virginia tobacco. This shows simply that cigarettes of such blends are more prone than others to be excessively dry and therefore harsh, pungent, and unpleasant in smoking, also more apt to crumble to dust. To avoid this, experiments have proved that it is possible to add some materials -- "moisture

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stabilizers" -- designed so that their application to such blends will bring low grade tobaccos up to high grade ones in so far as ability to hold a necessary amount of moisture.

An efficient humidor affords preventing undesirable changes in moisture content in cigarette packet, especially after opening the packet when no cellophane covering is there. Another function of humectants is their role as fixatives, that is, increasing resistance of the flavoring materials against evaporation. The quantity to be added differs according to the quality of the leaf tobacco and type of product obtained; in most cases it is two or three per cent of the weight of tobacco for glycerin and three to four per cent for glycol.

b. Cylinders

Both the Bright and Burley cylinder are usually equipped with a steam pipe at the entrance of the cylinder for conditioning and heating the tobacco, thus making it more susceptible for the casings. If the cylinder is heated to about the desired tobacco temperature, condensation and build up can almost be avoided. The casing is applied with several spray guns containing internally air mix nozzles which allow air and fluid to be mixed under approximately 15 psi while casing is applied. The number of casing nozzles required depend on the amount of fluid to be sprayed.

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Position of the nozzles, steam pressure, number of additional steam nozzles all depend on the cylinder size, tobacco flow rate, cylinder load, type of blend, etc.; they must therefore be adjusted individually.

The Burley top casing cylnder should be equipped with an explosion supression system. The purpose of the device is to automatically flood the cylinder in the event the temperature reaches a critical point that may cause a fire or explosion (see 9.4).

In some locations, shorts (< #6 mesh) are separated from the strips prior to the casing cylinder. This is done

- to avoid over-casing of shorts which may result in casing spots on cigarettes

- to avoid build up in the cylinder

The necessity of that screening depends on the amount of shorts in the strips: If the shorts are not screened out in the stemmery, the screening seems to be justified. However, once the shorts are taken out they should not be fed through the cutters, addition should be downstream of the cutters.

It should be noted that mere screening doesn't avoid build up generally; only the proper set up of the system, i.e., spray pattern, cylinder design, vapor exhaust, etc., will provide penetration of the solution into the tobacco, hence preventing build up.

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c. <u>Absorption</u>

The capability of the tobacco to absorb the casings depend on the type of tobacco and the temperature of it during spraying.

Recommended temperature: Bright: 120°F/50°C

Burley: 130°-140°F/55°C-60°C

The cylinder should be heated to about the desired temperature in order to avoid condensation and build up. Overheating of the tobacco can lead to sticky strips which might collapse and loose its fluffy appearance. Furthermore, a heated cylinder reduces the length of the section of the cylinder where the tobacco is heated up by open steam and hence lengthens the application section.

d. <u>Spray Application</u>

The spray pattern is to be adjusted to

- reach the maximum tobacco surface
- avoid turbulences which would twist the leaves and reduce the exposed surface
- create an optimal fine mist, thereby minimizing the risk of exhausting the casing

The specifications define usually the quantity of Bright casing per total batch which includes those parts not to be cased, such as reconstituted and expanded tobacco. If the

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uncased portion in a blend is increased and the amount of casing per blend stays constant, more solution is applied on the cased portions; this can lead to absorption problems and later on to spots on cigarettes.

Bright Casing Components:

- Isosweet/Cornsyrup
- Glycerine
- Polyproplene Glycol
- Water
- Flavors

Application rate: 10-60 gals per 10,000 lbs blend.

It should be kept at 130°F while cooking.

Burley Top Flavor Components

- Glycerine
- Polypropylene Glycol
- Water
- Alcohol
- Flavors

Application rate: 8-26 gals per 10,000 lbs blend.

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6.3 Blending Silo

a. Description

A blending silo consist of

- a blending feed shuttle conveyor ("blending band")
- a bulk holding unit
- a take-off discharge arrangement

The bottom of the bulk holding unit is in the form of a combination of chain and slat supported band conveyor ("apron"), onto which incoming material is deposited in even longitudinal layers by the shuttle movement of the blending band distributing material from a center length feed point.

In the emptying operation the bottom band moves the bulk of tobacco material at a variable controlled speed against the action of rotary discharge doffers which take off material from the full depth of the bulk, and thoroughly mix this. The number of doffers depends on the height of tobacco in the silo. The spiral arrangement and the special shape of the doffers guarantee an intensive loosening and lump free discharge over the whole cross section of the mixture with a minimum mechanical stress being applied to the tobacco.

The apron speed can be regulated. In this way the amount of tobacco being discharged can be adopted to suit the production flow.

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b. Fabrication Details

Philip Morris U.S.A. requires the following points to be observed for new silos:

Framework: It shall be fabricated from carbon steel.

Walls: They shall be constructed of fir plywood bonded with a water resistant adhesive. The inside surface of the plywood shall be clad with a thin stainless steel sheet.

Doors: One access door should be in the front and in the rear. Each door should have a large view panel in the center portion of the door. Each silo shall be provided also with view panels on each side of the silo.

Doffers: The doffers shall be a spiral formed carbon steel pipe. The fastest doffer should not operate over 42 rpm. The bottom doffer clearance must be less than 1/2 inch from the silo apron in order to help in the breaking up of the tobacco mat. The fartherest doffer from the drive motor should have a motion switch to indicate a stoppage of any doffer.

A recent Philip Morris study about the degradation caused by the doffing mechanism in a cut filler silo showed that

- less than 1% loss in longs can be achieved through the silo when discharging with the pin doffer inclined 15° into the product

- A two row 360° sprial pin arrangement achieves uniform cut filler discharging flow

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- A pin doffer rotational speed is set at 13 pin hits per each inch of apron travel. This is for cut filler only.

It has not been determined if these results also apply to strips.

Apron: The silo apron shall be constructed of stainless steel where it is in contact with the tobacco. The apron shall be a slat type apron with a chain on the edges used to advance the apron in the silo. The apron can be inclined up at the front end to accommodate the discharge conveyor under the doffers.

Note: This inclination compresses somewhat the tobacco by wedging. If the ceiling height allows it, the inclination should be dispersed with.

Shuttles: Each group of silos shall be supplied with one cross shuttle.

Nonmetal Materials: None of the in 1.4 c. listed materials should be used in the silo.

c. Silo Operating Modes

The tobacco can generally be fed into the blending silo:

(1) In layers which are spread over the complete width of the blending boxes. This is only recommended for relatively narrow blending silos (width < 1.5m). The tobacco is fed on to the blending band by a vibrating conveyor with a diagonal discharge end or with diagonally arranged base flaps.

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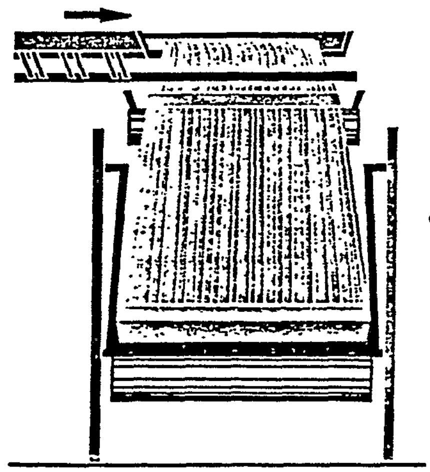

FIGURE 27: VIBRATING CONVEYORS AS CROSS-SHUTTLE (HAUNI)

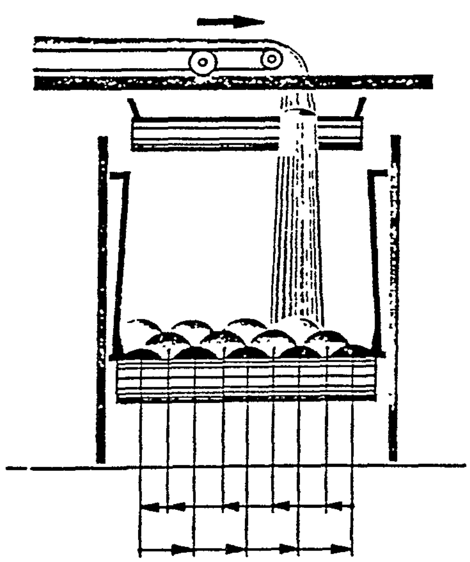

FIGURE 28: TO AND FRO MOVING CROSS-SHUTTLE

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(2) In cords which lie next to each other.

The tobacco is fed on to the blending band by the stepwise or continuous to and fro movement of a cross shuttle.

With each of these 2 laying arrangments, there are <u>3 filling modes</u>:

(1) Filling the entire silo (blend or bulk)

(2) Filling the front part of the silo only (blend)

(3) Filling the rear part of the silo only (blend)

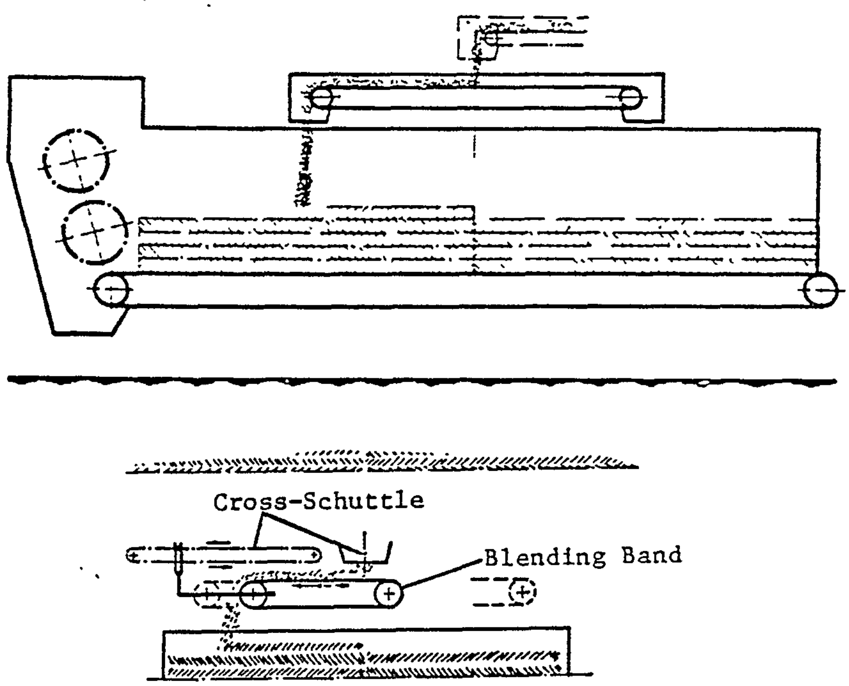

FIGURE 29: SCHEMATIC DRAWING OF THE FILLING OPERATION OF A BLENDING SILO (QUESTER)

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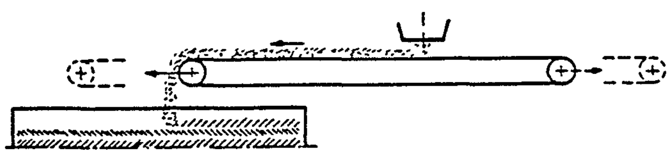
To (1): The silo infeed blending band (and eventually a cross-shuttle) distributes the tobacco flow in layers on the apron from side to side and end to end over the entire width and length.

The blending band has a drive common to band and carriage; for short traversing distances the blending band is incorporated with a cross-shuttle gear.

To (2) and (3): The silo infeed blending band (and eventually a cross-shuttle) distribute the tobacco flow in layers on the apron from side to side and middle to the front (or rear) end over the entire width and half the length of the silo.



d. Loading Pattern

In most cases total blend silos consist of cross-shuttle (not vibrating conveyor) and blending bands. The tobacco can be fed from the cross-shuttle to the blending band:

(1) by stepwise to and fro movement of the cross-shuttle. This can result in a piling up of the tobacco in the middle of the silo with less filling height at the

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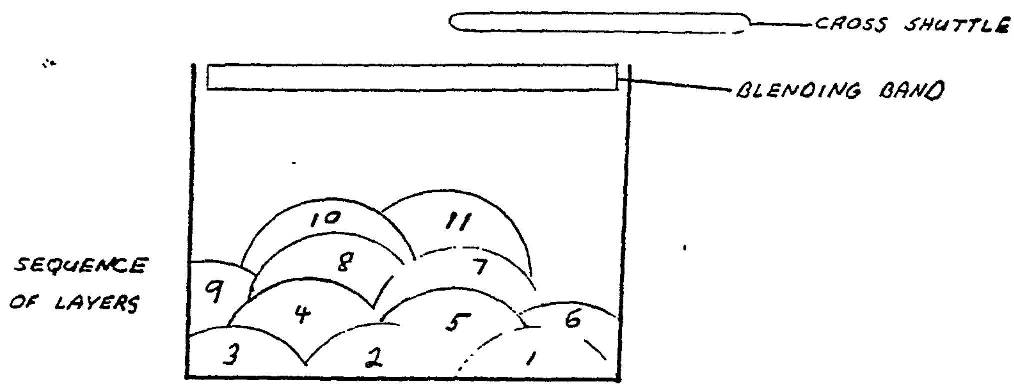

FIGURE 30: FORMATION OF AN UNEVEN SILO SURFACE PROFILE

walls. The reason for this is the sequence of tobacco layers discharged into the silo: If the silo is to be filled even, two consecutive layers would have to be laid near the walls; on the other hand, this would be detrimental to the goal of mixing the blend components.

(2) by continuous to and fro movement of the cross-shuttle. In that case the layers are put into the silo in a "8"-like pattern. This gives an even surface if the speed ratios of

- the cross-shuttle movement

- to the blending band movement

is adjusted properly to the individual silo. Figure 31 shows the layers created by a correct speed ratio (31a) and a non-adjusted speed ratio (31b).

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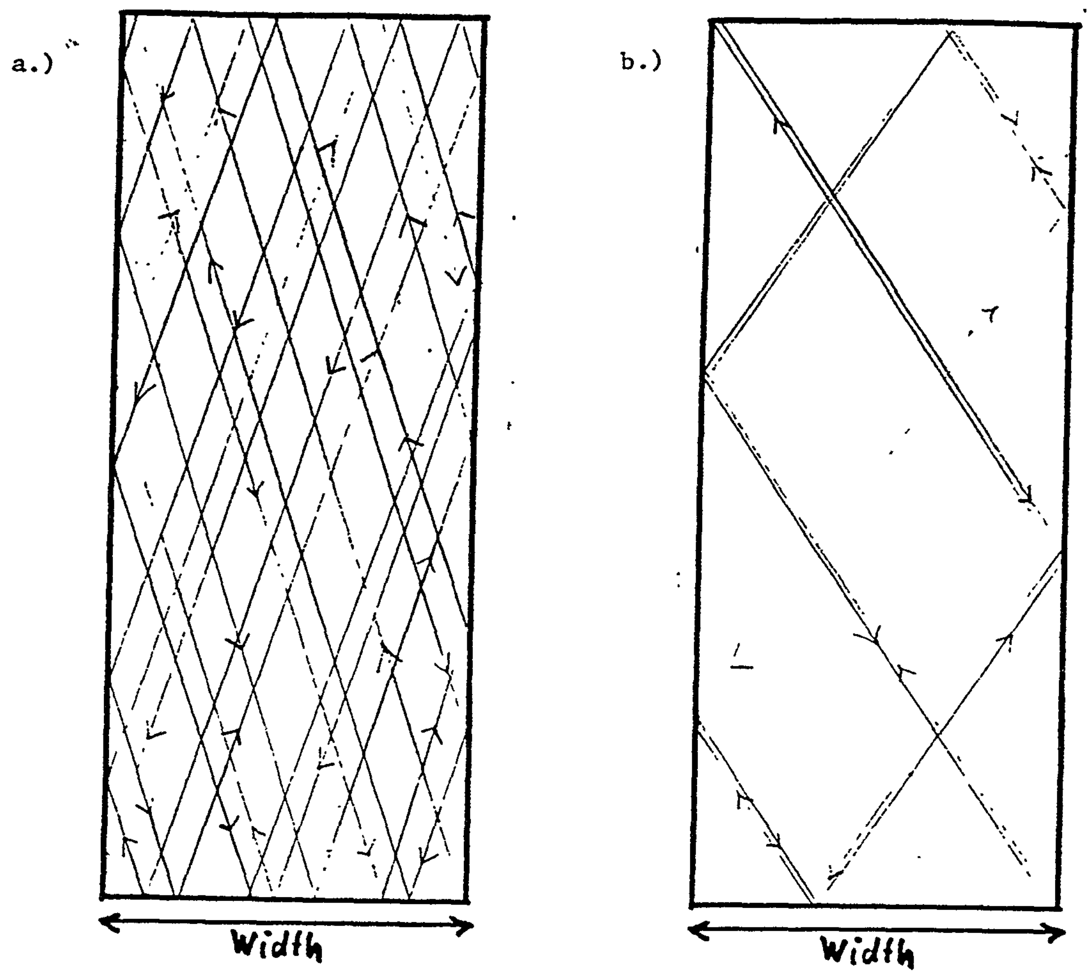

FIGURE 31: SILO LAYERS AT DIFFERENT RATIOS OF $\frac{\text{SPEED BLENDING BAND}}{\text{SPEED CROSS-SHUTTLE}}$

The desired speed ratio can be figured out graphically: The layers are drawn on a scaled down silo sketch with the angle corresponding to the speed ratio. In case the layer line ends up in a corner (Figure 31b), the layer goes back the same way; this results in an uneven tobacco distribution, i.e., the tobacco is piled up along a few layer lines.

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e. Storage Height

Silo storage levels are, of course, limited by the silo height which is frequently designed according to spatial conditions In general, the storage levels don't exceed 6 ft./1.83m.

R&D has done some tests in order to evaluate the effects on the physical properties of cased and uncased DBC Burley stored in silos at depths of six and eight feet. The results show, that sieve data for both the cased and uncased DBC showed no significant difference at a 95% confidence level. Large variations were noted in the individual sieve fractions from run to run for both the cased and uncased DBC Burley silo storage level tests.

The CV/OV data showed also no significant difference under the two simulated silo depths. As in the sieve analyses, large variations were seen from run to run.

6.4 Metal Detectors

a. Detector Arrangement

To protect the cutters, there are usually metal detectors, which are located on the strip recycle conveyors just prior to and after the surge feeder. If metal is detected a belt (or wigway) will reverse and drop the contaminated tobacco into a surge feeder that feeds a conveyor equipped with a second metal detector which will drop the contaminated tobaccos into a box. If no metal is detected, the tobacco should be conveyed back to the steaming cylinder for reconditioning.

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b. <u>How a Metal Detector Works</u> (Metlokate)

Metal detectors comprise two principle parts -- a search head and a control unit.

The search head consists of several equally spaced coils wound on a rectangular rigid form, through the centre of which the product under examination passes. The centre produces an electro-magnetic field known as the search field. This field induces a signal in each of the outer coils, called the search coils, but because these are connected in opposition the two signals subtract from each other. The result is zero when these signals are equal and the search head is balanced.

All metals have electric conductivity and when such detectable materials passes within the influence of the search field it disturbs the balance of the search coils causing a resultant signal. This signal is processed electronically in the control unit, and can be used to automatically reject the metal contaminated product from the line.

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7. Cutting

7.1 Quality Goals

We have to remind ourselves that cut tobacco qualities have adopted different standards over the years and that the type of tobacco supplied to the cutting in primaries nowadays has a much lower particle size than was normal a decade ago. Many changes have occurred in the primary processing of tobacco leaf and these changes have not assisted the cutting machines to maintain the qualities they were designed to produce.

