April 15, 1952 C. O. LAVETT 2,592,914

APPARATUS FOR REMOVING THE PRODUCT FILM FROM A REVOLVING DRUM SURFACE

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Fig. 1.

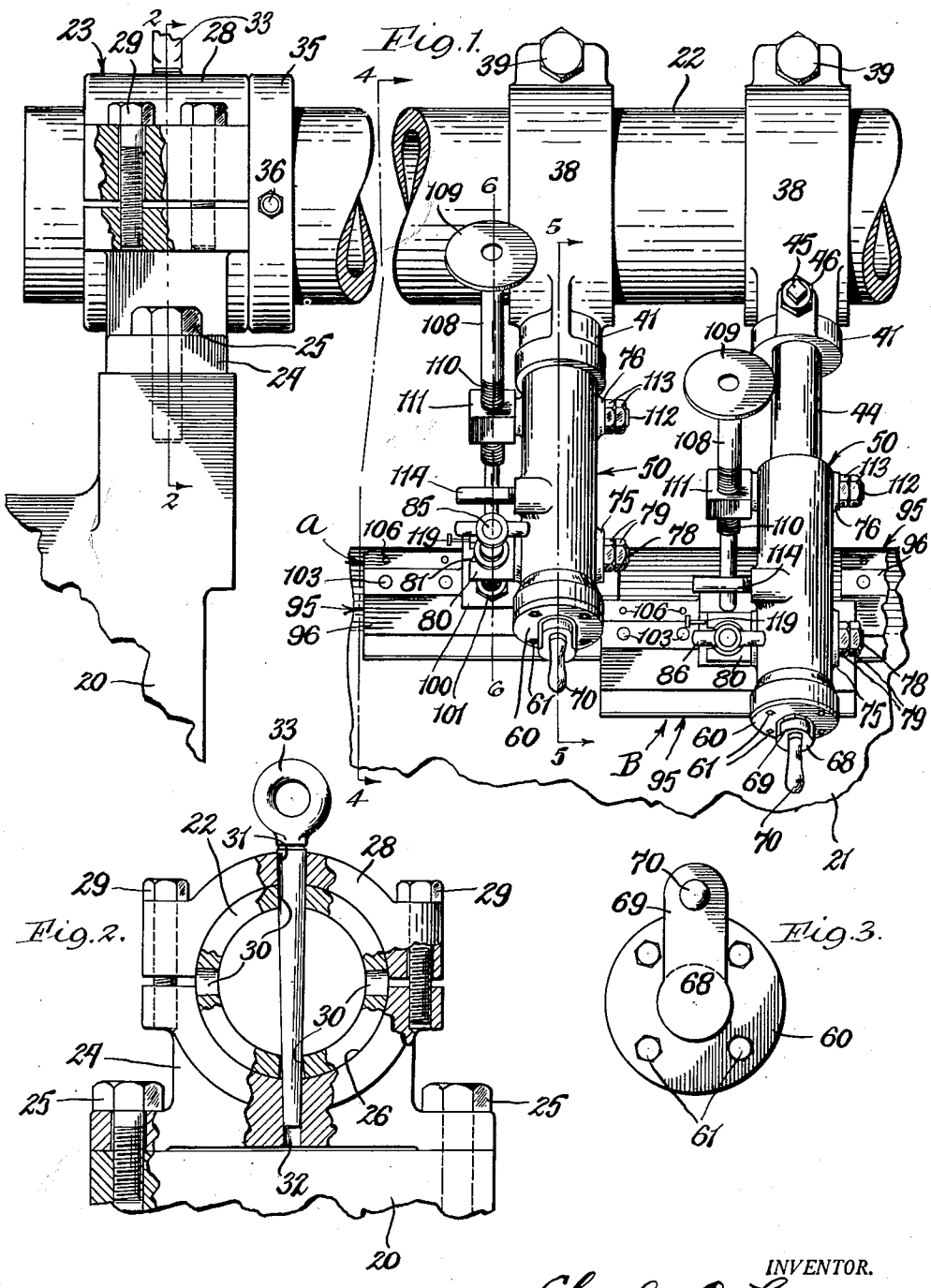


Fig. 2.

Fig. 3.

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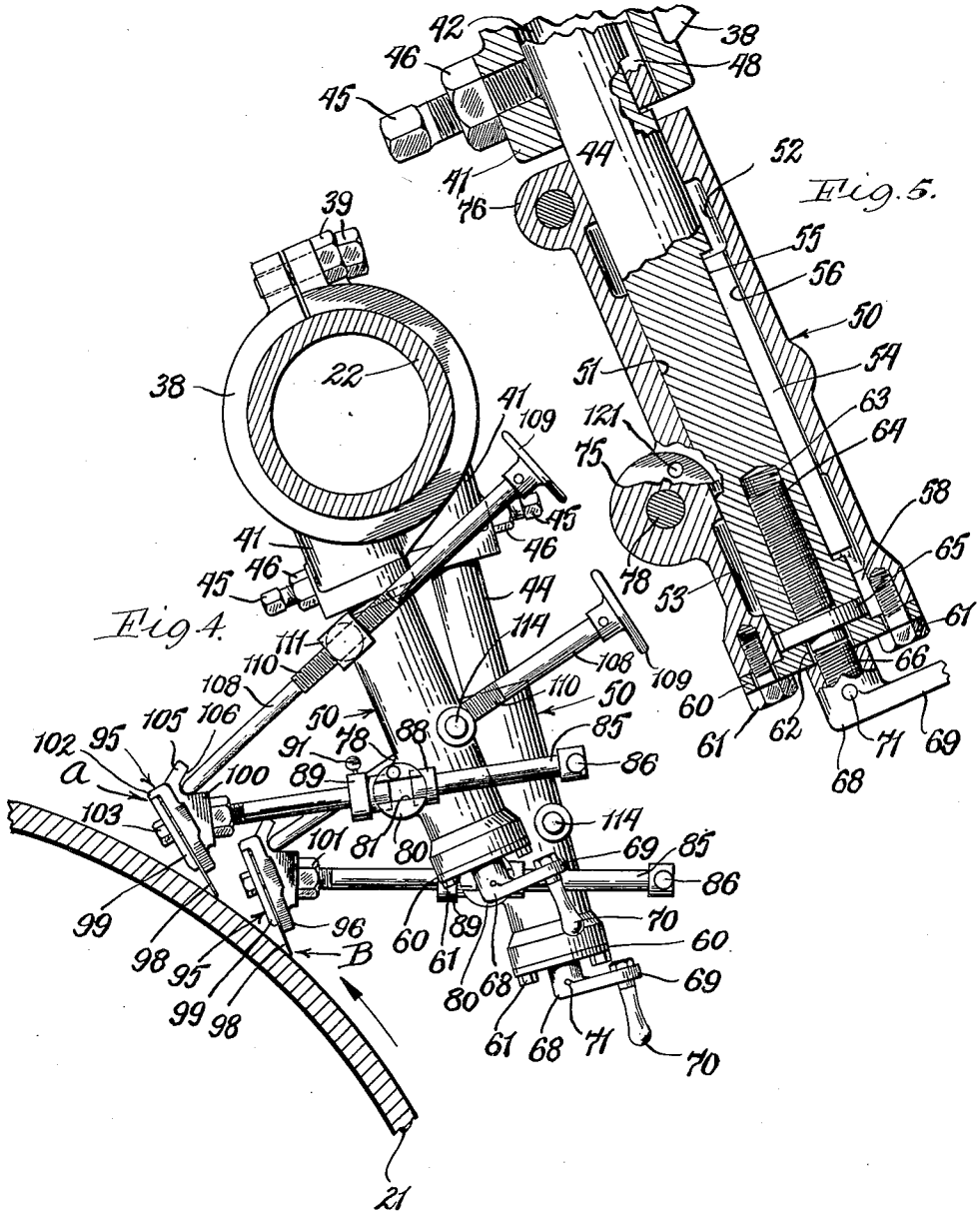


Fig. 5.

Fig. 4.

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APPARATUS FOR REMOVING THE PRODUCT FILM FROM A REVOLVING DRUM SURFACE

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Fig. 7.

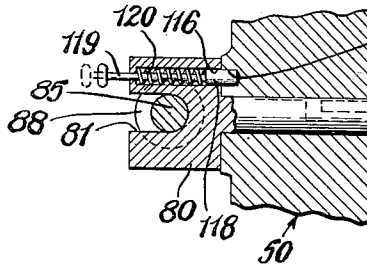


Fig. 6.