Irrespective of the type of cutter, the following quality-goals should be achieved in the cutting process.

- The target of width of cut must be consistent because it is a significant variable in the determination of filling power and it has an effect on "tar" and nicotine delivery.

- The leaves should be cut clean, i.e., with a large percentage of long and medium strands and a minimum amount of dust.

- The formation of the cheese should not become soft, porous and honey combed in appearance. This condition indicates that the mechanical feeding system to the cutter bands allow cavities to form in the leaf supply.

- The cut tobacco shouldn't contain flags or pull-outs; this must be watched particularly when sheet products are part of the blend.

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- Any gum formation on the cutting drum must be inhibited since it may deteriorate the quality of cut. This gum is due to the release of casings from the tobacco, a correctly heated cutting drum helps prevent gum formation.

- In order to get a better filling power of the cut rag, the time of the tobacco under compression (mouthpiece pressure) must be as short as possible and the pressure as low as possible consistent with good cheesing.

Up to date cutters do not possess automatic inspection devices like cigarette makers. Therefore, the above quality goals are mainly controlled visually and manually, except width of cut and filling power which can be measured.

Common methods of subjective control are:

- Hand compressing of the tobacco; the cut rag is to "spring-up" again after the hand compression has been released.

- Spreading of handful of cut rag and observing the length of strands, dust, and flags.

7.2 Cutter Details

a. Components Of A Cutting Line

The cased tobacco leaves the total blend area and passes to the cutting area, in which the main components are

- Steam cylinder
- Metal detector

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- Feeder
- Cutter feed conveyor with overflow loop
- Cutter
- Cutter take-away conveyor

The steam cylinder provides a means of adjusting the moisture and temperature of the cased strips. Atomized water and steam can be sprayed to increase moisture.

Hot air is circulated to increase strip temperature and in some cases can adequately remove a few tenths of a percent of moisture if this is desired. The metal detector can locate metallic objects and, by reversing a conveyor, reject the portion of tobacco containing the metal. This tobacco is then fed back into the process after the metal has been removed manually.

A possible air leg separation will remove some heavy contaminants, prior to manual separation.

The tobacco then passes to the feeder used to supply the cutter feed conveyor; this feeder also serves as a reservoir for the cutters.

b. Different Cutting Machines

There are only 2 manufacturers left who manufacturer cutters: Hauni and AMF-LEGG. Hauni makes the models

KTF 6 rated at 2000 kg/h

KTF 8 rated at 4000 kg/h

KTH 6 rated at 4000 kg/h

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KTH 8 rated at 4500 kg/h

KTC rated at 8000 kg/h

at a cutting width of 1mm and a rotational speed of the drum knife of 450 rpm, respectively 300 rpm for the KTF6.

AMF-LEGG has been producing the models

MM 3 rated at 2100 kg/h at 420 rpm

MM 3A rated at 2900 kg/h at 650 rpm

SS rated at 3500 kg/h at 650 rpm

RC-3 rated at 4500 kg/h at 275 rpm

RC-4 rated at 2100 kg/h at 500 rpm
(4 knives, 100mm mouthpiece opening)

RC-4 rated at 3500 kg/h at 500 rpm
(8 knives, 100mm mouthpiece opening)

RC-4 rated at 9100 kg/h at 500 rpm
(8 knives, 130mm mouthpiece opening)

These capacity figures refer to a warm American blend at a cut width of .85mm.

Moisture, temperature and feeding efficiency all influence capacity, but with correct feeding such as those shown above are attainable for cased leaf.

Philip Morris U.S.A. only uses Legg-cutters. In 1981 the Hauni KTC was tested, with the following results:

- KTC-cutter produces 2-3% less longs

- CV and cut width showed no difference

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- Despite no oil leak from the hydraulic drive occurred, it might be difficult to detect eventual contaminated tobacco.

AMF-LEGG has stopped building RC-3 and will stop MM3 and SS soon, so that only the RC-4 will be available. The capacity/ range covers high (RC-4-8x130), medium (RC-4-8x100) and low (RC-4-4x100), and each can be decreased by changing number of knives and reducing rpm and mouthpiece opening.

The <u>methods of cutting</u> the tobacco have varied in the past from the guillotine and the windmill types to the lawn mower or rotary drum type as used on the Legg and Hauni machines. The lawn mower type cutting drum is mounted on a frame pivoted on a horizontal or near-horizontal axis and has a number of knives which are fed forward and sharpened by a grindstone traversing the length of the cutting drum. The cutting angle of the knife of the RC is 66.5° from the horizontal axis of the tobacco feed, therefore its cutting action through the cheese is almost vertical, similar to a guillotine cut.

c. <u>RC-3</u>

<u>Feed to Cutting Drum</u>. The tobacco falls from the cutter feed conveyor into the cutter hopper. Figure 33 shows a sketch of the AMF-Legg RC-3 cutter used in Philip Morris U.S.A. The tobacco is pushed between the two converging feed band conveyors by a reciprocating compactor. As these feed bands advance, the tobacco is compressed. A pneumatic ram pushes down on the top feed band to apply the mouthpiece pressure. The goal is to cut at a uniform tobacco density (using minimum

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mouthpiece pressure) that prevents pull-outs (uncut tobacco). The tobacco at the mouthpiece is called the "cheese".

Cutting Drum, Knives, and Grindstone. The tobacco advances into the cutting drum, which has nine knives, and is cut at 30 per inch (CPI). The knives in the cutting drum are continuously sharpened by a grindstone. This grindstone is shaped to fit the cutting drum and travels the length of the drum. At one end of the grindstone travel, the knives are fed out automatically to make up for the knife wear. At the other end of the grindstone travel, the grinder is advanced toward the drum to compensate for grindstone wear. The grinder makes a complete traverse of the cutting drum length and returns in about 1 3/4 minutes. Grinder dust (bits of grindstone, steel, and tobacco) are collected in a filter dust collector located at the cutter. Details of the knife location in the cutter drum are shown in Figure 33.

Knife Protection and Wearlife. A knock-off cutting strip shuts down the machine if one of the knives encounters a hard material in the tobacco. This prevents additional cutter damage. The high carbon steel knife blades have a wear life of about 32 hours. The grindstone life is approximately 70 hours.

Varying Lbs/Hr and CPI. The cutter bands and drum are driven through a common gear box. The cutter rate (lbs/hr) is varied by changing the drum speed which in turn varies the band speed. The cutting width is varied by changing a pair of

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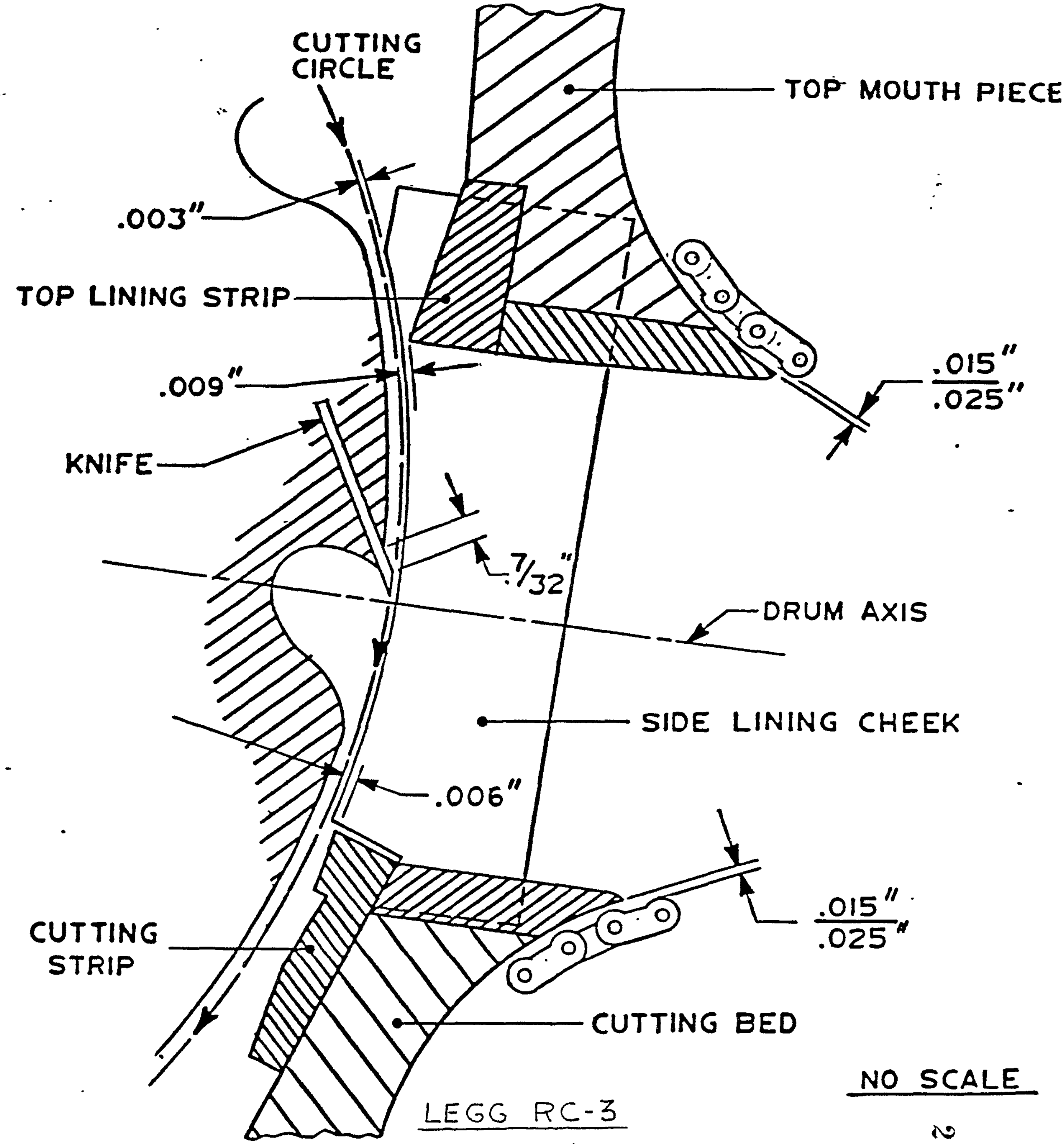

FIGURE 32: IDEAL SETTING FOR MOUTH
(TOBACCO CUTTING)

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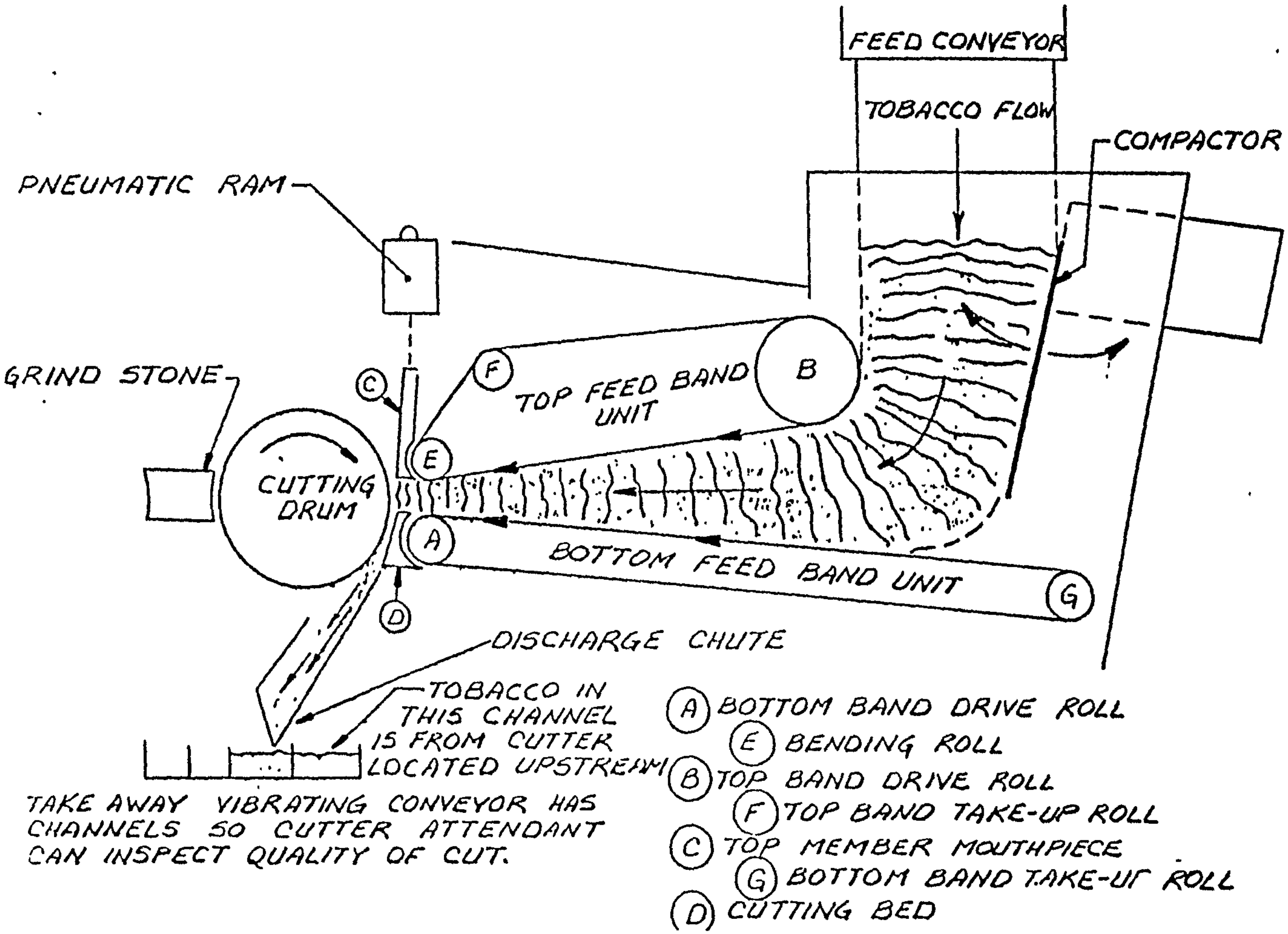

FIGURE 33: GENERAL OPERATION OF LEGG RC-3 CUTTER

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gears which changes the relationship between the cutter drum and the bands. This gear change takes approximately five minutes.

Capacity. The RC-3 cutter is rated by Legg to cut approximately 10,000 lb/hr at a drum speed of 275 rpm. Philip Morris cuts less than 8,000 lbs/hr per cutter at a drum speed of about 240 rpm. Tobacco exits the cutter at approximately 20% OV and 90°F. Tobacco not required by the cutters is recycled back to the cutter feeder. The ideal number of cutters in a line is the number required for the production rate plus one cutter on standby for cleaning and maintenance.

Cutter Discharge. The cut tobacco from the cutter drops through a chute and falls into a channelled vibrating conveyor so the cutter attendant can inspect the cut and identify cutter problems before the cut tobacco passes to the cut filler dryers.

7.3 Cutting Conditions

R&D studies and outside publications indicate, that

- cutting moisture
- cutting temperature

have a considerable influence upon

- cylinder volume
- shred size fractions

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Although there is still a running debate about the desirable or best cutting conditions, following statements can be made:

(1) Tobacco long-size-fraction and equilibrated filling power increase with moisture level at cutting

(2) Increasing temperature at cutting results in increased tobacco long-size-fraction, however, its equilibrated filling power is reduced

a. Effects of OV/Temperature Changes

The existing studies and publications give different figures about the extent of OV vs. temperature changes.

(1) The Manufacturing Center currently cuts at 85°F and about 21.5% OV. A study by Mr. J. E. Drake conducted in late 1975, indicates that the following results can be expected at the M/C for the cutting temperature indicated.

	Temperature °F	Temperature Difference, °F	Expected Change In C.V., cc/10 gm	Expected Change In % Longs
Current	85	0	0	0
	90	+5	-0.6	+1.55
	95	+10	-1.2	+3.10
	100	+15	-1.8	+4.65

(2) A study conducted in R&D by Osmalov and Sherwood with the R&D semiworks cutter (AMF-Legg MM) found that the CV could be fitted by multilinear regression analysis, with the equitation

$$CV = 32.62 - 0.0595T + 0.28390V$$

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The temperature range of the study was 87 to 145°F and the moisture range was 14.4 to 22.7% OV.

This means, that for each 10°F increase in temperature, CV decreases by 0.6 cc/10g, and for each 1.0 percentage unit increase in OV, CV increased by 0.3 cc/10g. A smiliar analysis for "longs" percentage resulted in the relationship

$$\% \text{ longs} = 117 + 0.71T + 10.27OV - 0.12(OV)^2 - 0.031(T)(OV)$$

Therefore, each 10°F increase in temperature yields a "longs" increase of about 3 percent and each percentage unit OV increase yields an increase in "longs" of about 2 percent. These results should be considered only tentative at this time.

(3) A subsequent large-scale test was conducted at Louisville by R&D and Tobacco Products Standards to confirm these results under production conditions. This test, using RC-3 cutters feed rates of approximately 7500 lbs/hr and <u>cutting OV's</u> of 20.5 and 26%, failed to find any correlation between cutting OV and either filler CV or sieve fractions.

(4) As a result of this apparent contradiction, a final study was conducted in 1982 using an RC-4 cutter and at feed rate of 2700 lbs/hr. The actual <u>cutting OV's</u> of the test and control runs averaged 23.8% and 18.8%, respectively. Many small clumps, consisting of filler shreds

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sandwiched together, were present in the exit-cutter samples taken from the test runs. These clumps appeared to be due to the failure of the cutter cheese to completely break up after cutting, probably a result of the high cutting OV. The clumps tended to inflate the 6 mesh fraction of the sieve test while lowering the apparent CV of the filler.

The clumps were apparently broken up by the ADT dryer as none were observed in the exit-dryer samples. Result: A 5 unit increase in cutting OV resulted in a 0.8 cc/10g increase in CV, a 4.67 unit increase in the 6 mesh filler percentage, and a 6.18 unit increase in the 12 mesh filler percentage. These differences were all found to be significant at a 95% confidence level.

(5) In 1966 Zhuravlev et al. investigated the interrelationship of temperature of the tobacco, % of strands, % of trash, and % of dust during cutting. Generally an increase in temperature effects an increase in % of strands, a decrease in % of trash, and a decrease in % of dust.

°C/°F	% STRANDS	% TRASH	% DUST
20/ 68	65.3	31.2	3.5
30/ 86	77.3	19.7	3.0
40/104	83.3	14.3	2.4
50/122	86.3	11.7	2.0
60/140	88.3	10.0	1.7
70/158	89.1	9.5	1.4

(6) In 1968 Chenikov and Sologubov studied moisture content and strand length as causes/effects during tobacco

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cutting. As moisture content of the tobacco increases, a decrease in % of dust is noted along with an increase in % of long strands and a decrease in % of short strands.

MOISTURE	% LONGS	% SHORT	% DUST
13.6	43.4	54.7	1.9
14.1	61.2	37.4	1.4
16.4	89.6	9.6	0.6
16.7	92.7	7.0	0.3
17.6	92.4	7.3	0.3
18.9	92.8	7.1	0.1
20.4	93.7	6.2	0.1

b. Recommendation

It would be best to cut tobacco between 110°F and 120°F with a moisture of 22.0 - 22.5%.

At this temperature and moisture range there seems to be the greatest percentage of longs and the least dust, with no CV losses. This is based on R&D studies and literature reports.

A different question is, if these targets can be met in the existing primaries. The steaming cylinders might not be able to raise the tobacco temperature enough considering the temperature loss during transportation from the cylinder to the cutting drum. Drying filler from 22.5% OV to the desired targets may cause problems with the dryers running at their upper capacity limit already. It must be tested if steaming tunnels just before the cutters and dryers can help solve these problems.

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7.4 Cutter Feeding

a. Throughput Control In Connection With Cutters

After the steaming cylinder and metal detector, the strips pass to the cutters. Cutting temperature and moisture can influence the cutter output considerably so that the tobacco flow after the cutters can fluctuate. These fluctuations could be quite troublesome for the subsequent dryers. Hence, the introduction of metering devices at this point. This can be done in different ways.

(1) A feeder before the cutter feed conveyor provides a reservoir of tobacco for the cutters. The feed conveyor can be a cascade conveyor or a vibrating conveyor with a hole above the cutter hopper; this system can be "choke-fed", i.e., the chute between the vibrator and the cutter hopper remains full. Electric eyes in the hoppers control the feeder speed prior to the cascade conveyor. The over-supplied strips return to the feeder via return conveyor.

In some affiliates the over-supplied tobacco is collected in boxes and fed manually back into the feeder.

Optional: In order to guarantee a constant output of the cutter, the mouthpiece opening controls the drum speed: Increasing mouthpiece opening slows down the drum speed and vice versa.

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(2) Hauni offers the following throughput control in order to operate without a feeder and return (see Figure 34). However, it could be seen as a disadvantage that the cutter is made dependent on the feed system.

A constant flow of tobacco is fed to the cutters and, if the flow from the cutters is to be kept constant too, the cutters must be able to process all the tobacco offered to them.

Photoelectric cells in the packer act upon the cutting speed and keep the tobacco level constant. The tobacco cutters thus adapt their knife head speed so that the output of cut tobacco remains constant at all times. Cutting drums would normally operate at a slower speed and lower output to allow for speed-up when tobacco flow increases for whatever reason.

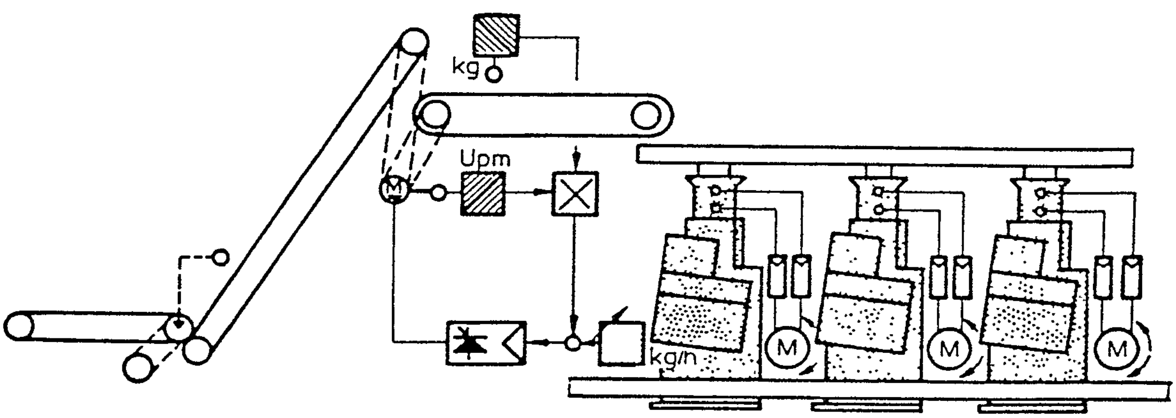

FIGURE 34: CUTTER-FEED CONTROL INSTALLED BEFORE THE CUTTERS

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(3) In this cutter control system (also presented by Hauni), a constant tobacco level must be kept in the dryer feeder box.

Two photoelectric cells, therefore, control the speed of the cutter, of which the advance movement of the tobacco cheese and the knife speed are coupled by means of a common drive. The flow of tobacco towards the cutters must always be greater than the flow from the cutters. This makes a return of surplus tobacco necessary.

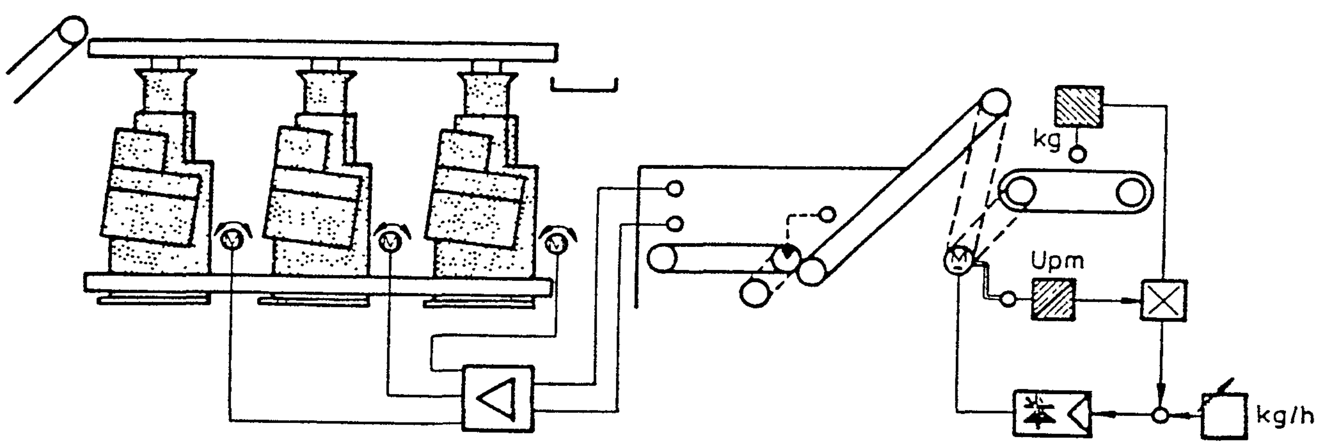

FIGURE 35: CUTTER-FEED CONTROL INSTALLED AFTER THE CUTTERS

b. Mouthpiece Pressure

As previously stated, the mouthpiece pressure, or cheese pressure, should be as low as possible, and the time the strips are compressed in the bands as short as possible.

In a cutter test, conducted in the PM-Catana affiliate in 1974, the cheese pressure (actually air pressure on the

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cylinder) was set at the normal 40 psi and 80 psi on the RC-3 cutter. The result was, that the lower cheese pressure yielded an improvement in sieve fractions and in corrected cylinder volume (exit dryer).

	Normal 40 psig	High 80 psig
Sieve Anal. exit ADT Dryer:		
Longs & Mediums, %	90.1	87.7
Small, Fines, & Dust, %	9.9	12.3
CCV exit ADT Dryer, cc/10g	36.2	35.3
% OV exit the cutter	19.6	19.9
Tobacco Temp. exit cutter, °F	109.4	111.2

It is necessary to mention the cylinder diameter when the mouthpiece pressure is discussed, for we regard mouthpiece pressure equal the air pressure in the cylinder.

Normal cylinder diameter (RC-3, RC-4): 12" -> 35-40 psi

Diameter of some older RC-3's : 16" -> 18-20 psi

Diameter of LEGG models MM2, MM3 : 8" -> 65-70 psi

7.5 Vibrating Feed

As mentioned, the high force required at the mouthpiece (typically 2900 lbs) to grip the "cheese" against the cutting force of the knives, results in a loss of filling power. This loss is probably due to "padding", i.e., the sticking together of 2 or more cut strands.

a. The conventional column type feed to cutters shown in Figure 36 forms a lay of lamina in the column which is substantially horizontal, when this lay turns the corner at the bottom of

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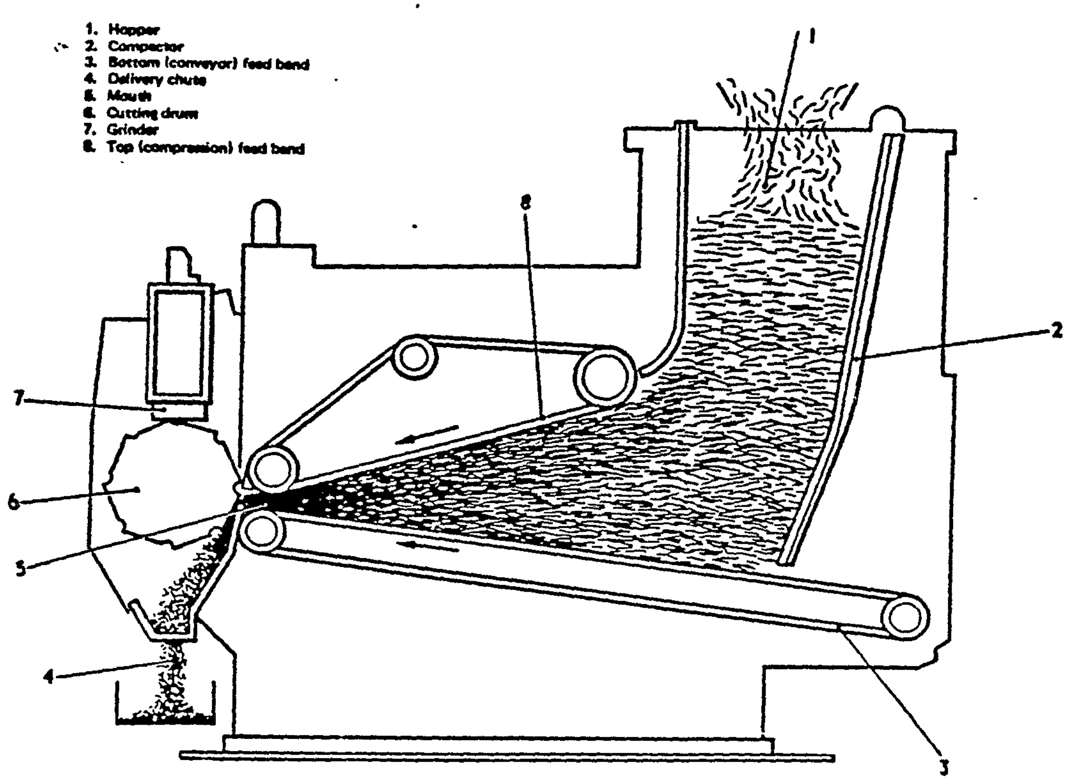

FIGURE 36: CONVENTIONAL COLUMN FEED

the column as it enters between the two compression bands it tends to be orientated into a vertical lay and at the same time there is a tendency for cavities to be formed. The subsequent compression of the lamina while oriented vertically means that there is a tendency for a piece of lamina to be folded upon itself and this, coupled with possible cavities, makes the lamina difficult to grip and thus high pressures are required to prevent pieces of uncut lamina being pulled from the cheese by the cutting action.

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b. Force Feed

The principal of that by Rothman's developed system is shown in Figure 37 and 38: The lamina is laid on to a band conveyor feeding into the back of the cutter. In falling on to the band it forms a substantially horizontal lay and this horizontal orientation is maintained as it is fed between the compression bands and up to the mouthpiece. This means that individual pieces of lamina present a larger surface to be gripped by the mouthpiece and thus, much lower pressures can be used, typically 22 lbs/10 kg of force on the mouthpiece. There is also, of course, less tendency for pieces of lamina to be folded upon themselves and this together with the reduced pressure gives a slight increase in filling power.

To assist the layer of lamina in bedding down and to avoid the formation of cavities, the unit is vibrated vertically, this is achieved by pivoting the unit about a point coinciding with the axis of the delivery end roll and mounting the rear end of the unit on an eccentric shaft unit, identical to that used on impulse conveyors.

Lamina is fed to the unit by a metering tube and metering band system as shown, the metering tube giving a 750mm wide carpet which has been found to be the minimum length of deposit along the length of the force feed necessary to give good results. Oscillating spreader plates, not shown in the diagram, are fitted at the end of the metering band to spread the lamina evenly between the vertical side walls of the unit.

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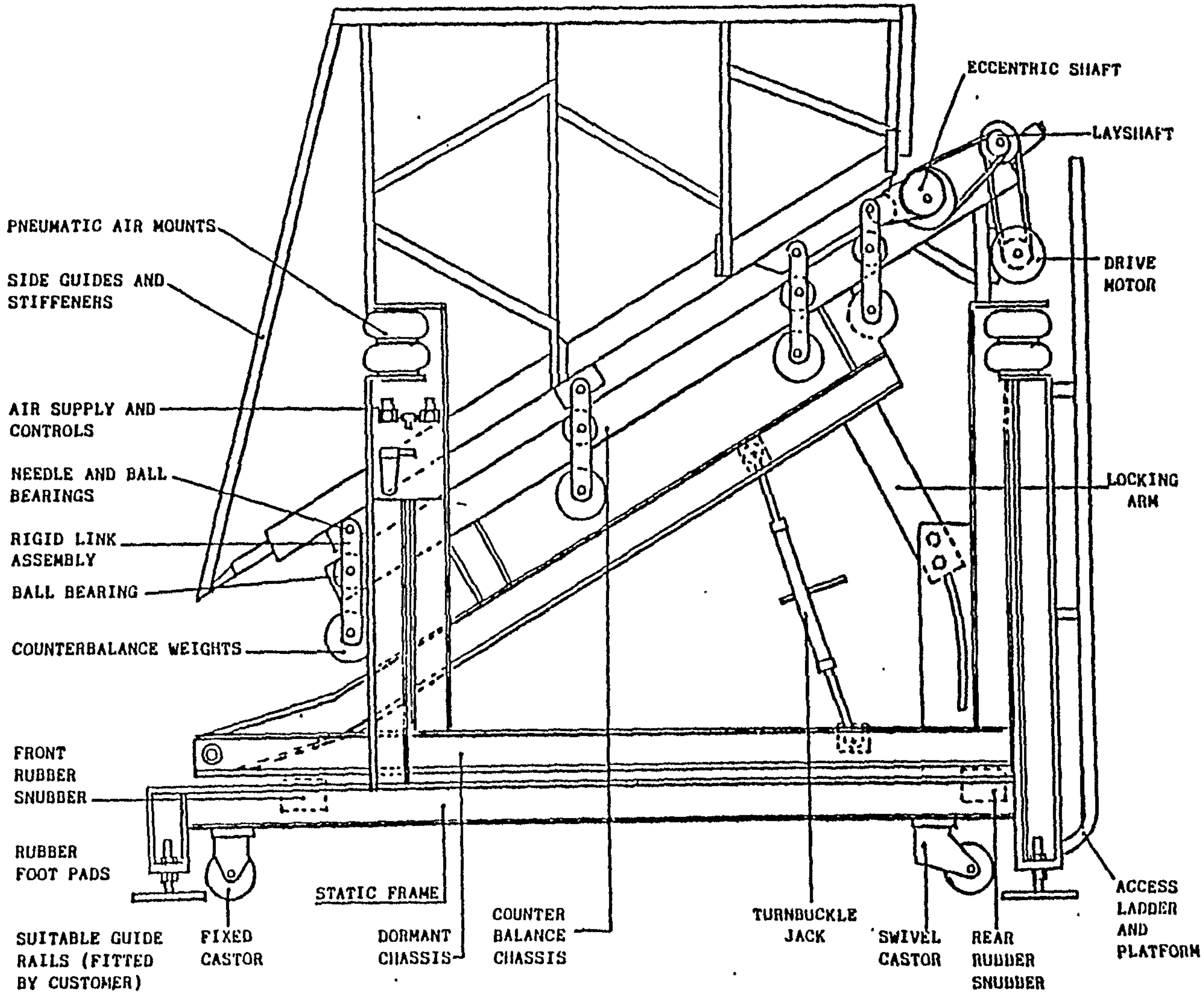

FIGURE 37: ROTHMAN'S FORCE FEED

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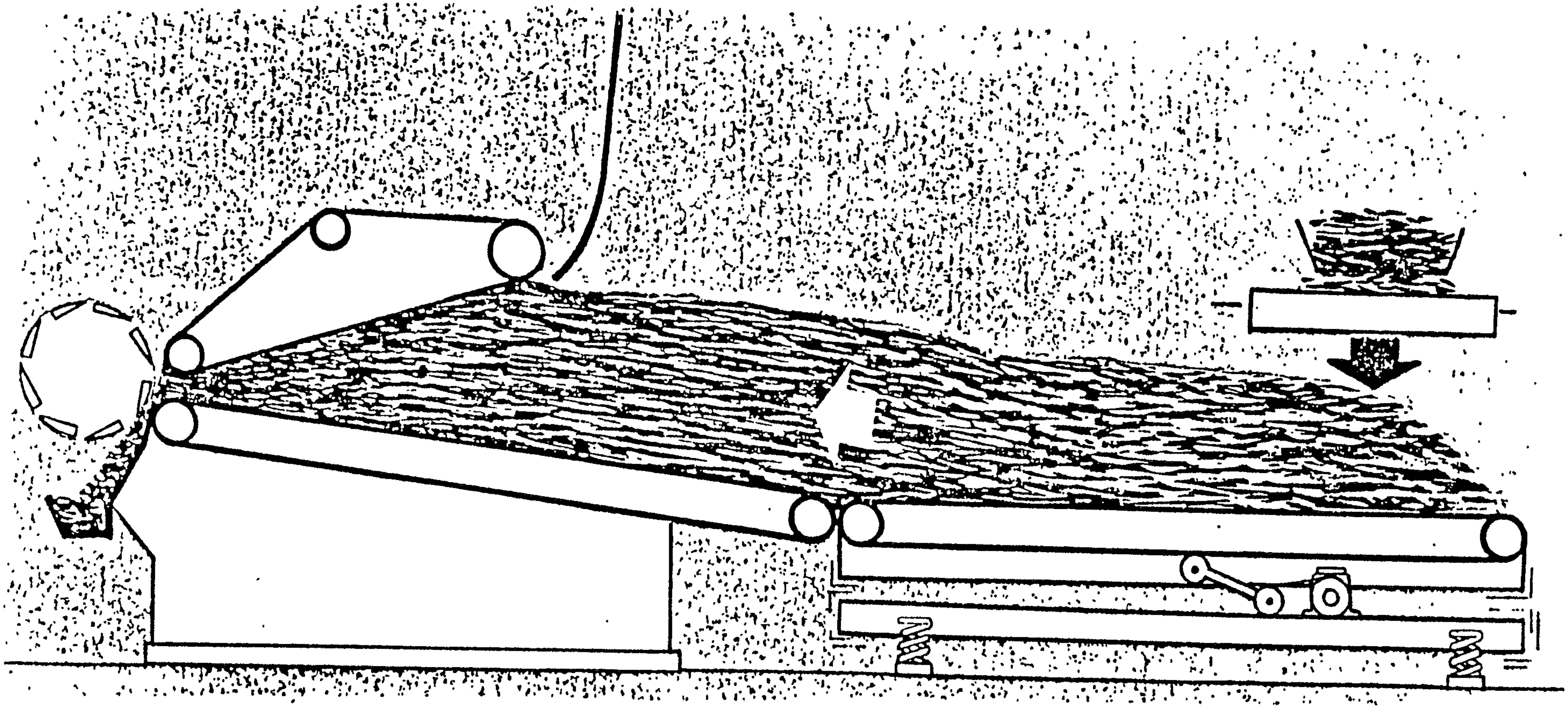

FIGURE 38: ROTHMAN'S FORCE FEED

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It should be noted that, because of the lower density of the cheese being extruded from the mouthpiece, there is something like a 20% reduction in the output from the cutter.

c. Performance of the Vibrating Feed System

AMF-LEGG modified Rothman's Force Feed and called it "Oribital Feed"; this was tested by Philip Moris with following results:

- At the cutter discharge small improvements in cut filler quality were indicated. These improvements averaged +0.34 CV units, +0.58 longs, -0.06% mediums, -0.67% shorts, +0.10% smalls, and +0.05% fines.