Fig. 8

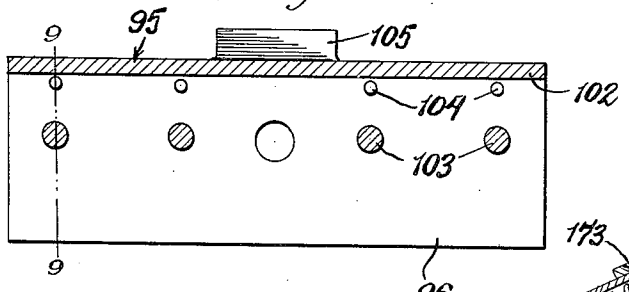


Fig. 9.

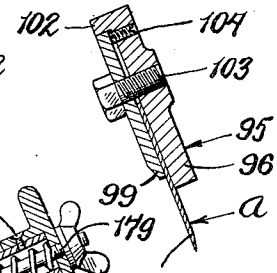
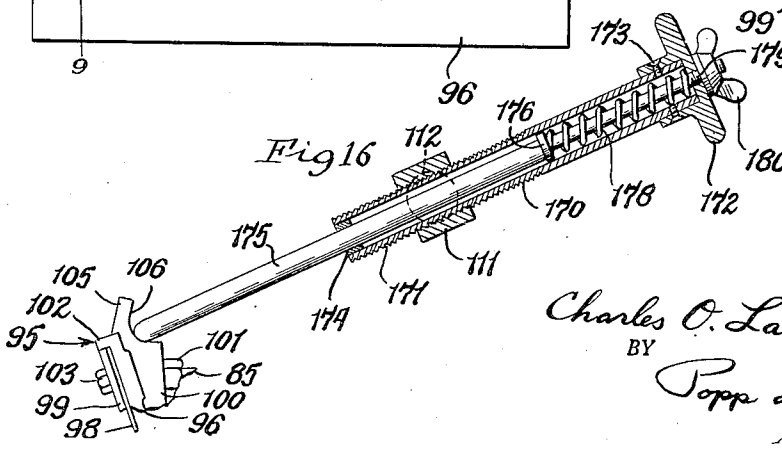


Fig. 16



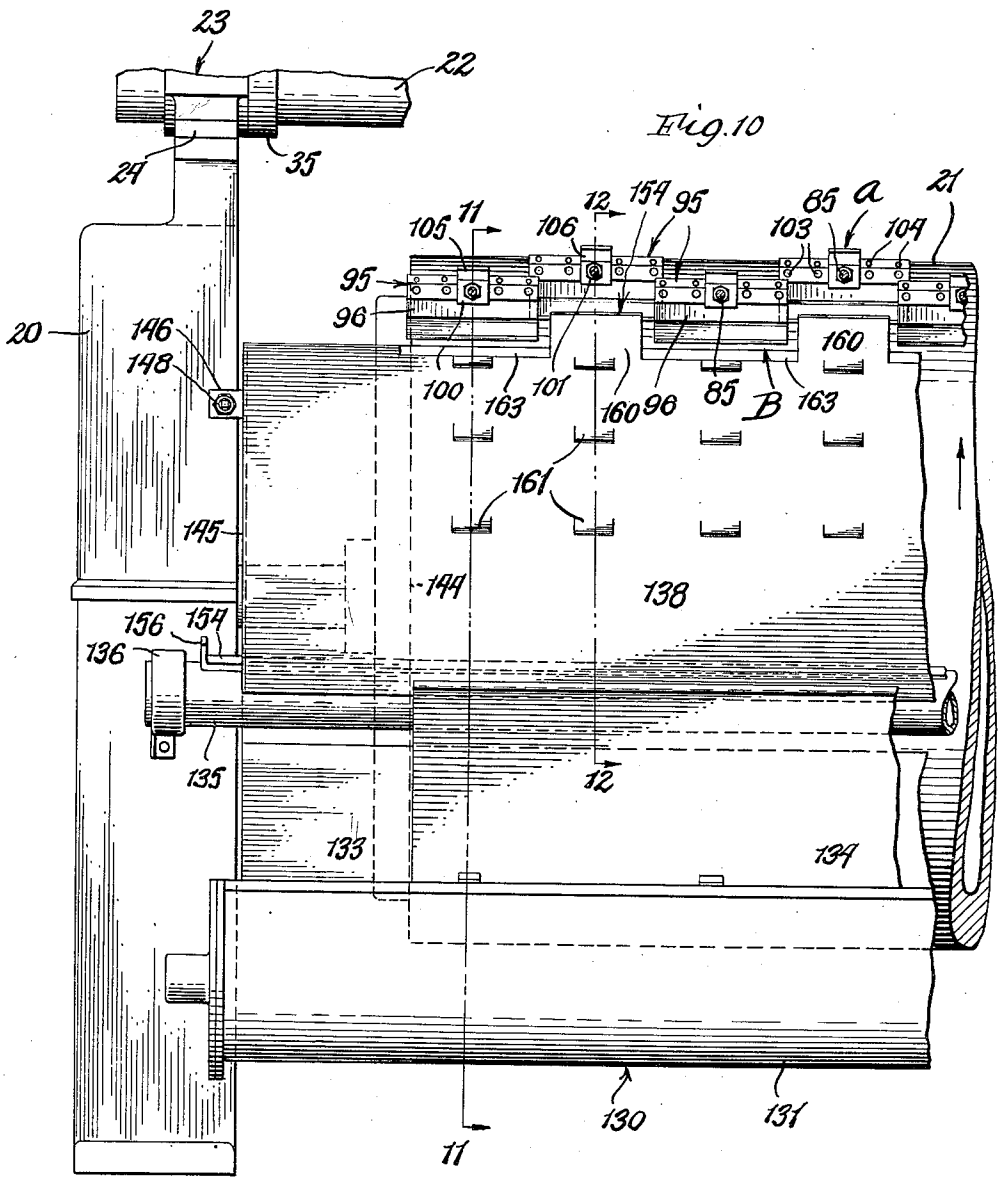
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APPARATUS FOR REMOVING THE PRODUCT FILM FROM A REVOLVING DRUM SURFACE

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Fig. 10



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APPARATUS FOR REMOVING THE PRODUCT FILM FROM A REVOLVING DRUM SURFACE

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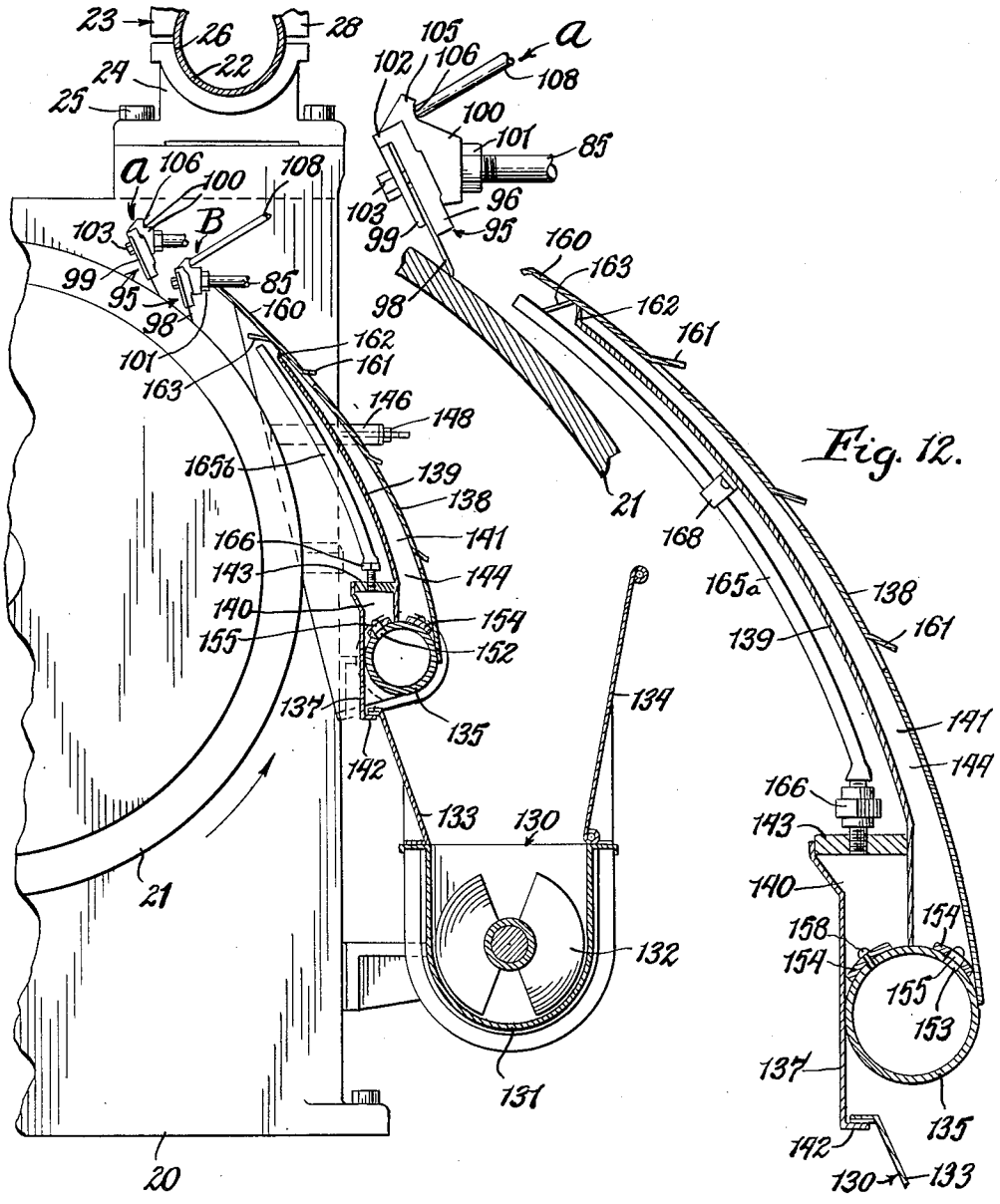