- No difference in cigarette quality was discernible for cigarette CV, sieves or firmness.

The oribital feed consists basically of a downward sloped vibrating conveyor with a round motion, thus presenting the cutter with a relatively dense stream of tobacco without a compactor. This feeding system will be installed in the Louisville plant as an "integral orbital feed", (see Figure 39 and 40), i.e., it is not a free standing device rather than attached to the cutter.

d. Improvement for Column Feed

Figure 41 a. shows a typical tobacco configuration in the hopper of a conventional column-feed: The strips are piling up in the middle.

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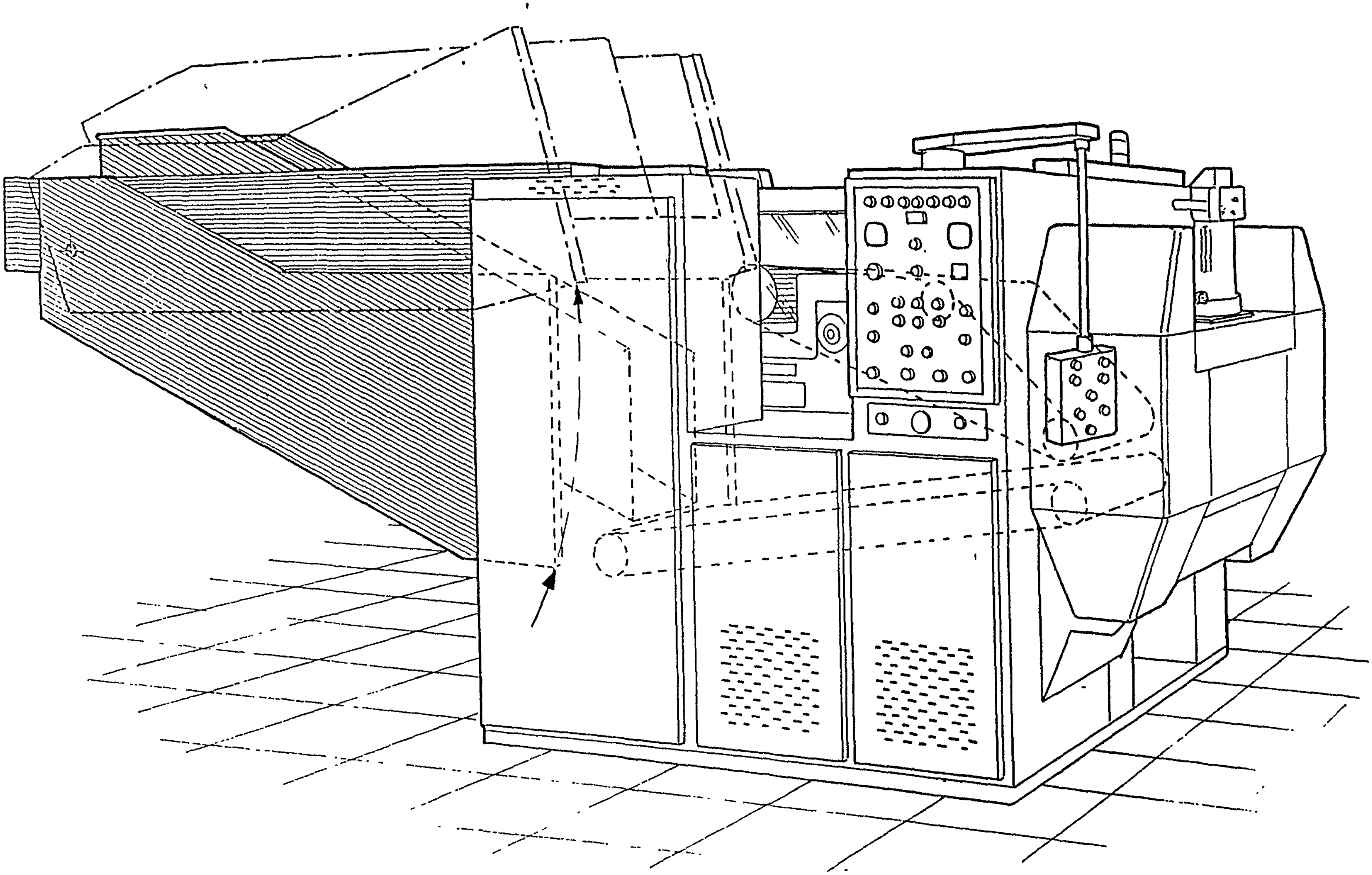

FIGURE 39: RC-4 INTEGRAL ORBITAL FEED

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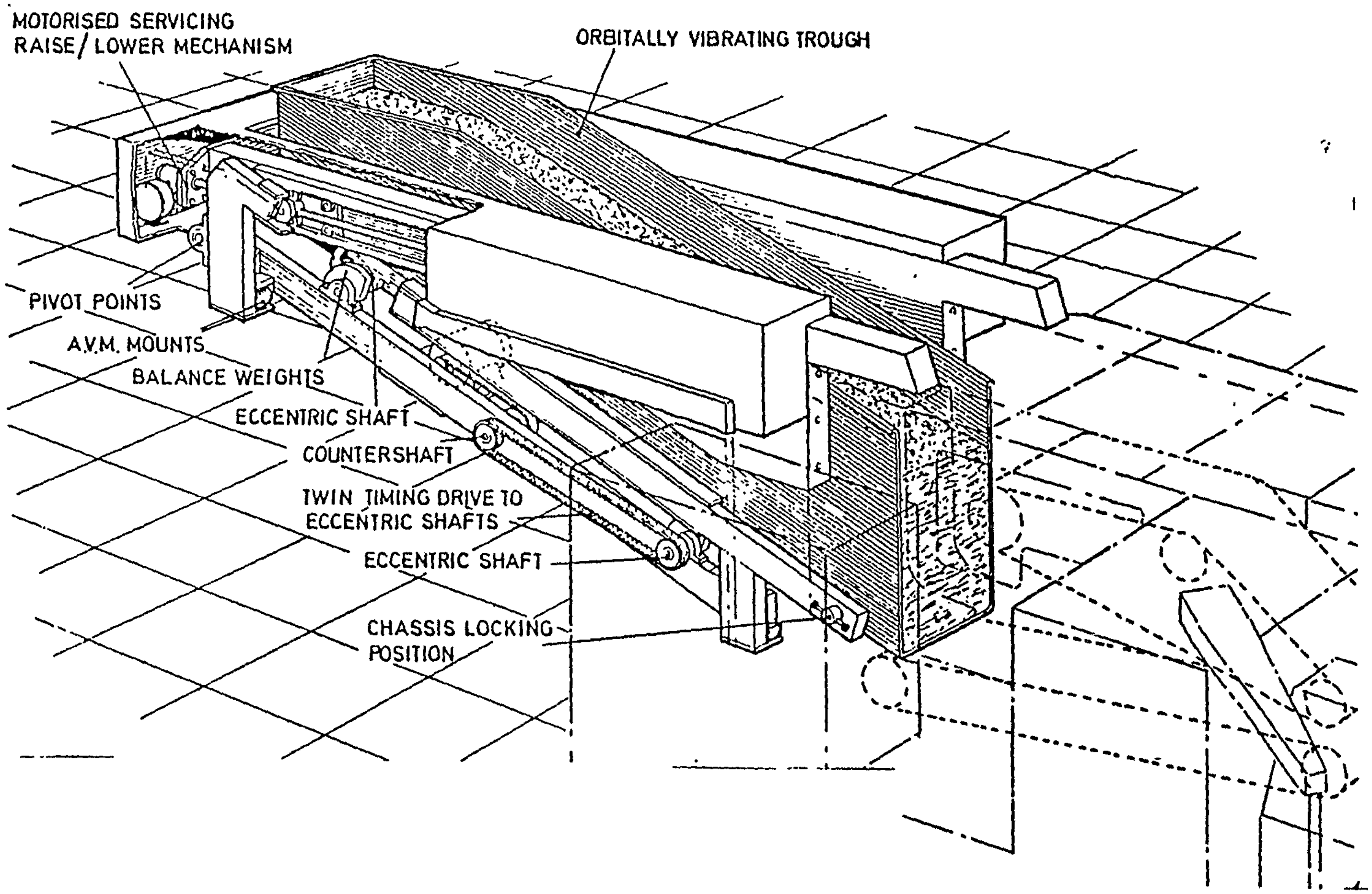

FIGURE 40: RC-4 INTEGRAL ORBITAL FEED

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This is not desirable, because the non-moving side-plates hold the strips back due to the unavoidable friction, thus decreasing the cheese density-level on the sides which may result in flags.

This can effectively be reduced by a piece of sheetmetal that directs the strips slightly to the sides causing a tobacco configuration in the hopper such as shown in Figure 41b.

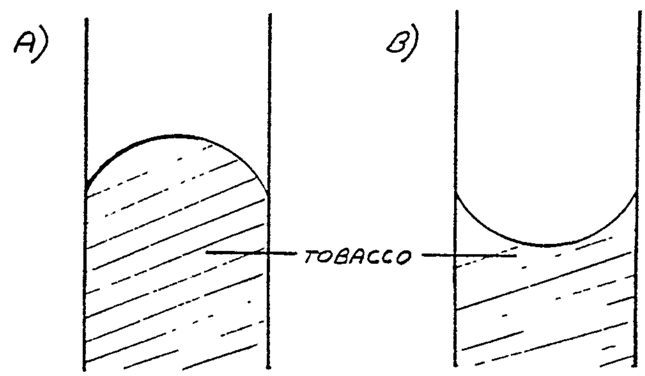

FIGURE 41: TOBACCO CONFIGURATION IN THE HOPPER OF A CONVENTIONAL COLUMN-FEED SYSTEM

Figure 42 depicts 2 possible shapes.

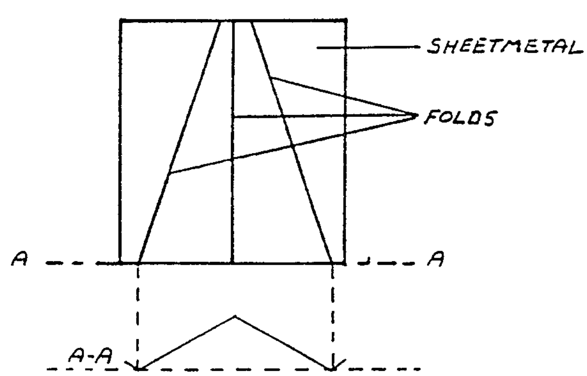

FIGURE 42: SHAPE OF SHEETMETAL

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7.6 Effects Of Cut Width

R&D has concluded that there is no filling power advantage at cuts checked at 20, 25, 30, 35, 40, 45, 60 CPI from the present 30 CPI. However, sieves are affected.

An increase in shred size will cause a decrease in static rate of burn: The rod length burn per minute decreased by some 4% with a 60% increase in tobacco and width.

On the other hand, puff count and cut width are directly related. An increase in shred size will yield a similar increase in puff count. Experiments at Philip Morris using puff count ratios (Figure 43), where the puff count of the altered cigarette is divided by that of a 30mm cut/inch control cigarette, show that an increase in cut width from 0.25 to 1.00mm will cause an increase in this puff count ratio from 0.87 to 1.10.

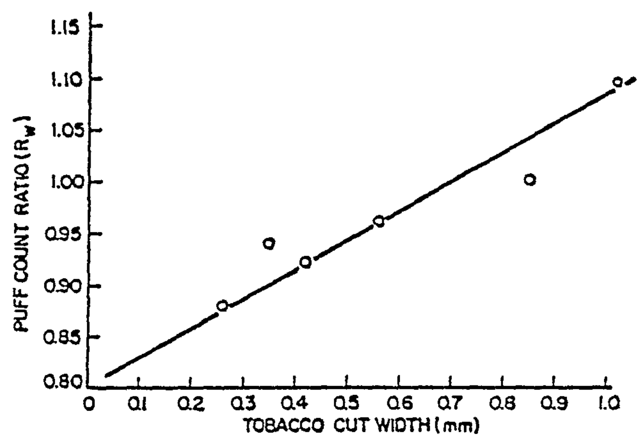

FIGURE 43: EFFECT OF CUT WIDTH ON PUFF COUNT RATIO

In another study, a normal cut width of 30-40 cuts per inch giving a puff count of 11 was used as a control. When this count

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cigarette was compared to a coarser cut of less than 20 cuts per inch, it was found the coarser cut to burn poorly and allow an increase in puff count to an average of 14 per cigarette. There is no uniform opinion whether the coarser cut results in higher total "tar" delivery, although the coarser cut provides usually for incomplete combustion. However, it is widely agreed upon that per puff deliveries of both "tar" and nicotine decrease with increased shred size.

As the cut becomes much finer, on the other hand, for example over 50 cuts per inch, no change in puff count was found. However, the decrease in filling power requires a larger amount of tobacco to be used to fill the rod and an increase in "tar" yield is the result.

Another study describes the change in smoke constituents on two extreme sizes of tobacco shred, 1.27mm and 0.42mm: The smaller cut showed a 27% increase in carbon monoxide, a 5% increase in carbon dioxide and a 21% increase in hydrogen cyanide, along with a 28% decrease in indole and a 18% increase in skatole. Although the smaller shreds burn faster and more efficiently, more carbon monoxide, for example is produced, ostensibly because there is more tobacco consumed.

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8. Drying of Cut Tobacco

8.1 Quality Goals

The removal of moisture from tobacco is primarily carried out in order to give it a definite and uniform moisture content best suited for cigarette manufacturing and final product quality. It has, however, becoming increasingly evident that dryers do not just simply reduce moisture content but also affect taste and burning characteristics, which are vital for a cigarette brand. Once these characteristics have been set and agreed upon, they must stay consistent. It has been demonstrated that some techniques for drying cut tobacco result in substantial increases in filling power, which is a very important smoke-delivery and economic factor if one wishes to produce cigarettes of consistent and acceptable firmness and with as little tobacco blend as is necessary. The drying process should not produce dust or shorts and as little off-spec tobacco as possible, i.e., a high yield should be achieved.

Furthermore, all fibers which are stuck together should be loosened in the rotating cylinder.

A personal, subjective evaluation of the dried cut tobacco should prove to be wooly and not brittle. Hand-compressed tobacco should spring-up, but not to quickly, thus showing being too dry and not too slowly indicating being too wet. The fibers are preferred to be long and not sticky.

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8.2 Drying Theory

"Drying" can be simply defined as the reduction in moisture content through the application of heat. Furthermore, the heat transfer causes both the evaporation of excess moisture and a chemical transformation of the tobacco, which improves the taste properties and curls the tobacco fibers, thus improving the filling power.

The mechanism of drying involves two steps:

1. Evaporation of water from the surface of the tobacco into the main body of the fluid (air)

2. Diffusion from the interior tobacco cells

Either process may be controlling, or both may be of importance in determining drying rate. In counter-current operation (see 8.3) there is some danger of overdrying the surface of the tobacco causing a layer of impervious material to be formed. This makes it difficult for moisture to diffuse to the surface, thus slowing down drying rate. Such a phenomenon in drying operations is called case hardening.

In some cases, both evaporation and diffusion of water occur. The way in which a solid dries and the point at which either of the two mechanisms predominates is a function of the physico-chemical properties of the material.

As long as the surface of the tobacco remains wet, evaporation proceeds at a constant rate, since during this period the surface behaves as a wet-bulb psychrometer, and the heat transferred from

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the warmer air and surroundings is quantitatively consumed in evaporating water at the surface of the material.

When, however, the moisture retreats to the interior of the tobacco, and the surface no longer behaves as thoroughly wet, the drying rate decreases, because it is a function of the concentration of the moisture left in the material. This is known as the falling rate period, and the moisture control at which this occurs is known as the "critical moisture content" (M_c). Eventually, the moisture content will reach equilibrium (M_e) with the air if the drying is proceeding to that point, and at this point, no further drying can occur. This is illustrated in Figure 44.

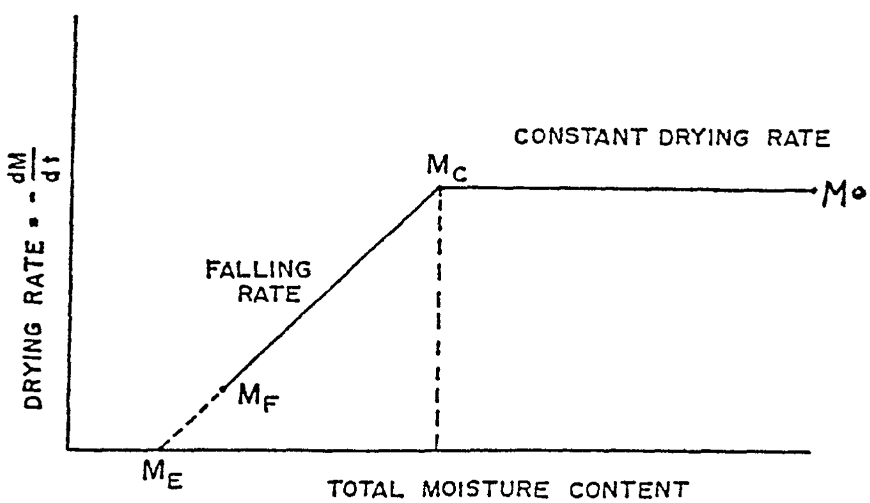

FIGURE 44: CONSTANT AND FALLING RATE DRYING PERIODS

In the falling rate period, the drying rate is primarily a function of the moisture content of the tobacco and the equilibrium moisture content of the tobacco whereas in the constant rate

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period, the rate of drying is primarily a function of the absolute humidity difference.

However, in most drying situations for materials of vegetable origin, one is dealing with the falling rate rather than the constant rate period. In reality, it is rare that the falling rate is linear with moisture as depicted in Figure 44.

The drying rate of tobacco can also be influenced by:

- the degree of maturity of the leaf
- treating or not treating the tobacco with hydrazide (MH30) and sodium chloride.

Maleic hydracide (MH 30) is used as a sucker control on the tobacco plant. The residue levels in the leaf mainly vary according to application practices, rain pattern and growth. In the last years these levels have been successfully lowered in the U.S.A. from 117 ppm in 1978, to 108 in 1981 and down to 98 in 1982. Some countries have set maximum levels, such as 80 ppm in West Germany.

Figure 45 shows two typical drying rates for flue-cured tobacco.

8.3 Dryer Design

a. Types of dryers:

- Rotary Dryers: continuous flow, co-current or counter-current
- Belt Dryers: Continuous flow, wire-mesh or solid, stainless steel punched plate

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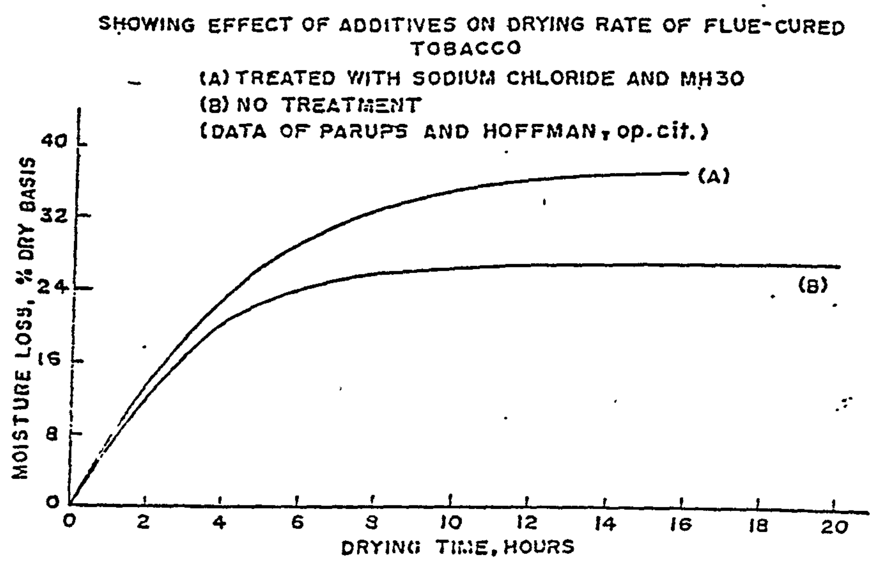

FIGURE 45: EFFECT OF ADDITIVES ON DRYING RATE

- Pneumatic: Designed by BAT

- Vacuum Dryers: Laboratory use only

- Atmospheric Oven Dryers: Laboratory use only

- Micro Wave Drying

In the selection of the proper dryer to be used, the following are generally taken into account:

1. The physical form of the material to be dried

2. The heat-sensitivity of the material

3. Cost: Capital investment and operating

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4. Local conditions, like available space and availability of energy (steam, natural gas, etc.)

5. Company's drying policy

Today, rotary dryers are predominantly used for drying cut tobacco. LEGG offers an "Annular" dryer with an internal heated cylinder and an external heated shell with the tobacco flowing through the annular space. High pressure hot water is used as the heating medium. This dryer has recently been tested with good results. ITM-DICKINSON makes a dryer with a gas-heated rotary shell and a unique moisture control system: The moisture of the product is changed by spraying water into the discharge end of the dryer to vary the evaporative load.

b. <u>Co-current vs. counter-current air flow:</u>

It has been demonstrated that filling power of tobacco can be increased by exposure to steam or high humidity atmospheres prior to or during the drying operation. Of the several known methods to accomplish this treatment, use of existing rotary dryers in a counter-current, low air flow mode is concluded to be the most feasible. This operation mode achieves the required steaming by providing a high humidity zone, and hence, high particle temperatures through condensation within the dryer at the tobacco feed end.

<u>Co-current drying:</u>

Cool tobacco meets with the warm and dry air which already leads to slight surface drying. Drying starts immediately,

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heating-up simultaneously. Fibres which are stuck together are not separated, but could, under certain circumstances even adhere more to each other. This is the case with heavily cased tobaccos.

Surface drying increases the danger of breaking.

At the dryer outlet, the air is being enriched with moisture and cools of at the same time. In the last section of the drier - the compensating zone - there is tobacco and air in thermic and hygroscopic equilibrium, relative to the condition which the tobacco should assume after drying.

Tobacco particles which are too dry are remoistened and those which are too moist are dried.

The effect is that the tobacco has a very even humidity after leaving the drier.

The temperatures of vapor and tobacco are almost even, at the drier outlet, and vary very litte. This condition is extremely stable.

Due to the higher exhaust temperature, the heat dissipated with the exhaust is greater than on the counter-current drier.

Counter-current drying:

Air streaming towards the tobacco entering has been enriched with water in the drier and cools off on meeting with the cooler tobacco. The dew point is reached here and moisture in form of mist and drops of water is separated out of the air.

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Tobacco is therefore moistened and dried in the drier inlet zone. With heavily cased tobaccos, it leads to separation of fibres which are stuck together. Surface drying at the drier inlet does not occur.

These are the advantages as opposed to the co-current drier.

With counter-current driers, air and tobacco are furthest apart from being in hygroscopic equilibrium at the drier outlet, so that drying is very intensive. This condition practically prevents moisture compensation so that the humidity of the tobacco leaving the drier is less even.

Increased surface drying takes place towards the end of the drying line which inadvertently leads to an increase of the formation of shorts - as with the start of co-current driers.

Temperatures of air and tobacco are far apart, depending on the starting temperature.

Tobacco temperature and humidity are less constant.

The exhaust temperature can here be lower than the tobacco temperature. If one remembers, however, that exhausted vapors will have to be dried off in order to prevent corrosion and keep the filter following operative, this plus-point with regard to energy saving, is inapplicable, as opposed to the co-current drier.

In Figure 46 and 47 the progression of tobacco moisture and tobacco temperature is shown for both drying-modes.

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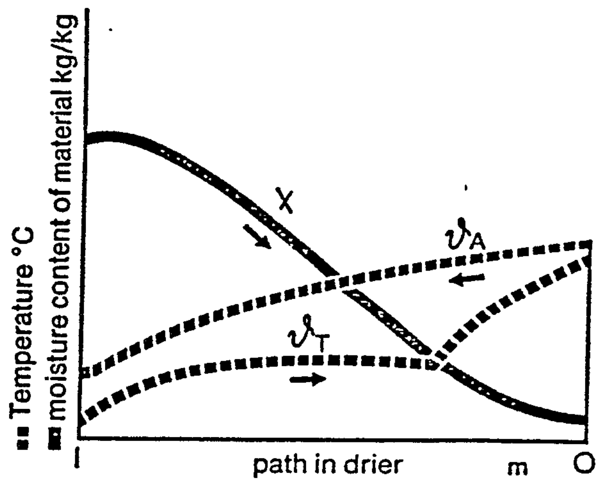

FIGURE 46: COUNTER CURRENT DRIER
Quantity of Air Corresponds with Amount of Material

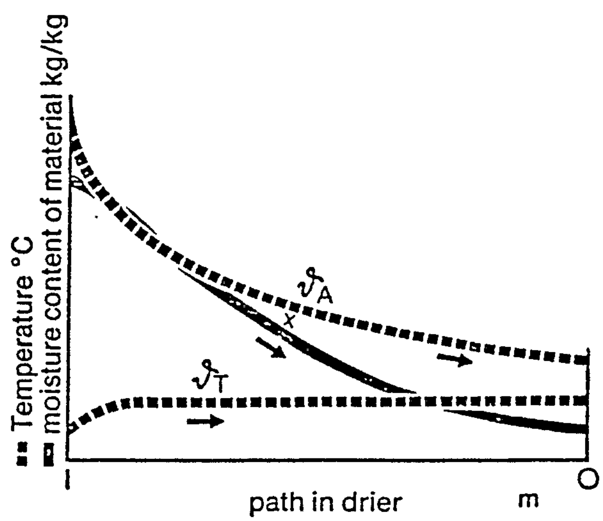

FIGURE 47: CO-CURRENT DRYER

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8.4 Process Parameters

a. Preheat Air Flow

The preheat air flow through a dryer affects the dryer gas humidity: As the air flow is increased, the amount of water evaporated (and, hence, introduced into the preheat air) also incrementally increases. The order of magnitude of the additional water evaporated, however, is not in proportion to the increase in preheat air flow and the net result is a reduction in dryer gas humidity. In Figure 48 the relationship of preheat air flow to the maximum dryer gas humidity is shown. This relationship results because the available quantity of water becomes more and more diluted as preheat air flow increases.

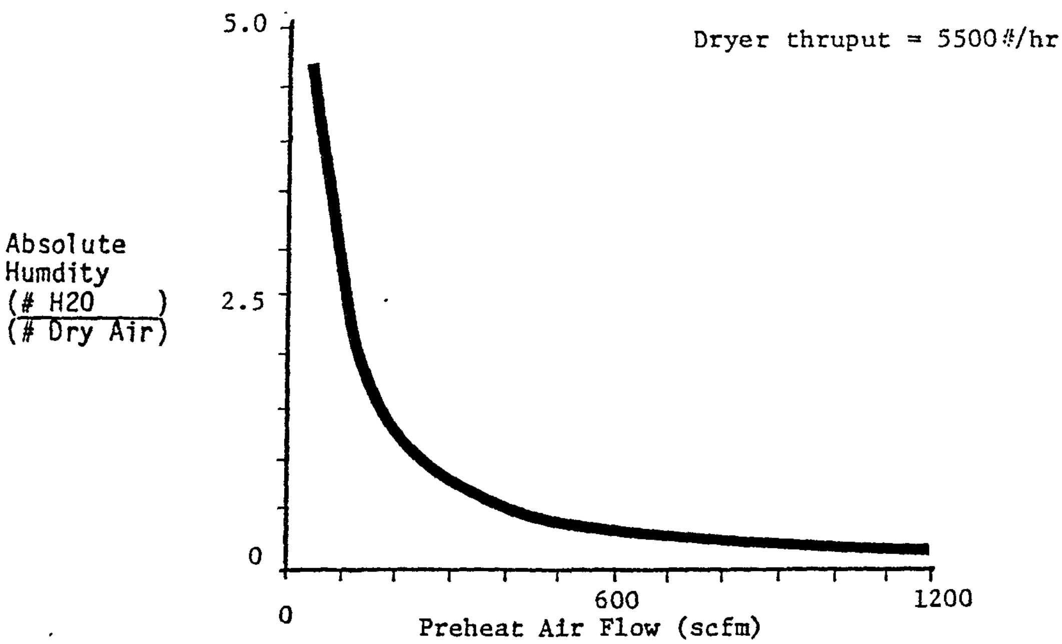

FIGURE 48: PREHEAT AIR FLOW (scfm)

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It should also be noted that there is an established psychrometic relationship between the humidity of air and the dew point temperature of the water/air mixture (Figure 49).

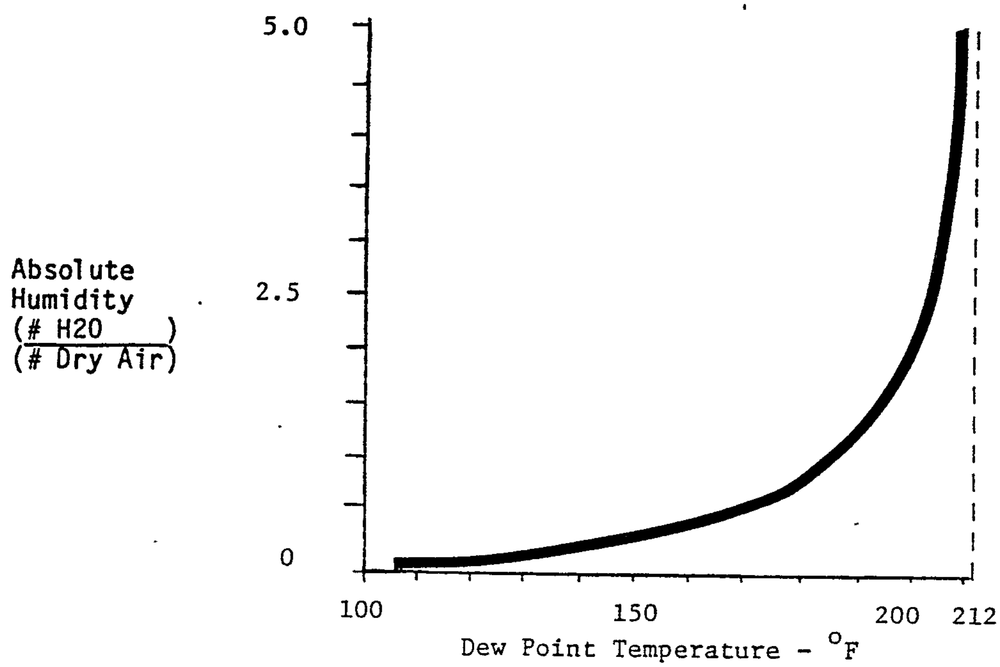

FIGURE 49: DEW POINT TEMPERATURE - °F

"Dew Point" is the temperature to which a mixture of air and water vapor must be cooled in order to become saturated, i.e., to be in equilibrium with liquid water.

b. Condensation in the Dryer

When considering a low gas flow (4 $m^3/kg\ H_2O$) counter-current dryer, as the cold tobacco enters the dryer, condensation of water from the dryer atmosphere begins to occur on the tobacco. The tobacco is heated up rapidly as the con-

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densing vapor gives up its latent heat to the tobacco. Condensation continues until the tobacco has heated up to the dew-point temperature of gas at which point drying will start to occur. Thus, the maximum temperature and OV that is reached by the tobacco in the dryer is a function of the dew-point temperature, which in turn is a function of gas humidity. Figure 50 illustrates these concepts.

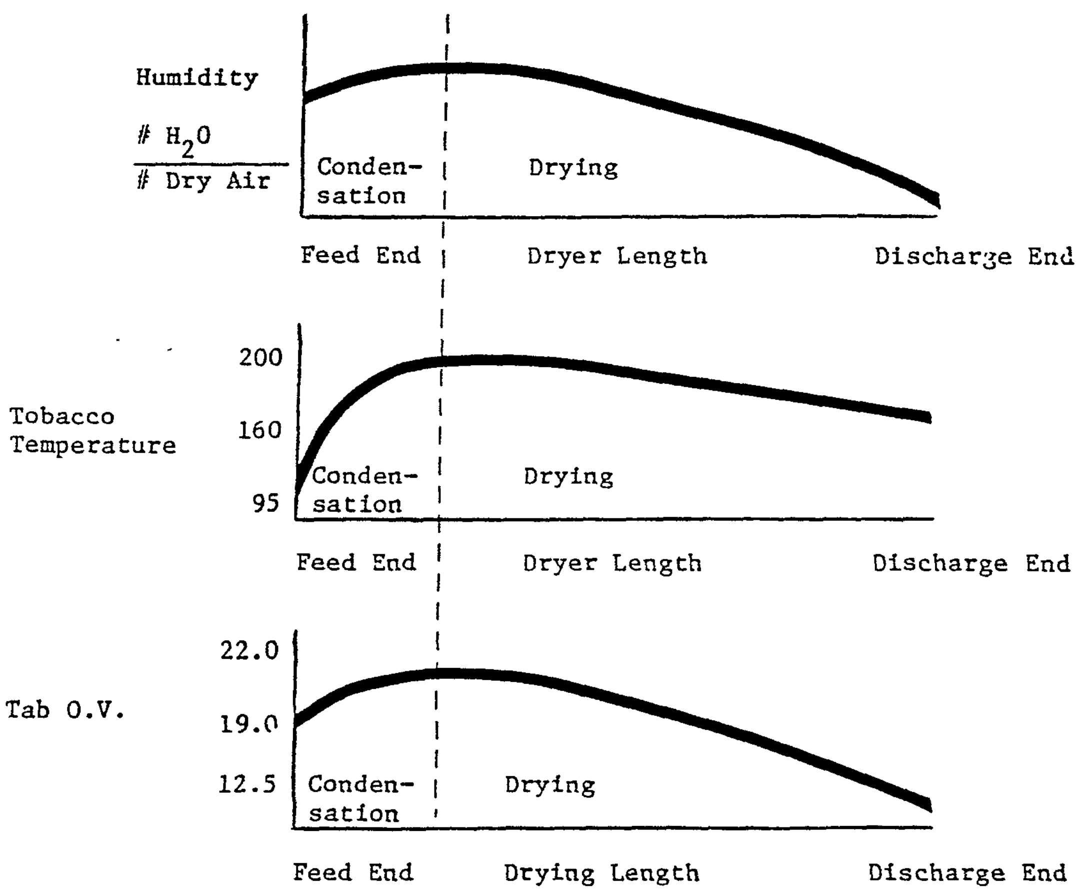

FIGURE 50: CONDENSATION IN COUNTER-CURRENT DRYERS

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c. Cylinder Volume (CV)

Experimental studies, wherein the tobacco feed OV was varied, have shown, that high OV levels yield greater increases in product CCV (= C.V. corrected to 12.5% OV). Furthermore, the product CCV is related to the process gas dew point temperature (and, hence, the particle temperature attained. Figure 51 and 52 show this graphically.

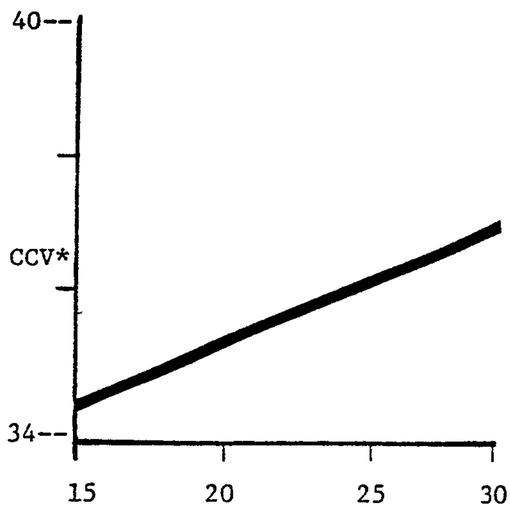

FIGURE 51: Feed O.V. (DWB) %

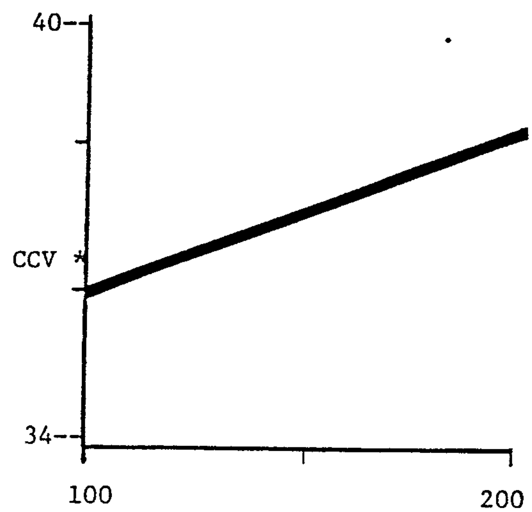

FIGURE 52: PROCESS GAS DEW POINT TEMPERATURE - °F

Combining the above two relationships, the increase in O.V. of the feed through condensation combined with the absolute humidity level of the process gas results in a C.V. relationship as follows (Figure 53).

As condensation occurs, the tobacco increases in both temperature and OV, moving along a path (indicated by the

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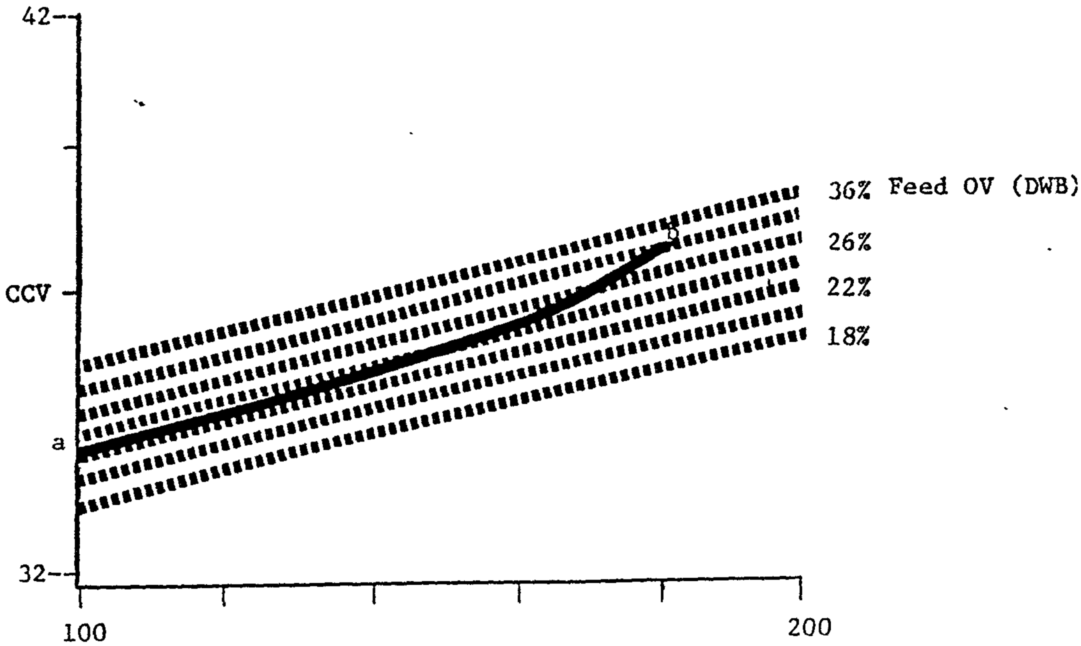

FIGURE 53: PROCESS GAS DEW POINT TEMPERATURE - °F

solid line) from point "a" to "b". Therefore, particle temperatures depend on the humidity of the process gas and the dew point and not primarily on the coil temperature which has no effect in filling power increase.

d. Dryer Throughput

There are several considerations unique to low air flow counter-current dryer operation which may result in reduced dryer throughput.