Fig. 11.

Fig. 12.

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APPARATUS FOR REMOVING THE PRODUCT FILM FROM A REVOLVING DRUM SURFACE

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Fig. 14.

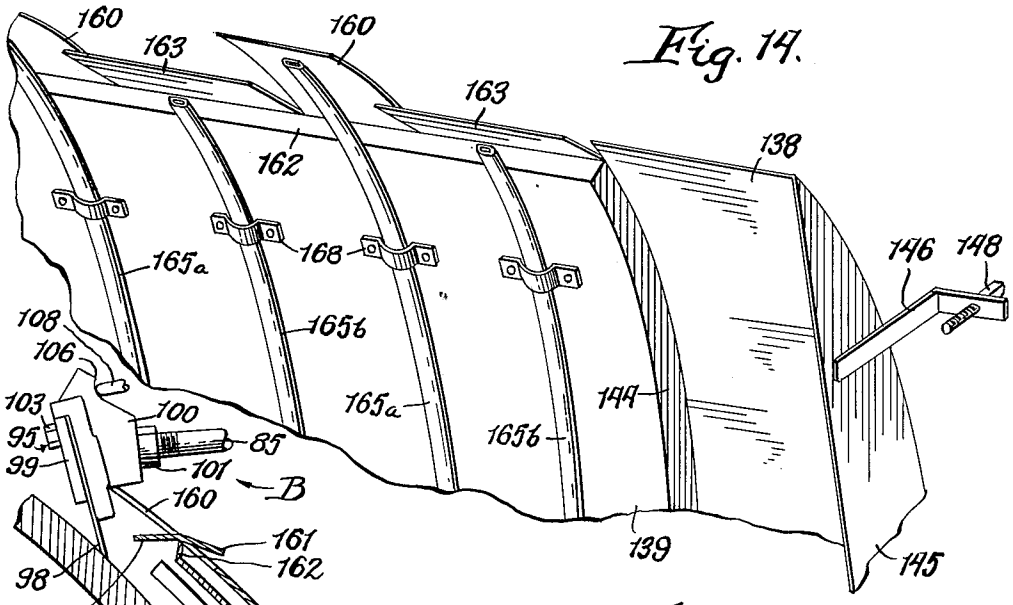


Fig. 15.

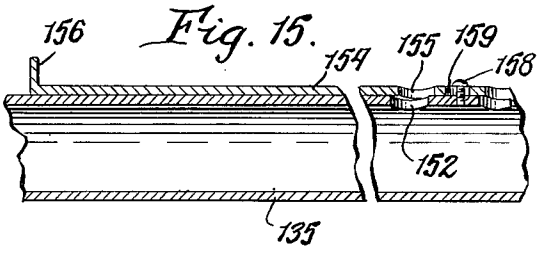
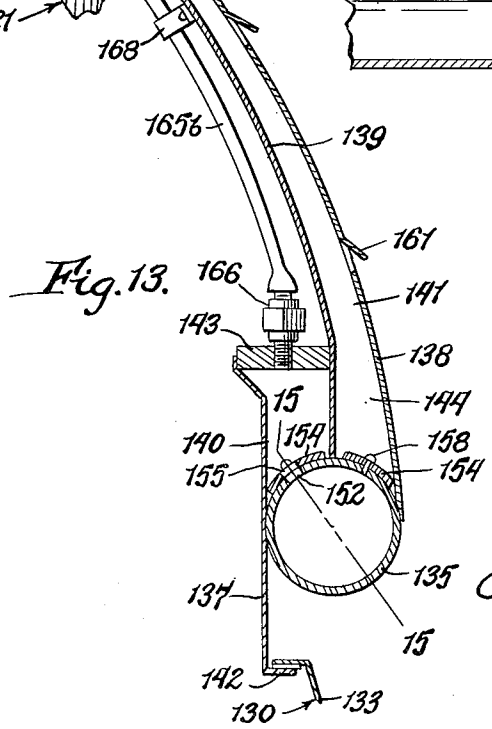


Fig. 13.



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UNITED STATES PATENT OFFICE

2,592,914

APPARATUS FOR REMOVING THE PRODUCT FILM FROM A REVOLVING DRUM SURFACE

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Application October 6, 1947, Serial No. 778,076

8 Claims. (Cl. 159—11)

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This invention relates to apparatus for removing the product film from a revolving drum surface and particularly to drum dryers where a liquid or semi-liquid product film is applied to a revolving hot drum surface for the purpose of drying or removing moisture and where the dry product film is continually removed before a full revolution of the drum has been completed. In such a drum dryer the continuous removal of the dry product film and the continuous application of a liquid or semi-liquid to the drum surface following the removal of the dry product film makes the drying process continuous.

On atmospheric double drum dryers the present practice is to use a single knife for each drum. When plant scale operations permit, large size dryers with drums up to 120" in length are preferred by the trade because of favorable proportionate dryer cost based on capacity as well as operating economy. The knife is clamped in a knife holder with sufficient exposure to obtain desired flexibility and to permit adjustments. The knife holder is usually mounted on the end heads at each end of the dryer, and means are also provided for exerting pressure upon the knife in contact with the drum surface. The knife angle in relation to the drum can be changed only by varying the distance between the drum and the knife holder or by varying the knife exposure beyond the holder, each of which requires a substantial mechanical alteration and requires complete shutdown of the dryer.

The knives for commercial sizes of drum dryers are usually $\frac{3}{32}$" thick and when new about 4–6" wide, varying with the size of the dryer, and slightly longer than the drum, one side of the knife being clamped to its holder while approximately $\frac{2}{3}$ of its width, with a sharp ground edge, extends beyond the holder.

The steam pressure in the drum or drums varies with the kind of product dried, on some products as high as 150 lbs. guage, equivalent to 366 deg. F. The heat from the drum plus the friction between the drum surface and the knife in contact with the drum under pressure causes unequal expansion of the knife which tends to warp the knife edge. Since the knife holder turns in bearings on fixed centers, the knife is not self-alining and in clamping the knife in the holder extreme care must be exercised for proper exposure of the knife beyond the holder. Thus, the knife edge must be parallel with the axis of the drum and rest as evenly as possible over the entire length of the drum, otherwise,

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when the knife edge is adjusted toward the drum, the portion of the knife edge first coming in contact with the drum will be subjected to greater pressure and consequently wear faster and thus reduce the serviceable life of the knife edge. Grinding long knives to obtain a perfectly straight edge is also difficult and further difficulties are encountered if the drum surface is not perfectly cylindrical or straight or if the operator in changing knives neglects setting the adjustable drum exactly parallel to the non-adjustable drum on double drum dryers. The extreme care which must be exercised in obtaining proper relation between a single knife blade and the drum surface therefore makes it difficult to properly remove a product film uniformly over the entire length of a hot drum surface.

In an effort to alleviate to some degree the effects caused by inaccuracy and warping of the edge of a long knife, it is present practice to provide closely spaced knife adjusting screws and which are adjusted to apply pressure where necessary in order to flex or bend the knife so that its cutting edge will follow the drum as closely as possible. Such adjustments are not satisfactory for while the buckling or warping is adjusted more uniformly to the drum surface the buckling or warping is not eliminated, and therefore this buckling or warping still causes unequal pressure and wear of the knife edge. Such inequality of pressure occasionally scores or even gouges the drum surface where pressure is the greatest. Further, those parts of the knife edge which are subjected to the greater pressure wear faster than the other parts of the knife and hence the serviceable life of the edge is reduced, being governed by the greatest wear at any given place along its length.