- The required low air flow reduces the drying potential that can be realized from the preheat air.

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- The condensation raises the feed tobacco OV. Thus, part of the dryer length does not contribute to the actual drying process thereby reducing the effective dryer length.

- The tobacco particles are significantly hotter over a portion of the dryer, compared to other modes of dryer operation, and the resulting ΔT driving force for the heat transfer ($T_{coils} - T_{tobacco}$) is thereby reduced.

8.5 Feeding System

A constant flow of tobacco through the dryer (or dryers) simplifies or solves many of the problems of drying control. If more than 1 dryer is used, the tobacco exiting the cutters is split into streams. This can be done by cascade conveyors, which are also referred to as water fall or hump-back conveyor. Metering tubes and a take-away conveyor guarantee a consistent and volumetric flow into each dryer (Figure 54).

a. Metering Tube

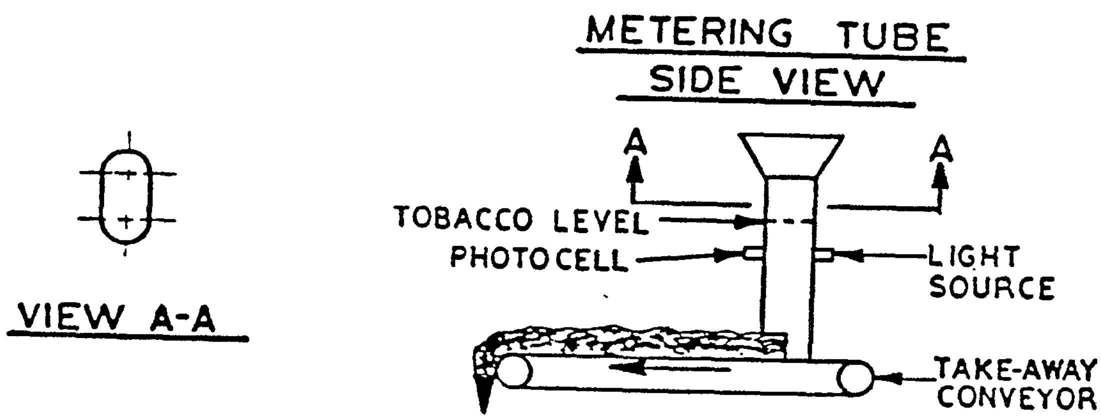

FIGURE 54: METERING TUBE

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b. Forward running cascade conveyors with refusing doffers feeding metering tubes

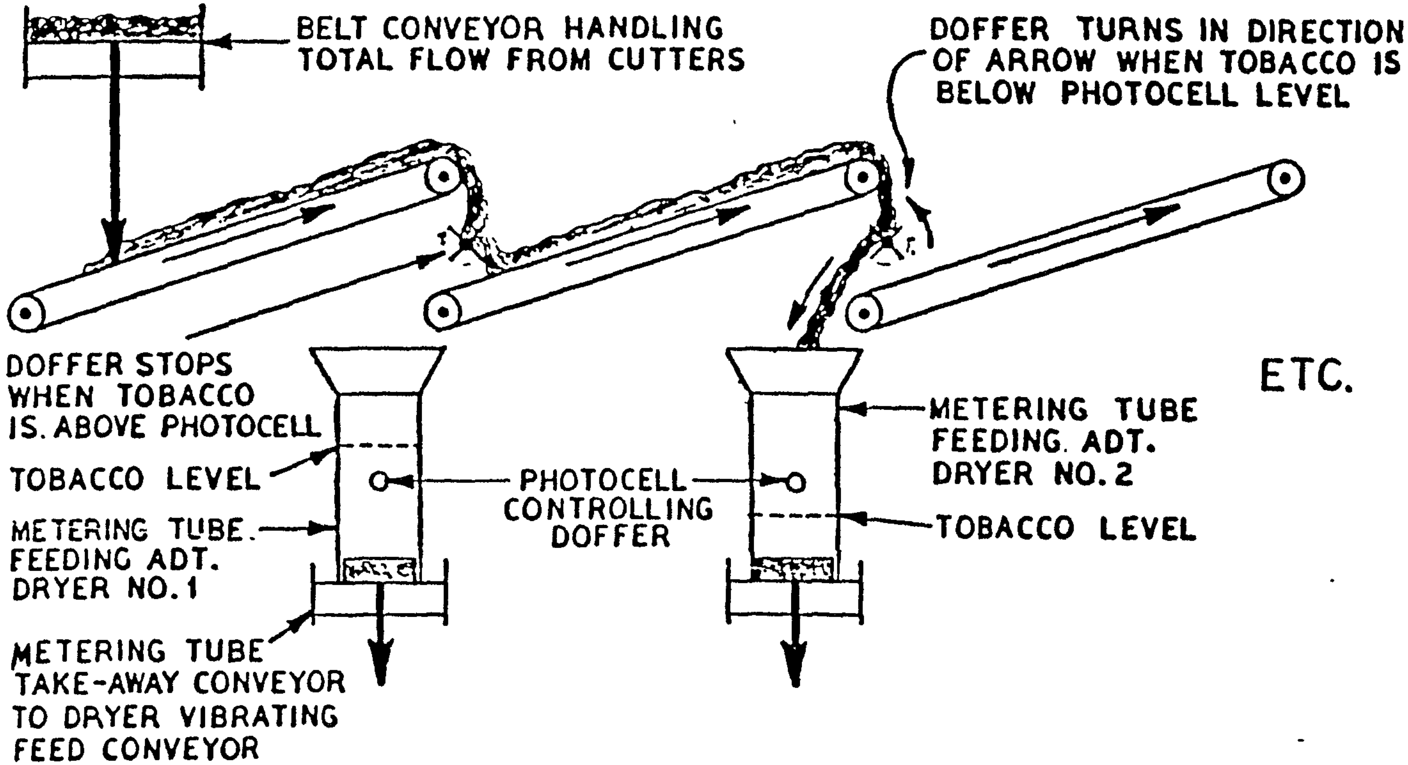

FIGURE 55: FORWARD RUNNING CASCADE CONVEYORS

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c. Reversing cascade conveyors feeding feeders which feed weight belts.

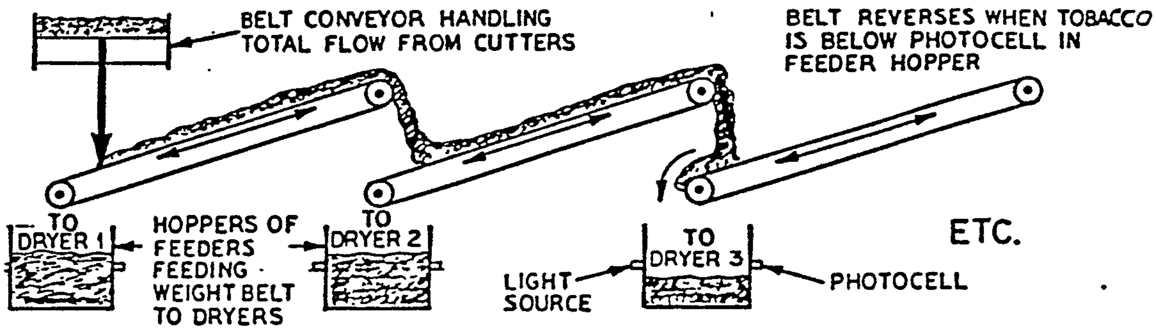

FIGURE 56: REVERSE RUNNING CASCADE CONVEYORS

8.6 Control of the Dryer

The tobacco moisture at the dryer outlet or behind the cooler is measured and thus forms the controlled variable of an air volume control unit. The LEGG-Annular dryer being tested has a different control mechanism. It uses an additional moisture meter in front of the dryer (Feed Forward) for controlling purposes.

In a counter-current dryer operation, the range of the air volume control is too small to smooth out all fluctuations. Furthermore, there are imposed limitations on preheat air flow volume in order to maintain control of product CV. This leaves the main heat source of the dryer, the steam coils, as the primary mode for controlling preheat air temperature and, hence, OV.

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It is important, that fresh air intake and exhaust remain balanced even during volume changes.

Generally, the short-term changes in the dryer are made by varying the preheat air volume, large moisture changes are made by varying the slower response steam pressure to the coils. Note, that a reduction from 120 psi to 80 psi appears large, the pressure, however, versus temperature diagram (Figure 57) shows that the coil temperature only decreases by 26°F. This 33% reduction in coil pressure results in only a 13% reduction in ΔT driving force ($T_{coils} - T_{tobacco}$) for heat transfer.

Automatic Dryer Control Program

The following program is realized in the Philip Morris U.S.A. dryers, it executes every 30 seconds, based on the moisture reading after the dryer.

a. Routine Control

- Airflow changed every 30 seconds based on moisture error (Moisture value minus moisture setpoint)

- Steam pressure changed every 10 minutes based on amount of airflow excess beyond nominal airflow operating range (250:400 CFM)

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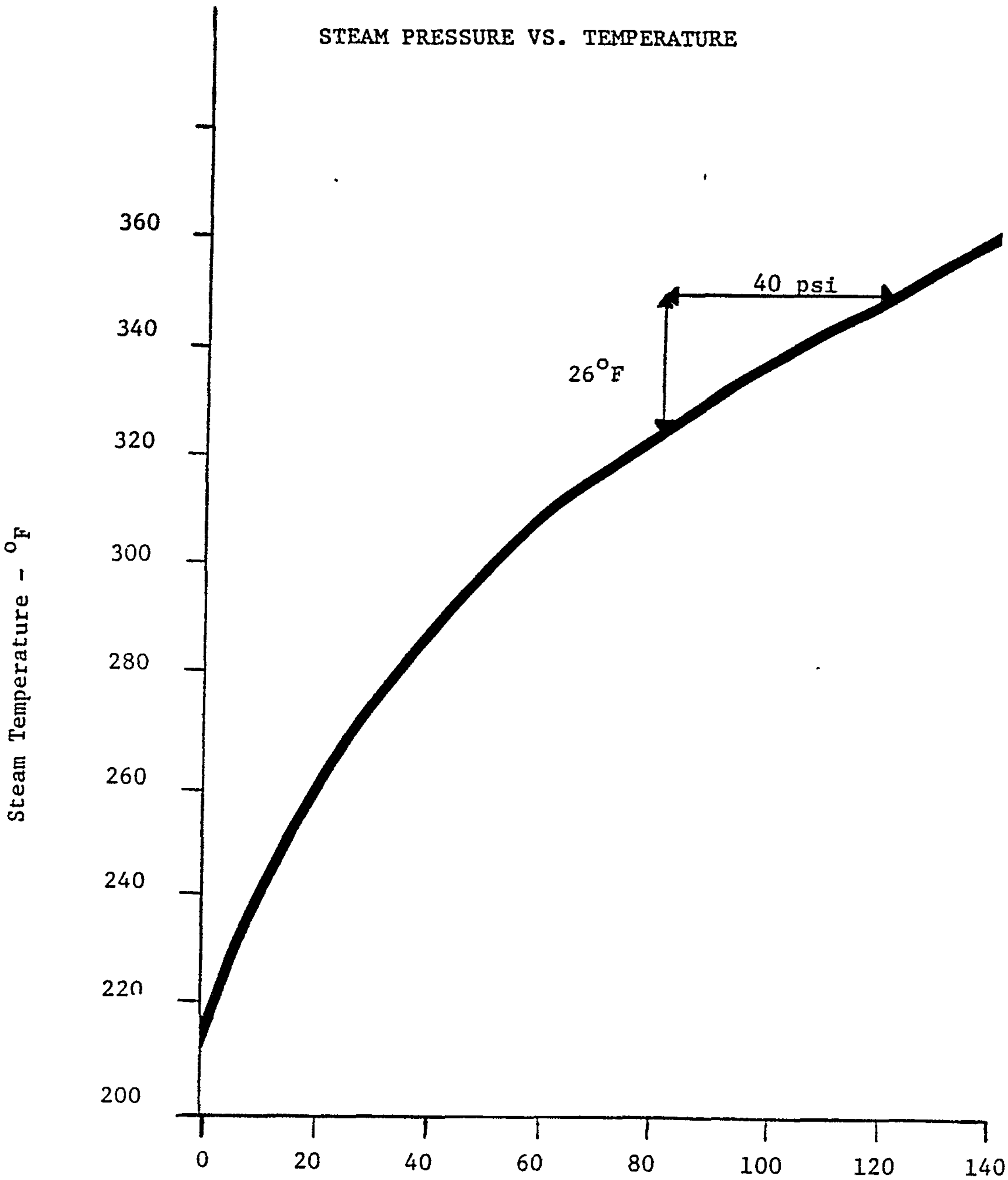

FIGURE 57: EFFECT OF COIL PRESSURE REDUCTION

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If average of last three minutes airflow is:

< 200 CFM -> Steam pressure reduction by 10 PSI

> 200 CFM)
< 250 CFM) -> Steam pressure reduction by 5 PSI

> 250 CFM)
< 400 CFM) -> No change

> 400 CFM)
< 450 CFM) -> Steam pressure increase by 5 PSI

> 450 CFM -> Steam pressure increase by 10 PSI

- After steam pressure change is initiated a counter is reset to allow ten minutes to pass before next steam change allowed.

- Airflow is then adjusted on a 30 second basis to eliminate moisture error generated by steam presure change thus forcing airflow back into the 250:400 CFM nominal operating range.

b. Shutdown Control

- Occurs when inlet tobacco flow passed downward through 1000 PPH over the feeder weigh belt

- Reduces steam pressure every 30 seconds (New steam pressure = Old steam pressure x .75).

- After three minutes into shutdown, steam pressure is set to 25 PSI

- A shutdown of less than 4 minutes: The dryer program goes back to normal control when the weight passes upward

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through 1000 PPH. Resumes set points used prior to shutdown

- A shutdown of more than 4 minutes: The dryer program will go into a startup when the weight passes upward through 1000 PPH

- Airflow changes are based on normal calculations during a shutdown

c. Startup Control

- Occurs when inlet tobacco flow passes upward through 1000 PPH

- Does not occur if dryer was not turning through shutdown.

  Controls airflow and steam pressure as follows:

  Steam pressure is delayed 4 minutes after startup. After 4 minutes the steam pressure is set to:

Moisture Setpoint	>	12.5	->	New steam setpoint	115	PSI
"	>	13.0	->	"	110	"
"	>	13.5	->	"	105	"
"	>	14.0	->	"	100	"
"	>	14.5	->	"	90	"
"	>	15.0	->	"	80	"
"	>	15.5	->	"	60	"

- Air flow is set to 0 CFM.

  When moisture value = .88 x moisture setpoint, startup airflow is set as follows: The delta moisture (inlet

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moisture - outlet moisture setpoint) x 285 - 1200 = startup airflow, (example: a delta moisture of 6% O.V. will equal 510 CFM start air). The dryer program will not allow startup air to go below 250 CMF and no higher than 700 CFM. Airflow is held at the startup air target for 1 minute, then allowed to return to normal control routine.

- When one minute has passed startup is terminated and a flag is set to allow the first steam pressure change in 5 minutes. Then steam control is returned to the normal routine (10 minutes between changes).

8.7 Steam

a. Requirements

The maximum steam pressure used for drying in rotary dryers is about 125 PSI. A dryer in good condition can evaporate about 1/2 lb. of water from the tobacco per lb. of steam consumed; this includes the steam required to preheat the air. In a low preheat airflow dryer (less than 75 CFM of air per 1000 lbs/hr tobacco feed) approximately 90% of the steam is consumed by the coils and only 10% is used to heat the preheat air.

b. Steam Quality

It is important to:

- Clear the condensate out of the steam lines and the dryer heating surfaces quickly - as soon as it forms. Different kinds of steam-traps do that.

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- Eliminate air and gas that are present in the lines along with the condensate.

Air may enter the boiler system either through the boiler make-up water, or it may be sucked back into the system due to condensation of the steam when the dryer is shut down. Other non-condensible gases such as carbon dioxide (CO_2) and occasionally carbon monoxide (CO) may also enter the system due to minerals in the boiler feed water and the chemical action that takes place during the boiling process.

These gases together with the air also tend to form in layers that act as insulating blankets in a similar way as the condensate does. In addition, when mixed with the steam, air and gas lower the temperature of the resulting mixture (Figure 58).

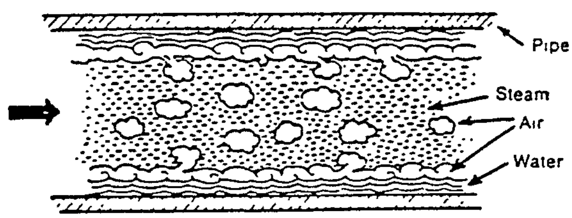

FIGURE 58: INSULATING LAYERS IN A STEAM PIPE

Therefore, a device must be installed, that

- Lets out the condensate but holds back the steam to save it for useful work

- Eliminates air and gas quickly, particularly on startup after the dryer has been shut down for a period

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- That accomplishes the required removal by responding promptly to changing conditions in the line.

This device is called "steam trap"; it may do this job by either responding to temperature changes in the line (hot steam vs. slightly cooler condensate) or it must be able to differentiate between liquid and vapor.

There are mainly 3 different types of steam traps:

1. MECHANICAL - This class operates on change of phase of the fluid coming to the trap, i.e, whether water or steam - they open to water or condensate - but close on steam.

2. THERMOSTATIC - Actuated by the temperature of the liquid flowing to the trap - open on cool condensate - close near steam temperature.

3. THERMODYNAMIC - Operate by utilization of the differences in thermodynamic energy available from steam and hot condensate.

c. Condensate Removal System

Previous System

The steam enters the dryer through a rotary joint at the end of the cylinder. This results sometimes in reheating the outgoing condensate which is picked up from the bottom of the cylinder by a siphon tube extending into the cylinder. Pressure in the cylinder then forces condensate out of the

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siphon tube past the incoming hot steam. If condensate is not picked up from the rotating cylinder at a constant rate, the siphon is filled with steam part of the time. When this steam reaches the trap it causes it to lock until the steam is condensed. This means that the condensate can clog up the whole cylinder sometimes, thus preventing the required heat transfer. Frequently the operator of the dryer just opens the by-pass valve of the steam trap to clear the cylinder; that means a manual interference with the process and a loss of steam.

Modified Condensate System

As Figure 59 shows, two major modifications have been made:

1. The relatively high pressurized condensate is fed through a preheating system, connected upstream to the main air heater. This cools the condensate further down and uses the remaining heat-energy for the drying process.

2. The condensate line coming out of the rotary joint is split into 2 pipes: One is sloped downward to let the condensate flow to the preheating system, the other goes straight up to an elevated thermostatic trap; this trap serves as air vent. The piping downstream to the trap leads into the floor drain.

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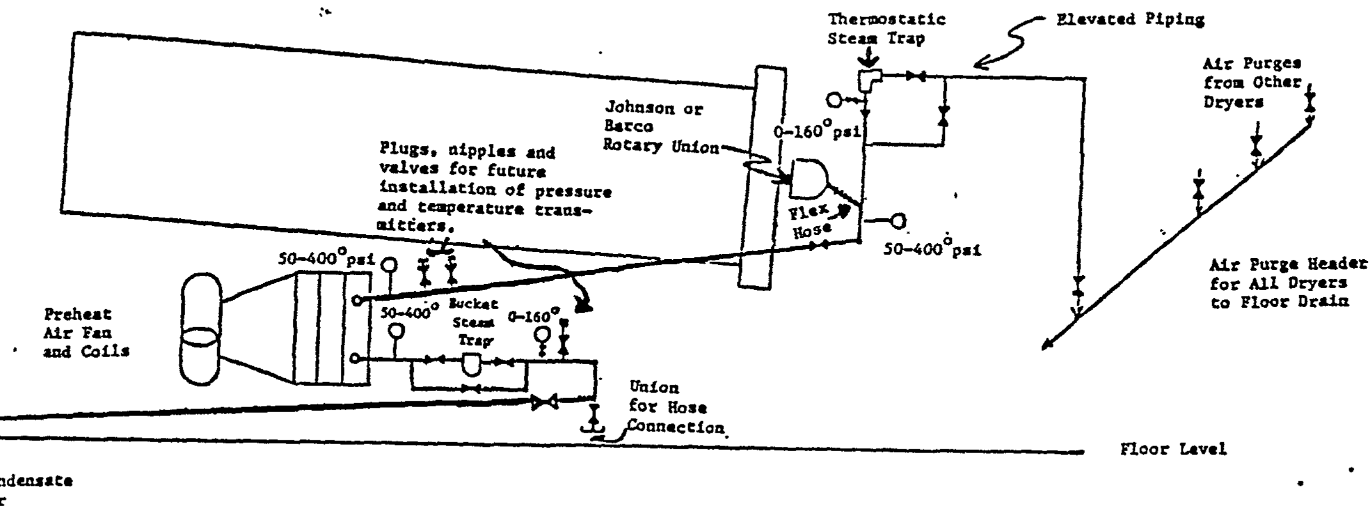

FIGURE 59: MODIFIED DRYER CONDENSATE SYSTEM

Notes: 1. All condensate lines to be sloped downward to assist gravity flow

2. Condensate piped to first preheat air coil only

This system has improved the heat transfer clearly as the following table shows.

To further increase the efficiency of existing dryers, they have been sandblasted on the inside to remove different kinds of build-up. The result is a better heat transfer, i.e., a low steam pressure and a high steam flow.

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STEAM AND AIR FLOW DATA

Conditions	Inlet OV, %	Exit OV, %	Tobacco Flow, #/hr	Steam Pres. psig	Steam Flow lbs/hr	Air Flow acfm
Before Sandblasting						
No Condensate Cooling	19.7	13.7	7,500	125	750*	1,200
After Sandblasting						
No Condensate Cooling	19.7	13.7	7,500	125	750*	1,000
With Cooling	19.7	13.7	7,500	45-50	1,100	200
With Cooling	19.7	12.7	7,500	95-100	1,200	400
With Cooling	21.5	13.5	7,500	125	1,400	1,000
After Sandblasting With Reduced Throughput						
No Condensate Cooling	21.5	13.5	6,000	125	750*	1,200
With Cooling	21.5	13.5	6,000	95	1,200	200

*Maximum steam flow due to condensate holdup

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9. AFTER CUT

The After Cut is the final flavoring applied to the tobacco before it is made into cigarettes. It is the only one applied to cut tobacco, as opposed to strip tobacco. Herbs, extracts, essential oils, and flavorants may be added to an alcohol/water base that may also include humectants. It is difficult to generalize about After Cut, because it is so dependent upon exactly what type of cigarette/taste you are trying to create. The usual goal is to enhance or modify the natural tobacco flavors, depending on the types and quality of tobacco in the blend. The usage level of flavorants may vary from parts per thousand to parts per billion, depending on the flavor, the degree to which you want to detect it, and whether or not you are using the flavor for its primary or synergestic properties.

9.1 Typical AC Cylinder

From the drying area, the cut filler is conveyed to the AC cylinders where AC flavor is applied. The exact type of system used will vary in each plant, depending on its needs, philosophy, and resources. The size of the cylinder will depend upon the throughput; one of the methods described in 4.4c might be used. Inside of a typical AC cylinder at the exit end is a spray nozzle rack housing from 2-12 air atomized nozzles. They are internal mix 1/4 inch or 1/8 inch series nozzles. The cylinder rotates about 14 RPM. After the tobacco is cut, flights 4-6" high are

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used in the cylinders instead of pins. They are usually set at 45° straight through the cylinder, and taper about 36" back from the front and exit of the cylinder.

In older primaries, the cut filler may be pneumatically conveyed from the cut filler dryers to the cylinder. This type of conveying has the advantage of cooling the tobacco exiting the dryer. However, filler breakage increases when compared to the belt or vibrating conveyors favored in newer primaries. Mix cylinders have been used after the flavoring cylinder to provide a better blending of the flavored tobacco, but cut filler storage silos with blending capabilities have essentially replaced them. Less breakage occurs in the silos.

9.2 Flavor Application

a. System Components

The degree of sophistication of an after cut flavor application system varies widely at PM installations around the world. Due to the criticality of this stage, it is usually the first application area to be upgraded in its process control. At a minimum, all systems contain at least a pump, a filter, a control valve if the pump is not variable speed, and a flowmeter. The pump is usually a positive displacement type. It may also be a precise metering pump utilizing a variable speed motor. In the latter case, a control valve would not be necessary. Moyno, oval gear, and piston pumps are all used for this service. The filter should have a 1/32" mesh basket inside.

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A/C systems also inculde a flowmeter, usually a magmeter. In the last year or two, the Micro Motion mass flowmeter has been installed in some locations instead of magmeters. It is sensitive to vibration, but is otherwise independent of viscosity, density, pressure, temperature, and suspended solids. Its readout is in mass, not volume. Both can be coupled to remote display in a panel. A PM AC system also typically contains a rotometer as a back-up flowmeter. Though not as accurate as either of the first two meters, it is cheaper and simple in its construction.

For additional control, we have already mentioned variable speed positive displacement metering pumps. PM has usually opted for control valves instead, coupled with an I/P converter. A case may be made for either one. Both methods also require a flow indicating controller to process the flowmeter signal. When a ratio station is added the FIC will also process the weighbelt signal. Where graphic records are desired, recorders are installed.

b. Process Control Modes

In the most basic operating mode, a variable speed pump will have a flow rate set either at the pump, on a thumbwheel potentiometer, or on a flow indicating controller (MANUAL position). If a single speed pump is used, the flowrate will be predetermined. The pump will then dose a fixed volume of AC flavor per minute, regardless of conditions. A flowmeter would only monitor under these conditions.

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The next process control mode would be the inclusion of a flow indicating controller (if not already present). Along with this, additional equipment would include either a flow control valve and an I/P converter, or a variable speed pump drive that accepts an electronic input. For this mode, the FIC would be used in the LOCAL position and a flow rate set. Now, any deviation from the set point that is detected by the flowmeter will be relayed to the FIC, which in turn will send correction instructions to either the variable speed pump drive or the flow control valve (via the I/P converter).

The third level of process control is the REMOTE mode on the FIC. This is known as ratio control, because the flow rate is now set on a ratio station (FrC), representing a certain flow rate of AC flavor per 1000 lbs or kilos of tobacco. A weigh belt is required to send a signal to the ratio station which in turn converts the signal and transmits it to the FIC. Now, the tobacco flow is compared against the flavor flow, and if they are not in balance, a correcting signal is sent out as in the LOCAL mode. This uses a floating or remote set point, instead of a fixed set point.

The highest order of process control PM uses incorporates dry weight control into the previous mode. A moisture meter feeds into a process controller (PC) or computer which converts the tobacco weight to a 0% moisture figure. Now, the last process variable, tobacco moisture, has been taken out of the equation to provide a ratio of flavor to constant moisture tobacco.

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Concerning the tobacco weight signal; this can be the sum of all weigh belts entering the cylinder (i.e., cut rag, expanded tobacco, expanded stems) or simply the cut rag weigh belt. In the latter case, the blend ratios of the other components must be factored into the flavor application rate formulas.

9.3 Interlock Systems

There are a number of interlock systems possible around the flavor cylinder. A list of some of the more common ones follows. This is not intended to an exhaustive list:

- The system shuts down upon loss of atomizing air.
- The system shuts down upon loss of flavor flow.
- The system shuts down upon loss of tobacco flow.
- The pump shuts off when the tank is empty.
- The pump shuts off upon high line pressure.
- A HIGH or LOW FLAVOR alarm sounds when the flow rate deviates more than "x" percent from set point.

Variations of these interlocks are also used.

9.4 Safety

In Philip Morris U.S.A. the AC cylinders are equipped with a FENWAL explosion suppression system. This system is used to suppress any explosion in the system due to a buildup of pressure in the system. It may include as many as 7 individual FENWAL units, strategically placed to cover both ends of the cylinder as well as the exhaust duct.

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Although there has never been an explosion in an AC cylinder within Philip Morris and stainless steel cylinders are generally not sparking, there is a (slight) possibility that another piece of metal (a pin for example) or an electric light in/near the cylinder might cause sparking. During the normal AC application the alcohol concentration in the major portion of the cylinder is too high for an explosion (flammability: 3.3-19% by volume in air). However, in start-up, shut-down and downtime periods, as well as in the entrance and discharge zones during normal operation, a potential danger exists, hence the Fenwal units.

The Fenwal system operates on the premise that there is a short time delay, usually millisecond, between the ignition of a spark and the buildup of explosive pressure. In those milliseconds, the system detects an increase in pressure due to the spark in the system. The Fenwal system then releases high pressure water to extinguish the spark.

Each Fenwal system has a power unit, detectors and suppressors and/or extinguishers. The suppressive container is a globe-like structure with a rupture disk which breaks to release high pressure water. The components of the units must be tested regularly and periodically replaced.

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10. Casing/Flavor Kitchen

10.1 Types of Casings/Flavors

There are four major casings and flavoring systems; Burley Spray, Bright Casing, Burley Top Casing, and After-Cut Flavoring. Burley Spray and Bright Casing are water-based casing solutions, whereas Burley Top is an alcohol-based casing solution and the after-cuts are alcohol-based flavoring systems. Figure I (page 12), a simplified flow diagram of the Primary Process, shows the points of addition of these casings and flavoring systems.

a. Burley Spray

Burley Spray is a water-based blend of raw sugar, licorice, and other sugar related flavor ingredients. It is the first of two casings the Burley strip receives. The purpose of the Burley Spray is to increase the naturally low sugar content of Burley tobacco. Burley Spray is applied to the Burley strip at an elevated temperature (180°F). The strip is then processed in an apron dryer to dry the sugar solids on the Burley strip.

b. Burley Top Casing

This is the second casing applied to the Burley strip after the Burley dryers and before the cutter. The flavor concentrates used are soluble in alcohol only; hence the Burley Top Casing is an alcohol-based solution. Since some of the flavors are volatile they dictate that the Burley Top Casing

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be applied after the Burley drying operation. The humectants and plasticizers in the casing solution make the Burley strip pliable to minimize breakage during cutting. Burley Top is the final casing the Burley strip receives before it is blended with the Bright/Turkish strip components prior to cutting.

c. Bright Casing

The Bright Casing is the only casing the Bright/Turkish strip components receive prior to cutting. The Bright Casing has a purpose similar to the Burley Top Casing. The flavor concentrates used in the Bright Casing are water soluble; hence the casing is a water-based solution. Bright Casing is prepared and applied at approximately 130°F.

d. After-Cut Flavor

After-cut flavor is a liquid flavoring applied to the total tobacco blend after cutting and drying. The flavor concentrates or "pre-blends" used are alcohol-soluble, and all the after-cut flavorings are alcohol solutions. The after-cuts are applied after drying due to the volatile nature of the flavoring systems. The after-cut Flavorings are the most important of the casing and flavoring systems in that they significantly contribute to the cigarette taste characteristics. For this reason, separate systems (tanks, pumps, and piping) are provided or dedicated for the preparation, storage and application of each after-cut flavor system.

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10.2 Typical Flavor Room

The purpose of the flavor room is to receive flavor ingredients and raw materials, measure and blend these into specific pre-blends, casings, or flavors, and to supply these blends to the proper tobacco processing areas in ready-to-apply consistencies and quantities. Figure 60 depicts a typical flavor room.

A flavor room is divided into at least two main areas, sometimes as many as four areas. At minimum, one area for receiving and storage and another for blend preparation are necessary. Sometimes blend preparation is separated into explosive (alochol-based) and non-explosive (water-based) areas. The explosive area may be further divided into a pre-blend and a Burley Top Flavor/After Cut blend area. In factories where the application tanks are not beside the cylinders, or where buffer tanks are employed, a storage area is often established. The casings and flavors may then be pumped directly to the application cylinders.

a. Receiving and Storage

This area usually consists of a "tank farm" for bulk ingredients, a small volume liquid area for drums, and a storage area for dry ingredients. In the first area, tanker trucks are offloaded by a pumping station. Each line has a quick disconnect, its own pump(s), and safety features. Every tanker truck load should be tested by Q.A. before offloading. The bulk storage tanks are large, typically 1000-6000 gallons. They may be located inside or outside of the factory, although

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for safety reasons, the alcohol tanks are always buried underground outside the factory in compliance with local fire and safety codes. The alcohol may also need to be de-natured with methanol, depending on local regulations. The tanks are dedicated to one ingredient only, and some may need to be heated if they are located outside. A 10-30 days working supply is generally recommended, though individual supplier details will dictate specific policies. The ingredients are held in the tank farm until required for blending, and then are pumped directly to the blend tanks.

In a separate area in the flavor kitchen, 55 gallon drums of small volume liquids are kept, sometimes on pallets. Dry granular, powdered, and solid ingredients are stored on pallets in another area. For a large scale operation, tote bins with scales and a screw conveyor are sometimes added to handle bulk dry ingredients. This type of set-up can alleviate some of the dust problems common to powdered ingredients.

b. Pre-Blending

In the pre-blend room, the pre-blends or flavor concentrates are prepared for use in the specific casings or flavorings. Fifty-five gallon drums of small volume flavor ingredients are stored on racks in the preblend room. Smaller volumes of concentrated flavor ingredients are stored in bottles and cans. Pre-blends are prepared in both small volume portable and permanent tanks. They are usually prepared on a daily basis and either stored in 55 gallon drums for future use or pumped into

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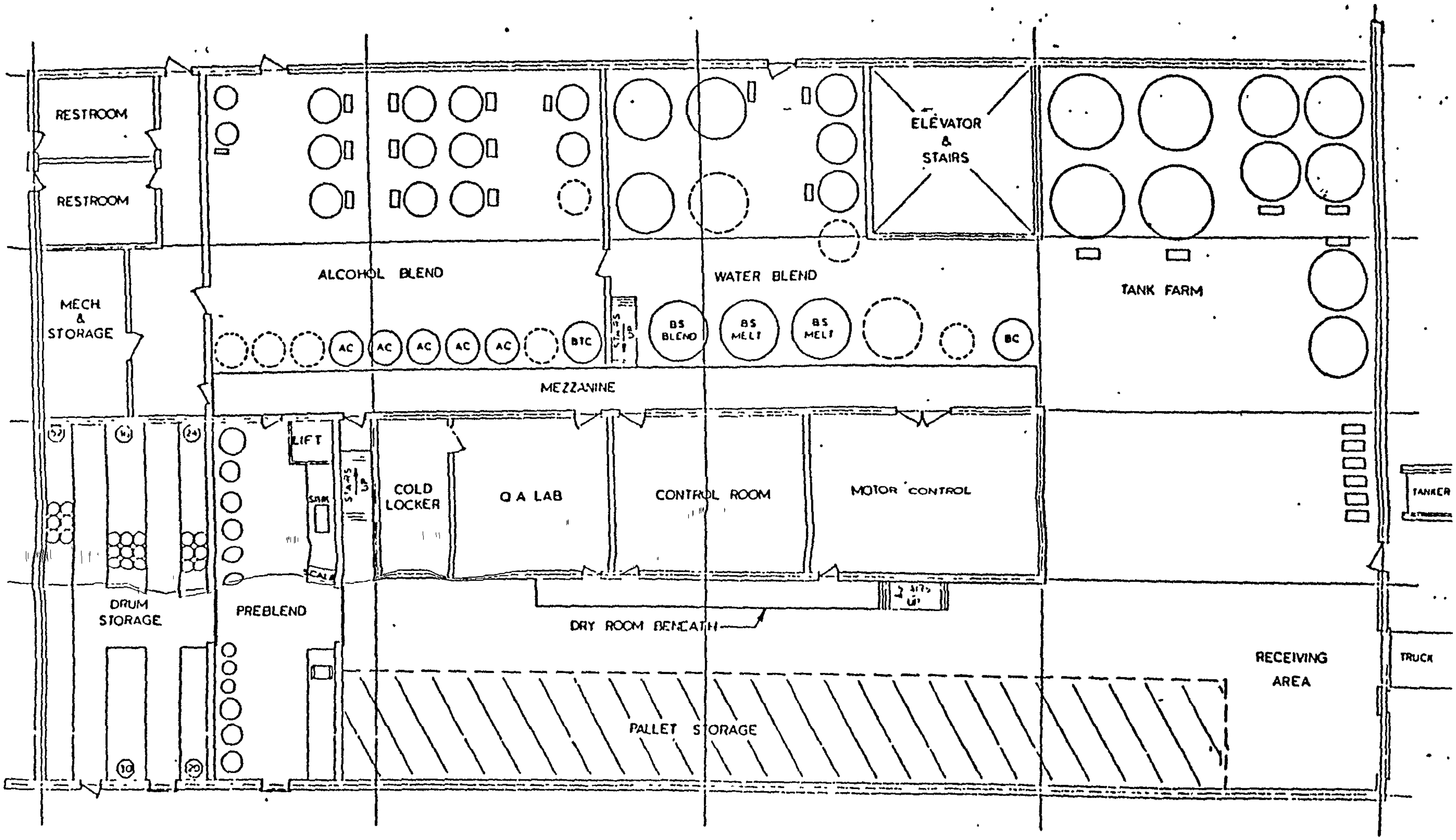

<u>FIGURE 60</u>: TYPICAL FLAVOR ROOM

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portable tanks for transportation to the proper blend tanks. All pre-blends are classified flammable liquids, and therefore special regulations are applicable (USA: Class 1A or 1B/ National Fire Protection Association (NFPA) Code 30 applies to this room).

Not all locations use pre-blend rooms. Some add the concentrates directly to the blend tanks.

c. Casing Blending and Storage

Ideally, the casing and flavor blending areas are located in separate rooms. Otherwise, due to the alcohol in the flavor blends, the entire blending area must be classified as a hazardous (Group 1, Class 1, Division D) area. In the casing room, Burley Spary, Bright Casing, and if applicable, Stem Casing, are all prepared. All casings, especially Burley Spray, are designed to be prepared and used the same day. The blend tanks are all steam heated and insulated Burley Spray to 180°F and the other two to 130°F. The tanks are usually mounted on a platform for better access. All tanks, blending and storage, are 304 or 316 stainless steel. The same holds for the process piping. The agitators are mounted on an angle in the tank.