As the knife edge wears, a distinct contact area is formed which increases and renders the knife progressively less efficient. As the knife efficiency decreases, the present practice is to increase the pressure on the knife to improve its cutting qualities, however applying too much pressure causes the knife to flex and bring the leading edge away from the drum and the heel or trailing edge in firmer contact with the drum surface, thereby destroying effective removal of the product film. When the leading edge of the knife blade is so moved away from the drum surface, this edge also tends to split the product film, allowing part of such film to pass under the knife. This part of film left on drum where the knife is dull, may at first be very thin, appear like a discoloration of the drum surface, however,

the grinding effect on knife edge by material passing under it causes the knife edge to wear faster, gradually increasing the thickness of the film passing under it and which on some products will scorch or carbonize. Such burned on film on some products are wholly or partially removed by the knife periodically, resulting in inferior quality product, reduction in dryer capacity and frequent shut down of dryer to change knives with complete loss of production during such shut down.

The film removed from the drying drum is usually carried away by means of a screw conveyor and when removed in the form of a continuous sheet it must be cool or brittle enough by the time it reaches this conveyor to break up into a condition where it will be satisfactorily conveyed by the conveyor. Moisture is continuously evaporated from the film on the hot drum surface until it is removed and on an atmospheric drum dryer a considerable amount of the hot vapors on the knife side of the drum moves upwardly and collects under the downwardly moving removed film, escaping from under the film at the end of the drum. These hot vapors retard the cooling of the film. On some products air is introduced under the film being removed but the efficiency of this air cooling is greatly reduced due to the presence of the large amount of hot vapors trapped under the film.

One of the principal objects of the present invention is to provide means in the form of a plurality of knives for the removal of the product film and which are not subject to the above disadvantages of the single drum length knives now in use.

Another object is to provide such a knife which is selfalining.

Another object is to provide such a knife in which expansion due to heat will not affect the cutting qualities of the knife.

Another object is to provide a mounting for such knife which permits of adjustment of its angle in relation to the drum while in operation, such adjustment permitting the sharp cutting edge to be maintained in close contact at all times thereby to maintain optimum cutting qualities and increasing the life and serviceability of the knife.

Another object is to provide such a knife assembly in which the frequent necessity for regrinding of the cutting edges is materially reduced.

Another object is to provide a knife which can be replaced without interrupting operation, this eliminating the necessity for shutting down the dryer.

Another object is to provide a knife assembly which removes the film in the form of a series of ribbons, this permitting the hot vapors to escape readily from under the ribbons.

Another object is to provide, in combination with such a knife assembly removing the product film in a series of ribbons, forced air cooling means which rapidly and effectively cool the individual ribbons to condition the ribbons for proper transfer to the conveyor and breaking up therein, such forced air cooling means also preventing the entrapment of any substantial amount of hot vapor at the knives and avoiding danger of overheating of the product film through the heat retained therein.

Another object is to provide apparatus for continuously removing a film from the drum, which

produces a better quality and more uniform product through the more efficient removal of the dry product film.

Another object is to provide a knife which will closely follow the drum surface even though the drum may not be perfectly cylindrical.

Another object is to provide such a knife which requires less pressure per inch of length than is necessary with a single knife, to maintain close contact with the drum surface, thereby to reduce the danger of scoring or gouging the drum surface.

Another object is to provide such a knife assembly in which the necessity for regrinding of the cutting edges is materially reduced.

Another object is to provide such a knife assembly in which thinner and hence less expensive blades can be employed.

Another object is to provide such a knife assembly comprising a plurality of knives, in which the cutting edges of the knives can be sharply reground by the operator of the dryer on a small portable or bench grinder, thereby to eliminate the expense and delay attendant upon shipping the long knives long distances for regrinding, such shipment being necessary in view of the special problems involved and the special facilities required for regrinding a long blade.

Other advantages and objects of the invention will appear from the following description and drawings in which:

Fig. 1 is a fragmentary side elevation of one end of an atmospheric drum dryer having a knife assembly embodying the present invention.

Fig. 2 is a fragmentary vertical transverse section, partly in elevation, taken on line **2—2**, Fig. 1.

Fig. 3 is an end view of one of the knife holders shown in Fig. 1.

Fig. 4 is a fragmentary vertical transverse section taken generally on line **4—4**, Fig. 1.

Fig. 5 is a fragmentary vertical enlarged transverse section, partly in elevation, taken on line **5—5**, Fig. 1.

Fig. 6 is an enlarged vertical transverse sectional view taken on line **6—6**, Fig. 1.

Fig. 7 is a fragmentary slightly enlarged vertical sectional view taken on line **7—7**, Fig. 6.

Fig. 8 is a generally vertical sectional view taken on line **8—8**, Fig. 6.

Fig. 9 is a vertical sectional view taken on line **9—9**, Fig. 8.

Fig. 10 is a fragmentary side elevational view of one end of an atmospheric double drum dryer embodying the present invention, a part of the knife holder structure being broken away and this view in particular showing the manner in which cooling air is supplied under pressure against the undersides of the strips or ribbons being separated from the drying drum.

Fig. 11 is a fragmentary vertical transverse sectional view taken on line **11—11**, Fig. 10.

Fig. 12 is a fragmentary enlarged vertical transverse section taken on line **12—12**, Fig. 10.

Fig. 13 is a fragmentary enlarged sectional view similar to Fig. 11 and showing the parts in greater detail.

Fig. 14 is a fragmentary perspective view of the upper part of one end of the cooling air supply structure as viewed from the surface of the drum below the knives.

Fig. 15 is a fragmentary longitudinal sectional view taken on line **15—15**, Fig. 13.

Fig. 16 is a fragmentary view, similar to Fig. 6, and showing a modified form of push rod for the blade in the knife holder.

The invention is shown in conjunction with a conventional atmospheric drum dryer which can be either of a single or double drum type and which is shown as having the usual end heads or standards 20 in which the opposite ends of a drying drum 21 are journaled. This drum is internally heated in any suitable manner and the liquid or semi-liquid to be dried is applied to its descending side, the drum rotating in the direction of the arrows indicated in the drawings. The film or layer applied to the descending side of the drum 21 is dried while passing under and up the rising side of the drum and is then removed by the knife assembly embodying the present invention. In accordance with the present invention a plurality of short, self-alining knives are arranged in two horizontal rows or series, designated at A and B, with the knives of one row alternating with the knives of the other row and in overlapping relation therewith so that the entire length of the drum surface is contacted by the knives. Each knife operates independently and is adjustably supported so that the angle of the knife in relation to the drum surface can be adjusted while the dryer is in operation.

The two rows of knives are supported on a hollow tube 22 which is arranged above and parallel with the drum 21 and extends beyond the end of the drum and over the upper ends of the end heads or standards 20. The opposite ends of this tube 22 are adjustably supported in brackets indicated generally at 23, these brackets being secured upon the standards 20, as best illustrated in Figs. 1, 2 and 11. Each of the brackets is shown as comprising a lower block 24 which is secured to the upper face of the corresponding end head or standard 20 by screws 25 or in any other suitable manner, and as having a semi-cylindrical seat 26 for the corresponding end of the tube 22. This end of the tube is secured at the seat by a semi-cylindrical clamping member 28 which embraces the upper half of this end of the tube and is secured to the supporting block 24 by screws 29, or in other suitable manner. The tube 22 is preferably adjustable about its axis to different positions in its supporting brackets 23 and is capable of being held in any of such adjusted positions. For this purpose each end of the tube is shown as having a plurality of radially extending holes 30 which are arranged to register with holes 31 and 32 extending vertically through the clamping member 28 and supporting block 24, respectively. A tapered pin 33 is passed through the registering holes 30 and 32 and it will therefore be seen that these tapered pins hold the tube 22 in the selected position. The purpose of the adjustment provided by the tapered pin 33 is to permit the tube 22 to be turned and held in any position for convenience in cleaning, adjusting and inspecting the knife assembly carried by this tube. In order to prevent endwise displacement of the tube while so being turned after the tapered pins 33 have been removed, a collar 35 is provided at each end of the tube 22, these collars being arranged in contact at opposing sides of the supporting blocks 24 and the supporting brackets 23. These collars may be secured in any suitable manner as by the set screws 36.

The two rows A and B of short, self-alining and overlapping knives, are arranged in staggered relation and are secured to this tube 22. For this purpose each knife is carried by a holder, the holders for the two series or rows A and B of knives being arranged to support the two series in the desired overlapping and staggered relation. As the holders for both series A and B are substantially identical in construction the same reference numerals have been applied and the same description applies to both.

Each holder of each series is shown as having a split collar 38 which embraces the tube 22 and is clamped to the tube by a cap screw 39, these cap screws 39 extending through the ends of the split rings 38 and drawing these ends together to clamp the supporting tube therebetween. Each of these clamping collars 38 is provided on its lower side with an integral neck 41, which is arranged on one side of the split collar and extends transversely of the axis of the tube 22 to one side thereof and is provided with an axial bore 42.

Each split collar 38 carries a rod 44 which has its upper end fastened in its bore 42 and is adjustably secured therein by means of a set screw 45 having a lock nut 46, this set screw extending through the neck 41 and bearing against the corresponding side of the rod 44. Each rod 44 is also held against turning by means of a key 48 arranged in corresponding keyways provided in the rod 44 and its supporting neck 41. A sleeve 50 is mounted on each of the rods 44, this sleeve having a through bore 51 in which the rod 44 is slidingly fitted and this bore being shown as provided with annular enlargements 52 and 53 adjacent its opposite ends. Each sleeve 50 is movable lengthwise on its rod 44 but held against rotation, and for this purpose an elongated key 54 is provided which is shown as fitted in a keyway 55 in the rod 44 of substantially the same length as the key, and also as fitted in a keyway 56 provided in the sleeve 50 between the annular enlargements 52 and 53 of the bore thereof. As best shown in Fig. 5, the upper end of the enlargement 52 serves as a stop which engages the upper end of the key 54 and limits the downward movement of the sleeve 50 on its supporting rod 44. To permit disassembly of the sleeve and rod, a groove 58 is provided at the lower end of the sleeve 50 in alinement with the keyway 56.

A cap 60 is secured to the lower end of each of the sleeves 50 by means of cap screws 61 or in any other suitable manner, this cap having a central hole 62 which is in line with the axis of the rod 44 and sleeve 50. In line with this hole the rod 44 is provided with an axial threaded bore 63 for receiving an adjusting screw 64, this adjusting screw being provided with an integral collar 65 which is interposed between the lower end of the rod 44 and the cap 60. This adjusting screw 64 is provided with a lower threaded extension 66 which extends through the hole 62. On this extension 66 is screwed the hub 68 of a crank 69, this crank having a handle 70 for convenient manual manipulation thereof. The hub 68 is further fastened by means of a pin 71, this pin serving to hold the cap 60 in closely fitted relation to the integral collar 65 of the screw 64 and to the hub 68 of the crank 69 so that the screw 64 is rotatably mounted on the cap 60 but is held against substantial axial movement relative thereto. It will therefore be seen that turning each crank 69 serves to move the corresponding sleeve 50 axially relative to its supporting rod 44. It will be noted that the upward movement of the sleeve in this direction is limited by the engagement of the collar 65 with the end of the rod 44 and that the downward movement of the sleeve in this direction is limited by the engagement of the upper end of the key 54 with the

upper end wall of the enlargement 52 of the sleeve bore 51.

On the side of the sleeve 50 toward the drum 21 are two projections 75 and 76, each provided with a hole drilled therethrough parallel with the drum 21. In the projection 75 is arranged a knife holder swivel pin 78 which turns freely in this projection and is held in place by nuts 79, as best shown in Fig. 7. The head 80 of this knife holder swivel pin 78 is shown as being cylindrical in cross section and is provided with a slot 81 which extends transversely of the axis of the knife holder swivel pin, as best shown in Figs. 4, 6 and 7. In addition, this head is counterbored, as indicated at 82 and 83, at the opposite ends of this slot 81. The slot 81 so counterbored receives a knife holder rod 85 which is shown as provided with a handle 86 at its outer end and also with an enlarged cylindrical portion 88 which fits the counterbore 82. On the opposite side of the head 80 a sliding sleeve 89 is mounted on the knife holder rod 85, this sleeve having an end 90 which is adapted to fit into the other counterbore 83. When so fitted the sleeve 89 is held against axial displacement by a setscrew 91.

It will be seen that by loosening the setscrew 91 the end 90 of the sleeve 89 can be slipped out of the counterbore 83. This permits the knife holder rod 85 to be withdrawn so as to free the enlargement 88 from the counterbore 82. In this position the knife holder rod 85 can be removed sidewise from the slot 81 so as to be completely freed from the head 80 of the knife holder swivel pin 78.

The inner end of the knife holder rod 85 carries a knife head, indicated generally at 95, and which generally is in the form of a safety razor head. As best shown in Figs. 6–9 this head is made of two pieces, one part 96 being in the form of a backing frame to which the corresponding blade 98 is held by a clamping plate 99. The backing frame 96 is provided with an internally threaded neck 100 into which the threaded end of the knife holder rod 85 is screwed, these parts being held against displacement by a lock nut 101. The backing frame 96 is elongated parallel with the drum and is formed to provide a flange 102 along its upper edge and against which the upper edge of the clamping plate 99 is disposed. This clamping plate is secured in position by a plurality of screws 103 which anchor in the backing frame 96 so that the blade 98 is securely clamped between this backing frame and the clamping blade as best shown in Figs. 6 and 9. In order to hold the clamping blade 99 in parallel relation with the blade 98 a plurality of screws 104 are provided which extend through the backing frame 96 into abutment with the inner face of the clamping plate 99 at its upper end, these screws projecting outwardly from the drum side of the backing frame a distance equal to the thickness of the blade 98 and thereby serving to space the upper end of this backing plate the thickness of the knife blade away from the backing frame.

The upper side of the backing frame 96 is provided with a flange 105 projecting upwardly therefrom and in a direction away from the drum 21, this flange forming a socket 106 for the reception of the rounded end of a push rod 108. This push rod is provided with an end knob 109 at its outer extremity and is threaded intermediate its ends, as indicated at 110. This threaded part 110 of each push rod is screwed into the square head 111 of a bolt 112, this bolt being rotatably mounted in the projection 76 of the sleeve 50. This bolt is held against displacement by a pair of nuts 113, as shown in Fig. 1.

It will be seen that essentially each individual blade mounting is a triangular truss. The triangle is defined by a cantilever beam in the form of the sleeve 50, an adjustable tension member, in the form of the knife holder rod 85, hinged to the end of the cantilever beam 50, an adjustable strut, in the form of the push rod 108, hinged to an intermediate point along the cantilever beam 50, said strut 108 and tension member 85 converging toward the apex of the triangular truss, a blade clamp secured to the tension member 85 and bearing on the end of the strut 108 at the apex, and means for varying the length of the cantilever beam 50 between its support and the hinge to the adjustable strut 108.

Means are provided for limiting the swinging movement of each push rod 108 when released from the socket 106 sufficiently for the rounded end of the push rod to clear the projections 105. For this purpose each sleeve 50, Fig. 4, carries a stop pin 114 which is shown as screwed into the side of the sleeve 50 and arranged above its companion knife holder rod 85 sufficiently far to clear the knife holder rod 85 and handle 86 when the push rod 108 is resting on the stop pin 114.

It is also desirable to be able to hold each knife holder in an elevated position clear of drum surface 21 when not operating or to prevent the knife holders from piling up against one another when the main tube 22 is loosened and turned in its brackets 23 for cleaning or any other purposes. To this end the slotted head 80 which supports each knife holder rod 85 is provided with a bore 116 which contains a spring loaded detent pin 118, as best shown in Fig. 7. This pin is provided with an operating plunger 119 which projects outwardly from the head 80 and its spring 120 urges the pin against the adjacent face of the enlargement 75 of the sleeve 50. This pin is adapted to enter a latching hole 121 which is located as shown so that when the knife holder is swung about its knife holder swivel pin 78 in raising the knife holder, the spring loaded detent pin 119 enters the hole 121 and holds the knife holder in an elevated position until it is released by withdrawing the plunger 118 of the detent pin.

The material removed by the knives falls into a side conveyor 130 comprising a trough 131 arranged alongside the drying drum and containing a screw or helix conveyor 132 which is rotated so as to break up the material and convey it to an end of the trough 131. An inner apron 133 is provided along the inside of the trough and an outer apron 134 is provided along the outside of the trough so as to direct falling material into the trough.