The basic preparation steps for the water-based casings are similar. The bulk ingredients from the tank farm are metered to the blend tank one at a time, dry ingredients are added, then the batch is heated while under agitation until the

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application temperature is reached. The batch should then be ready for transfer to buffer or application tanks. The blending operation can vary from completely manual to highly automated, or anything in between. The most sophisticated primaries are capable of punching a brand code into a computer or PC, which will then recall the formula for that brand, pump the necessary quantity of each bulk ingredient through a flowmeter to the designated prep tank, open all the correct valves, and tell the operator when to add manual ingredients. The bulk manual ingredients are fed into a hopper and transported up by a screw conveyor. Smaller quantities are added directly into the top of the tank. Steam is turned on and off automatically by level, as is the agitator. When the batch is completed, a buffer or application tank is chosen, but the routing to that tank is selected automatically. The transfer piping may be heat traced or merely insulated. The flow may be metered or it can be controlled by tank volume.

Most primaries do not employ all of the automation mentioned above. Key and inaccessible valves may be solenoid valves, or all manual valves may be used; in either case automatic routing is impossible. Bulk ingredient quantities typically must be set each time one is pumped. There may be no screw conveyor for dry ingredients, nor automatic heat control. While all these make the job easier, quality casings can be made without them. Automation minimizes the opportunity for operator error, as much as anything else. The more manual an operation, the more important are the operators to achieve good, uniform batches.

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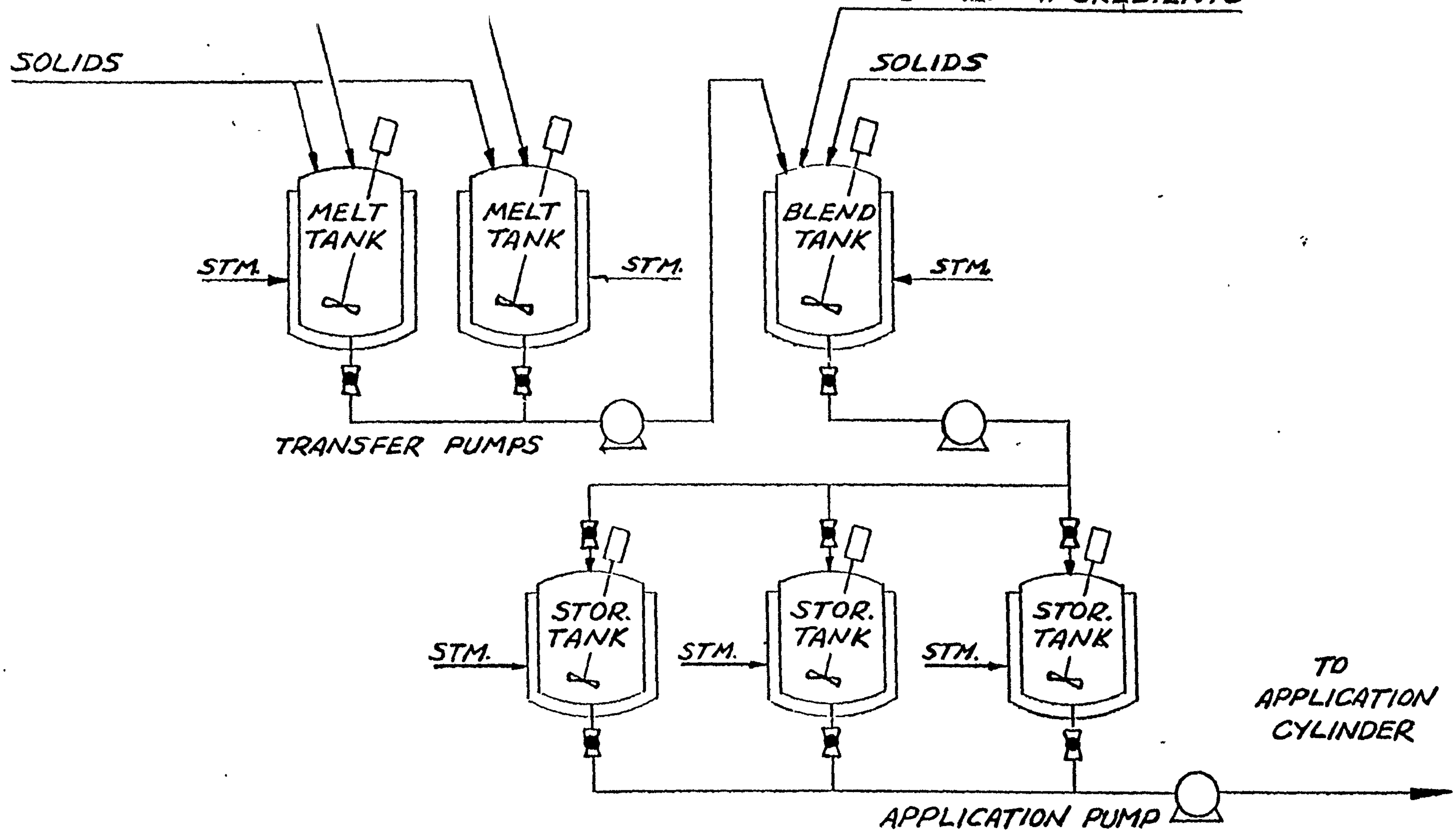

FIGURE 61: BURLEY SPRAY PREPARATION

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d. Flavor Blending and Storage

This area may just be an extension of the casing preparation area, though the benefits of having it in a separate room have already been mentioned. For primaries that do combine the blending areas in one room, the safety requirements for the flavor prep area apply to the entire room.

The blending of Burley Top Flavor and Atter Cut is similar to casing preparation, except neither one is heated, though, and alcohol, rather than water is the solution medium. Water is still a major component of these flavors. It is not uncommon to find dedicated After Cut prep tanks, due to the differences in the flavorants used in various brands. As a compromise, a separate tank for menthol, exotic, and normal AC blends is often used. Unlike the water-based casings, the alcohol-based flavors may be kept for about a week with no deterioration.

e. Auxiliary Rooms

In addition to the main areas mentioned, a Q.A. lab for testing flavors and bulk ingredients may also be a part of the flavor kitchen. Sometimes, this function is incorporated into another lab. An office of some type is usually included in the kitchen. When there is a central control room for an automated flavor kitchen, the office is generally included in it. A central control room will house the panels to select blends, choose routing, and transfer flavors. PC's are usually located here. The system is graphically displayed to allow the supervisor to monitor the process.

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10.3 Special Safety and Fire Requirements

The After Cut Flavorings, Burley Top Casings, and pre-blends contain alcohol and are (in the USA: classified as Class I) flammable liquids (flash pts. below 100°F). As Class I flammable liquids, these casings and flavoring solutions pose special safety and fire hazard considerations to the design of a flavor room, and must meet certain code requirements such as the NFPA Code 30 in the U.S. Some special requirements imposed by the code on the design of a flavor room are as follows:

(1) Special room construction including, but not limited to, provisions for selected fire resistance ratings for walls, roofs, and doors; access for fire fighting equipment; and explosion venting of room.

(2) Provisions for curbs and drains to prevent the overflow of flammable liquids to adjacent areas of the building.

(3) Provisions for positive mechanical ventilation in the rooms where Class I flammable liquids are stored and dispensed. Exhaust rate to be at least 1 CFM per square foot of floor area.

(4) Electrical wiring and equipment located in rooms used for Class I liquids shall be suitable for Class I, Division 2 classified locations as a minimum as provided by the National Electrical Code. In some cases, Class I, Division 1 locations exit.

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(5) Limitations on the amounts of Class I liquids that can be stored in drums or portable tanks are made according to the construction and location of the room.

Other code requirements apply to the design of the flavor room depending on the exact classification of the liquids (1A, 1B, and 1C, and etc.), and the specific nature of the physical operations in the flavor room. Best information available on the specific safety and fire requirements is found in NFPA Code 30.

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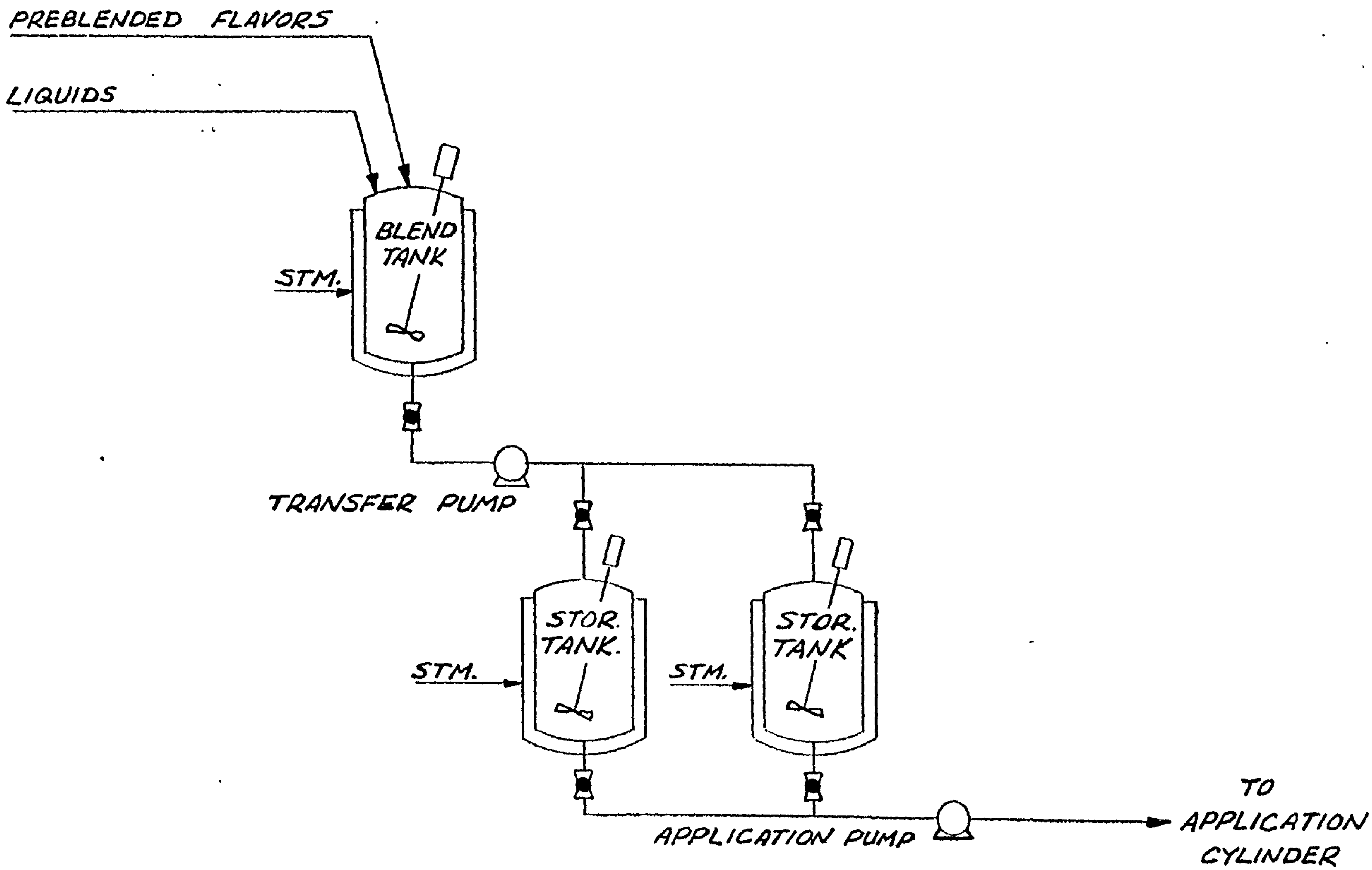

FIGURE 62: BRIGHT CASING PREPARATION

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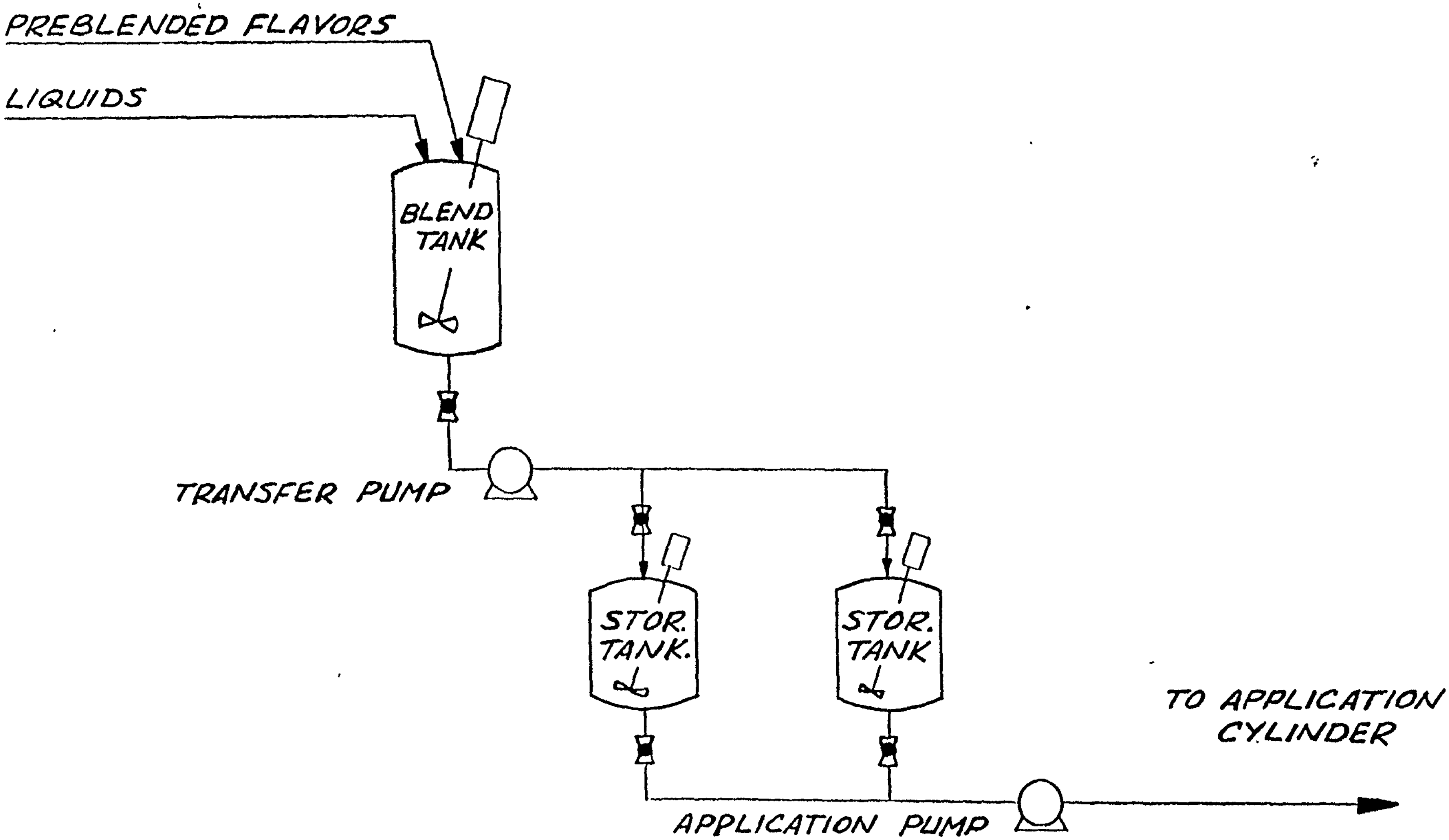

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FIGURE 63: BURLEY TOP CASING PREPARATION

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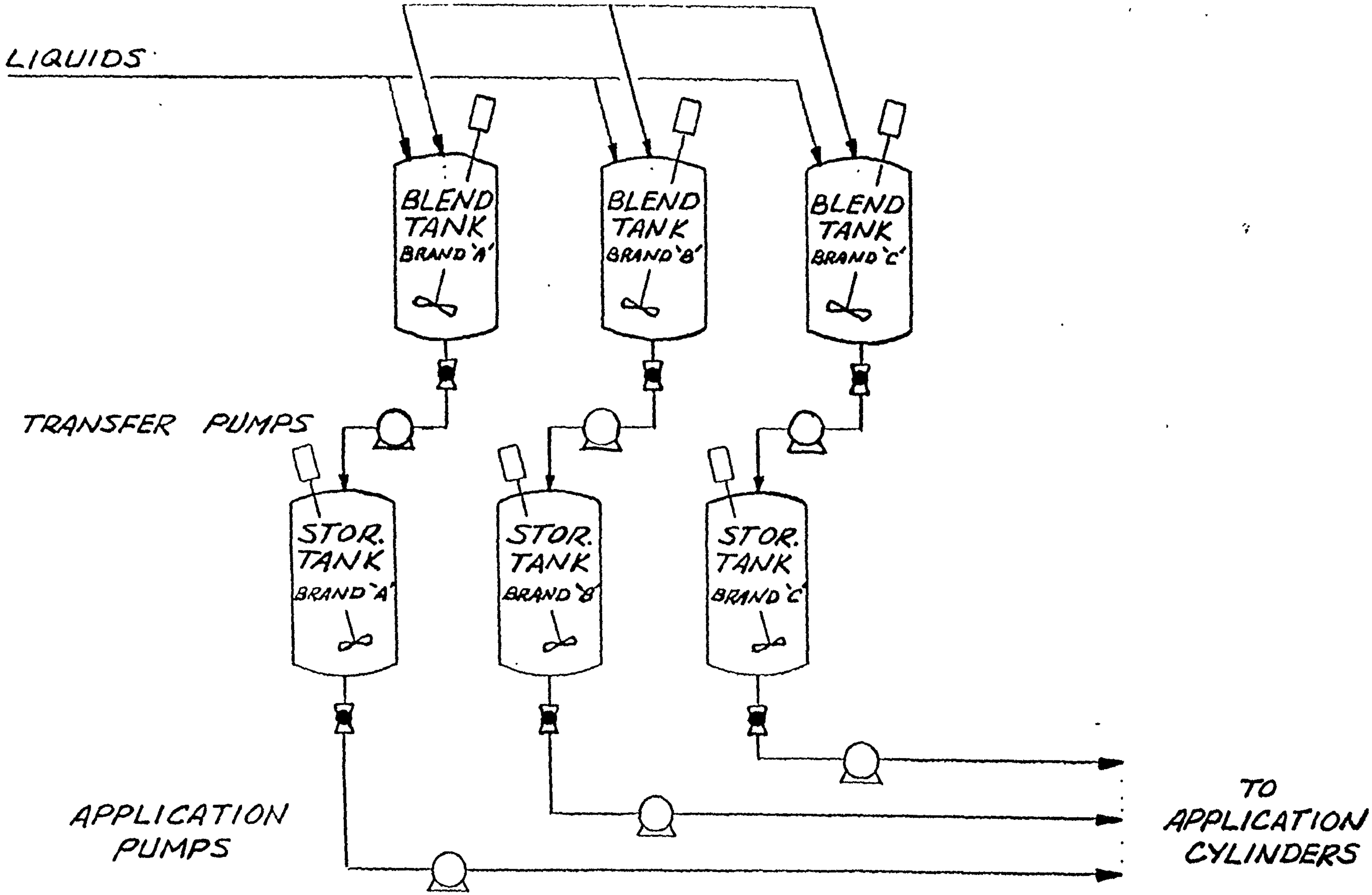

FIGURE 64: AFTER-CUT PREPARATION

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END OF FILE FORM

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( ) END OF HANGING FILE FOLDER

( ) END OF EXPANDABLE REDROPE FILE FOLDER

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