On materials removed by the knives in the form of flakes, crystals or powder, the upper edge of the inner apron 133 is arranged as close as possible to the drying drum 21. The dried product, in flake, crystal or powder form, will then roll down over the drying film on the upwardly moving drum surface and drop into the side conveyor 130. Such materials convey readily without any additional air cooling and if cooling should be necessary to prevent overheating in storage, etc. it is usually done after the material leaves the dryer. Where there are objections to the dry material rolling down over the upwardly moving and drying film the position of

the knives on the drum surface can be lowered to a point where the material will fall away from the drum as removed, that is, the knives are located at any point along the drum periphery to suit removal of the product being dried.

On products removed from the drum in the form of solid continuous ribbons, the physical character of the product determines the cooling procedure. On products such as dried skimmed milk, the dry film as removed does not adhere to the knife edges and large amounts of vapor are liberated from the drying film on the upwardly moving drum surface. These liberated vapors, mixed with some natural circulation of air, causes the thin films to actually float on those vapors and air mixture and in spite of the heat it cools sufficiently by the time it reaches the screw conveyor to permit the material to be handled by the conveyor screw 132 without any additional cooling.

Other products such as distillery slop or stillage, when removed by the knives and in a hot state, are soft, somewhat sticky and temporarily adhere or gather in front of the knives so that the film leaving the knives is considerably thicker than the film on the drum surface. Thus, the periphery speed of the drum may be three times the speed of the film leaving the knives, and the film leaving the knives under these conditions would theoretically be three times as thick as the film on the drum. The hot soft film so retarded and thickened on leaving the knives, unless cooled quickly has little tensile strength, and tends to retain its heat to a point of overheating which on most products reduces its value. Thus the hot soft retarded film at knife, unless cooled quickly, has insufficient strength to properly support the weight of the hanging film and pull exerted upon it by the side conveyor, tearing easily and intermittently at the knife and dropping down into conveyor trough to be wrapped around conveyor flight thus interrupting operation due to inability of conveyor screw to break up the soft film and carry it away from dryer. It is therefore essential that proper means be provided for cooling of the removed films in order to obtain uninterrupted operation and a product of the desired quality.

To provide for such cooling, in accordance with the present invention, a blast of cool air is introduced under each ribbon or film a short distance below each knife, this blast of air cooling the ribbon film sufficiently to toughen the film and prevent it from being torn from the knife. These blasts of air also cool the ribbons sufficiently to prevent overheating after leaving the drum surface and also accelerate the overall cooling. These blasts of air also aid the movement of the ribbons and float the ribbons and accelerate their cooling on their way to the screw conveyors 130. The means for effecting this cooling, in accordance with the present invention, are preferably constructed as follows:

The numeral 135 represents an air supply pipe which is supported from the end heads or standards 20 of the dryer in any suitable manner, as by the brackets 136, and is arranged alongside the drum above the inner apron 133 for the side conveyor 130. To the inner side of this air supply pipe 135 is suitably secured a vertical metal sheet 137, and to the outer side of this air supply pipe 135 is similarly secured an outer curved metal sheet 138. Intermediate these two metal sheets, a third central metal sheet 139 is secured to the air supply pipe 135 so as to form an inner manifold chamber 140 and an outer manifold chamber 141. The inner vertical metal sheet 137 extends downwardly a short distance from the air supply pipe 135 and is formed along its lower horizontal edge with an outwardly extending horizontal lip or flange 142 on which the upper flanged edge of the inner apron 133 for the side conveyor removably rests and this inner vertical metal sheet 137 extends upwardly a short distance from the air supply pipe 135 and is secured to the rear edge of a horizontal tube plate 143 which is secured at its front edge to the central metal sheet 139 so as to enclose the top of the manifold chamber 140. The ends of chambers 140 and 141 are enclosed by end sheets 144 which conform to and are secured to the opposite end edges of metal sheets 137 and 139 and tube plate 143, each of these end sheets 144 extended forwardly to engage the rear face of the outer metal sheet 138 and downward to engage supply pipe 135 as best shown in Figs. 13 and 14. The opposite ends of outer metal sheet 138 project beyond these end sheets 144 and are secured to end sheets or flanges 145 which project inwardly from the extremities of the outer metal sheet 138 and are arranged alongside the inner or opposing faces of the main end heads or stands 20 of the dryer.

The entire air supply manifold structure as above described is adjustable toward and from the drying drum 21. For this purpose the air supply pipe 135 is capable of rotating in its brackets 136 and an L-shaped metal arm 146 is welded to each end sheet or flange 145 and carries a generally horizontal adjusting screw 148, as best shown in Fig. 14. The inner end of each of these adjusting screws 148 is positioned to bear against the vertical side face of the corresponding main end head or stand 20 of the dryer and since the drying drum 21 is journaled in these end heads or stands 20 of the dryer it will be seen that screwing in the adjusting screws 148 will move the upper end of the air supply manifold structure away from the drum 21 to effect any desired relative spacing thereof.

The inner manifold chamber 140 is supplied with air from the supply pipe 135 through a plurality of orifices 152 and the outer chamber 141 is similarly supplied with air from the air supply pipe 135 through a plurality of orifices 153. The flow of air through these two series of orifices 152, 153 can be regulated in any suitable manner, each series of these orifices being shown as covered by a longitudinally movable slide 154 having orifices 155 arranged to register with the corresponding orifices in the air supply pipe 135. Each of these slides is shown as being manually adjusted by means of an upstanding flange 156 at one end thereof and as secured to the air supply pipe 135 by screws 158 extending through slots 159 provided in the slide.

The metal sheets 138 and 139 are curved and arranged so that their upper extremities are arranged adjacent the knife holders. The outer metal sheet 138 is provided at its upper end with a series of spaced rectangular extensions 160 which project upwardly between the knife holders of the lower series B and to a position immediately adjacent the knives 98 of the upper series A. This outer metal sheet is also provided with a series of downwardly and outwardly projecting louvers 161 which are arranged in spaced relation over its entire surface, as best shown in Fig. 10. These louvers 161 are struck from the outer metal sheet to provide air escape openings therein, the streams of air from these openings being deflected

downwardly by these louvers 161. The intermediate metal sheet 139 is provided with an outwardly and upwardly extending flange 162 along its upper edge, the extreme forward edge of which flange 162 is welded or otherwise suitably secured to the inner face of the outer metal sheet 138 so as to enclose the upper part of the chamber 141.

To facilitate the movement of the ribbons or strips of material removed by the lower series of knives B to the exterior face of the outer metal sheet 138 and to the zone of action of the stream of air issuing from under the louvers 161, this outer metal sheet 138, between its upwardly extending rectangular extensions 160, is flanged inwardly, as indicated at 163, these flanges being directed toward the blades 98 of the lower series B of knives, as best shown in Fig. 13.

A feature of the invention resides in the provision of an individual blast or jet of air for each strip removed by each blade 98 of the series A and B. This blast or jet of cooling air is directed against the underside of the strip or ribbon leaving each knife and to this end a series of vertical open ended air tubes 165a, 165b are mounted on the under side of the central sheet 139. The lower end of each of these tubes 165a, 165b is connected to a screw fitting 166 which is screwed into a vertical threaded opening provided in the tube plate 143. It will therefore be seen that air from the manifold chamber 140 escapes through this series of tubes 165a, 165b. Each of the tubes 165a is arranged under a corresponding knife holder 95 of the series A and each of the tubes 165b is arranged under a corresponding knife holder 95 of the series B, the series of tubes 165a thereby being in alternation with the series of tubes 165b. The tubes 165a, 165b can be held in position in any suitable manner as by the U-shaped sheet metal holders 168.

The tubes 165a are longer than the tubes 165b and the upper end of each of the tubes 165a is arranged under the corresponding rectangular extension 160 of the outer metal sheet 138, this upwardly directed open end of such tube 165a thereby discharging a stream of cooling air upwardly along the underside of this rectangular extension 160 against the under side of the ribbon or strip of material being removed by the corresponding blade 98 and passing from this blade over the rectangular extension 160 and down the exterior of the outer metal sheet 138. The shorter tubes 165b are arranged to discharge upwardly against the under sides of the lips 163 and hence against the under sides of the strips or ribbons of material being removed by the lower series B of knives. The air so discharged by the tubes 165a and 165b serves to quickly cool and float the strips or ribbons so removed for delivery onto the rectangular extensions 160 and lips 163, and the mixture of cool air from the tubes and hot vapors escapes freely from under and among the strips so that there is no pocketing of a body of hot vapors and air mixture under these ribbons or strips.

As these strips move down the exterior face of the outer metal sheet 138, they are further floated and aerated by the streams of cooling air issuing from the openings provided by the louvers 161 so that the strips are air-cooled in their travel down this outer metal sheet 138 and hence properly conditioned before being deposited in the side conveyor 130.

In Fig. 16 is illustrated a modified form of push rod for the blades and which is characterized by being resiliently extensible so as to exert an adjustably resilient pressure against the blade holder and thereby permit greater freedom of the blade in following, say, an out of round drying drum. The push rod structure shown in Fig. 16 is designed to supplant the form of push rod 108 shown in the other figures of the drawings and for this purpose comprises a tube 170 which is threaded at one end, as indicated at 171, in order to screw into the threaded aperture through the nut 111 of the bolt 112 in the same manner as with the push rod 108. An adjustable knob 172 is shown as secured to the outer end of the tube 170 by set screws 173 and in the opposite end of this tube is arranged a bushing 174 which slidingly receives a rod 175, the free end of this rod being rounded to fit into the socket 106 formed by the flange 105 of the blade holder 95, in the same manner as with the push rod 108. Within the tube or sleeve 170 the rod 175 is provided with an enlargement or collar 176 which slides within the bore of the tube 170. A helical compression spring 178 is interposed between this collar 176 and the knob 172 so as to normally urge the rod 175 axially toward the blade holder 95. The rod 175 extends through an opening in the knob 172 and is threaded, as indicated at 179, to receive a wing nut 180 which due to urging of the compression spring 178 prevents rod 175 from moving forward beyond a set point.

It will be seen that the pressure exerted by the rod 175 against the blade holder 95 can be adjusted by turning the knob 172 in a corresponding direction to move the sleeve 170 lengthwise in the nut 111. At such adjustment the helical compression spring 178 will exert a predetermined pressure against the socket 106 of the blade holder so as to impress a corresponding pressure against the blade 98. In the event that the drum 21 is out of round, the push rod 175 can move rearwardly against the resistance of the helical compression spring 178, thereby to permit the blade 98 to breathe or move in respect to the undulating surface of the drying drum 21. Since in other respects the structure shown in Fig. 16 is identical to that shown in Figs. 1–15, the same reference numerals have been employed.

In the operation of the drum dryer shown a liquid or semi-liquid product film is applied to the descending side of the internally heated rotating drum 21, this film being carried around the underside of the drum and up its rising side to the two series A and B of knives. During this movement of the film on the heated drum 21, moisture is evaporated from the film and since this film is continuously being applied and continuously being removed by the knives, the operation of the dryer is continuous. This film first encounters the blades 98 of the lower series of knives designated at B, this series of knives extending lengthwise of the drum 21 and these knives being in spaced relation, these knives thereby removing a part of the film in the form of a series of spaced ribbons. The portions of the film on the drying drum 21 passing through the spaces between the knives 98 of the lower series B continue upwardly until they are engaged by the blades 98 of the upper or second series of knives designated at A. The lengths of the blades 98 of the two series A and B of knives are such as to overlap and hence the strips on the drum passing between the blades 98 of the lower series B of knives are completely removed

in the form of ribbons by the second series A of these knives.

These ribbons so removed by both series A and B of knives curl outwardly over the air supply manifold and slide downwardly along the outer metal sheet or plate 138 of this air manifold. As best shown in Figs. 11 and 12, this outer sheet 138 of the air supply manifold is curved and extends downwardly and outwardly to lead the ribbons so removed by the knives into the space between the aprons 133 and 134 of the screw conveyor 132. This screw conveyor picks up these ribbons and conveys them lengthwise to one end of the conveyor trough 131, this screw conveyor 132 serving to break up the ribbons into pieces capable of subsequent handling in a flaker or the like.

With many materials in order to condition the ribbons so removed by the knives it is necessary to provide auxiliary cooling means for reducing the temperature of the material removed from the drum 21 by the blades 98. This auxiliary cooling is performed by the air supply manifold which functions as follows:

In its operation cooling air under pressure is introduced into one end of the air supply pipe 135 from which it escapes through the two series of openings 152 and 153. The amount of air so escaping from these openings is under control of the valve slides 154, these valve slides having readily accessible finger pieces 156 at one end as shown in Figs. 10 and 15. The longitudinal adjustment of the slides 154 adjusts the effective sizes of either series of openings 152 or 153, thereby to adjust the amount of air admitted to the chambers 140 and 141. The chamber 140 communicates with the interior of the two series of tubes 165*a* and 165*b*. The tubes 165*b* are relatively short and each delivers the air against the under side of the corresponding lip or flange 163. The tubes 165*a* are relatively long and each delivers an upwardly directed stream of air under the corresponding rectangular extension 160.

Since the ribbons or strips of material removed by the series A of knives travel over the rectangular extensions 160, and since the ribbons or strips of material removed by the lower series B of knives travel over the flanges 163, it will be seen that an individual blast of air from the corresponding tube 165*a* or 165*b* impinges against the underside of each band or ribbon being removed from the drum and serves to cool and toughen each band or ribbon as well as to lift or float the ribbon and insure smooth delivery of these ribbons to the outer metal sheet 138 of the air supply manifold. It will also be seen that since the product film is removed from the drum in the form of strips or ribbons the blasts of air so directed by the tubes 165*a*, 165*b* against the under sides of these ribbons readily escape through the spaces between these ribbons so that there is no pocketing of vapor-laden air under the film being removed from the drying drum as would be the case if this film were removed in a single continuous sheet.

As the ribbons continue their downward journey over the outer side plate 138 of the air supply manifold they pass over the louvers 161 which deflect further jets of cool air against these ribbons. This air is supplied from the chamber 141 through the openings provided in forming the louvers 161, as best shown in Figs. 12 and 13, and the jets of air so delivered through these openings and deflected downwardly by the louvers 161 provide for further cooling of the film to insure their proper conditioning for ready handling by the screw conveyor.

The pressure of the knife blades of either series A or B can readily be adjusted to suit the particular product being removed from the drum. This pressure is individually adjusted for each knife holder and is effected by turning the hand wheels 109. Turning this hand wheel for each knife holder 95 screws down or backs up the threaded connection between the corresponding push rod 108 and the nut 111 supporting this push rod. This longitudinal movement of the push rod 108 increases or decreases the pressure exerted by the push rod on the upper side of its knife holder 95 and thereby increases or decreases the pressure of the sharpened edge of the knife blade 98 against the surface of the drying drum 21, the rod 85 for each knife holder being free to oscillate about its pivot 78. In the event the form of push rod shown in Fig. 16 is employed the knife blade 98 is yieldingly held against the drum 21 by the reactance of the spring 178 which tends to expand longitudinally the push rod shown in this figure.

A worn knife blade can be replaced very rapidly by the following procedure and without shutting down operation of the dryer.

With a knife holder 95 whose blade is worn, the operator grasps hand wheel 109 turning it counterclockwise a few turns to back up the push rod 108 far enough to free it from socket 105 and flange 105 on knife holder 95 dropping the push rod 108 onto stop pin 114.

The operator then grasps the handle 86 of this rod 85 and moves it downward, thereby to elevate the knife holder 95, until the spring loaded detent 118, operated by the plunger 119, snaps into the recess 121 provided in the ear or extension 75 on the sleeve 50 and which rotatably supports the head 80 which carries the knife holder rod 85. With one hand on the handle 86 the operator loosens the thumb screw 91 and pushes the collar 89 two inches or so toward the knife holder 95 and then tightens this thumb screw 91 to keep the collar 89 from sliding. He then pulls on the handle 86 until the collar 88 is removed from the recess 82 and clears the head 80 of the swivel pin 78. The operator then removes the rod 85 sideways from the slot 81 thereby freeing the entire knife holder assembly from the swivel pin structure 78, 80.

With another knife holder assembly containing a sharp blade 98 available, the replacement can easily be effected by a reverse of the above procedure. Thus the operator takes the fresh knife holder assembly and moves the collar 89 an adequate distance on the rod 85 toward the knife holder 95 and tightens the thumb screw 91 so that this collar will not slide on the rod. He then slides the shaft 85 between its collars 88 and 89, sideways into the slot 81 in the head 80 of the swivel pin 78. He then pushes forward on the rod 85 until the collar 88 enters the counterbore 82 as far as it will go and loosens the thumb screw 91 and moves the opposite collar 89 into the counterbore 83 and tightens the thumb screw 91.

He then turns the crank 69, 70 a few turns clockwise so as to slide the movable sleeve 50 upwards as far as it will go, this upward movement of this sleeve being effected through the screw 64 and its collar 65. This sets the pivots 79 and 112 for the rods 85 and 108, respectively, so that at the start of use the knife blade 98 will operate at its minimum angle. The operator,

with one hand on the handle 86, then pulls out the small plunger 119, this freeing the detent 118 from the hole 121 and permitting the head 80, and the rod 85 carried thereby, to swivel about the axis of the pin 78. He then slowly raises the handle 85 to lower the knife blade 93 to engage the drum 21. Since the swivel pin 78 for the head 80 turns freely in its mounting on the sleeve 50 and the rod 85 with its collars 88 and 89 turn freely in this head 80 of the swivel pin 78, it will be seen that the knife blade 93 automatically alines or fits itself to the surface of the drum 21.

The operator then raises the handwheel 109 of the push rod 108 to aline this push rod with the socket 106 of the knife holder 95 and turns the handwheel 109 clockwise. This moves the push rod, through its threads 110, longitudinally to bring its lower end into contact with the socket 106 and to exert the desired pressure on the blade 93 through the knife holder 95.

While the above description appears lengthy, the time required to make a complete knife change is very short. By actual timing it requires approximately a half minute to remove a worn knife and replace it with a new knife as described.

It will also be seen that the angle of each knife blade 93 with reference to the surface of the drum 21 can quickly be altered. This is important in extending the life of the knife blades 93. Thus, a fresh or sharp knife blade is started at the minimum angle relative to the tangent at the line of contact of the knife with the drum surface and is subjected to light pressure contact against the drum surface. In use a flat is worn on the knife blade, this flat being in contact with the drum surface and growing with wear. When the wear or increase of the flat surface in contact with the drum becomes sufficient to impair proper removal of the product film from the drum, the knife angle, with reference to the tangent at the line of contact of the knife blade with the drum surface, is increased slightly so as to bring the knife blade toward a radial position. This slight change in angularity of the knife moves the flat worn at its edge away from the drum surface and leaves only the sharp cutting edge in contact with the drum surface so that the product film is again effectively removed with light knife blade pressure. As a second flat wears on the newly positioned knife blade, its angle can be again increased to move this second flat away from the drum surface and again leave only the sharp cutting edge of the knife in contact with the drum surface.

This increase in the angularity of each knife blade with reference to the drum surface can readily be effected by turning the crank 69, 70 to lower the sleeve 50 supporting the knife blade. This downward movement of the sleeve 50 is effected through the screw 64 and its collar 65. The downward movement of this sleeve lowers the pivot points 78, 112 about which the knife holder rods 65 and 108 swivel and hence it will be seen that this increases the angle of the knife blade 93 relative to the drum surface to so increase the effective life of the blade.

From the foregoing it will be seen that the present invention provides a simple and effective means for removing the film from the drum of a drum dryer and for air cooling the same to place it in proper condition for handling by the conveyor and provides a knife assembly in which the blades are self-alining, readily adjusted to obtain the maximum life, and are readily removed, reground and replaced when required.

I claim:

1. Apparatus for removing the product film from the surface of a revolving drum, comprising a plurality of knife blades arranged along the periphery of said drum and with their cutting edges in engagement therewith, and means forming the sole support for at least one of said knife blades, comprising a rod mounted adjacent the periphery of said drum and parallel with an adjacent tangent thereof, a sleeve slidably mounted on said rod for non-rotative movement lengthwise thereof, means for adjustably positioning said sleeve lengthwise of said rod, an arm pivoted exclusively on said sleeve and projecting toward said drum, a supporting head connected centrally to said one of said knife blades and mounted on the end of said arm adjacent said drum and in position to engage the periphery thereof, and a member movably mounted on said sleeve and urging said one of said knife blades into engagement with the periphery of said drum.

2. Apparatus for removing the product film from the surface of a revolving drum, comprising a plurality of knife blades arranged along the periphery of said drum and with their cutting edges in engagement therewith, and means forming the sole support for at least one of said knife blades comprising a rod mounted adjacent the periphery of said drum and parallel with an adjacent tangent thereof, a sleeve slidably mounted on said rod for non-rotative movement lengthwise thereof, means for adjustably positioning said sleeve lengthwise of said rod, an arm pivoted exclusively on said sleeve and projecting toward said drum, a supporting head connected centrally to said one of said knife blades and mounted on the end of said arm adjacent said drum and in position to engage the periphery thereof, and means on said sleeve and urging said one of said knife blades into engagement with the periphery of said drum comprising a longitudinally adjustable push rod mounted on said sleeve at a place in spaced relation to the pivotal mounting of said arm and having one end connected to urge the end of said arm adjacent said drum toward said drum.

3. Apparatus for removing the product film from the surface of a revolving drum, comprising a plurality of knife blades arranged along the periphery of said drum and with their cutting edges in engagement therewith, and means supporting at least one of said knife blades, comprising a supporting rod arranged adjacent the periphery of said drum and parallel with an adjacent tangent thereof, a sleeve slidably mounted on said rod for non-rotative movement lengthwise thereof, means for adjustably positioning said sleeve lengthwise of said supporting rod, a swivel pin mounted on one end of said sleeve to swing about an axis generally parallel with the axis of said drum and having a head, a blade holder rod detachably secured to said head to extend transversely of said swivel pin and toward said drum, a holder for said one of said knife blades mounted on the end of said rod adjacent said drum and in position to engage the periphery thereof, a push rod pin rotatably mounted on the opposite end of said sleeve to swing about an axis generally parallel with the axis of said drum and having a head, said last head being provided with a threaded hole extending therethrough transversely of the axis of said push rod pin, a threaded push rod screwed in said hole, one end of said

push rod being operatively connected to said blade holder rod to urge said one of said blades into engagement with the periphery of said drum.

4. Apparatus for removing the product film from the cylindrical surface of a revolving drum, comprising a holder arranged adjacent said cylindrical surface, a cantilever beam carried by and projecting from said holder, a tension member hinged to the outer end of said cantilever beam and projecting toward said cylindrical surface, a longitudinally adjustable strut hinged to an intermediate point along said cantilever beam and projecting toward said cylindrical surface in converging relation to said tension member, a knife head secured to the end of said tension member adjacent said cylindrical surface and bearing against the adjacent end of said strut, a knife blade carried by said knife head and having a cutting edge engaging said cylindrical surface in opposition to its movement, and a member secured to said cantilever beam and operable for varying the effective length of said cantilever beam between said holder and its hinged connection with said strut.

5. Apparatus for removing the product film from the periphery of a revolving drum, comprising a holder mounted adjacent the periphery of said drum, a swivel pin mounted on said holder to swing about an axis generally parallel with the axis of the drum and having a head, said head being provided with a transverse slot, a rod fitted in said slot and extending transversely of the axis of said swivel pin and toward said drum, a member releasably retaining said rod in said slot, and a knife blade mounted on the end of said rod adjacent said drum and having a cutting edge engaging the periphery thereof in opposition to its movement.

6. Apparatus for removing the product film from the periphery of a revolving drum, comprising a holder mounted adjacent the periphery of said drum, a swivel pin mounted on said holder to swing about an axis generally parallel with the axis of the drum and having a head, said head being provided with a transverse slot, a rod fitted in said slot and extending transversely of the axis of said swivel pin and toward said drum, said head being provided with retaining sockets at opposite ends of said slot, a collar fixed to said rod and fitting one of said sockets, a collar slidable on said rod and fitting the other of said sockets and releasably secured therein, and a knife blade mounted on the end of said rod adjacent said drum and having a cutting edge engaging the periphery thereof.

7. Apparatus for removing the product film from the periphery of a revolving drum, comprising a holder mounted adjacent the periphery of said drum, a plurality of knife heads, a knife blade mounted on each of said knife heads and having their cutting edges arranged in opposition to the moving surface of said drum, a supporting arm secured to each of said knife heads, a pivotal connection between each of said supporting arms and said holder, and a manually releasable detent interposed between each of said supporting arms and said holder and arranged to latch said arm in an inoperative position against pivotal movement.

8. Apparatus for removing the product film from the periphery of a revolving drum, comprising a holder mounted adjacent the periphery of said drum, a swivel pin mounted on said holder to swing about an axis generally parallel with the axis of the drum and having a head, a rod detachably secured to said head to extend transversely of said swivel pin toward said drum, a knife blade mounted on the end of said rod adjacent said drum and having a cutting edge engaging the periphery thereof in opposition to the movement thereof, a pin rotatably mounted on said holder in a position to one side of said rod and to swing about an axis generally parallel with the axis of said drum and having a head, and a push rod extending through said last head transversely of the axis of its pin and adjustable longitudinally therein, the end of said push rod adjacent said drum being operatively connected with said knife blade to urge its cutting edge into firm engagement with the periphery of said drum.

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