

Oct. 24, 1967

J. F. KING, JR., ETAL

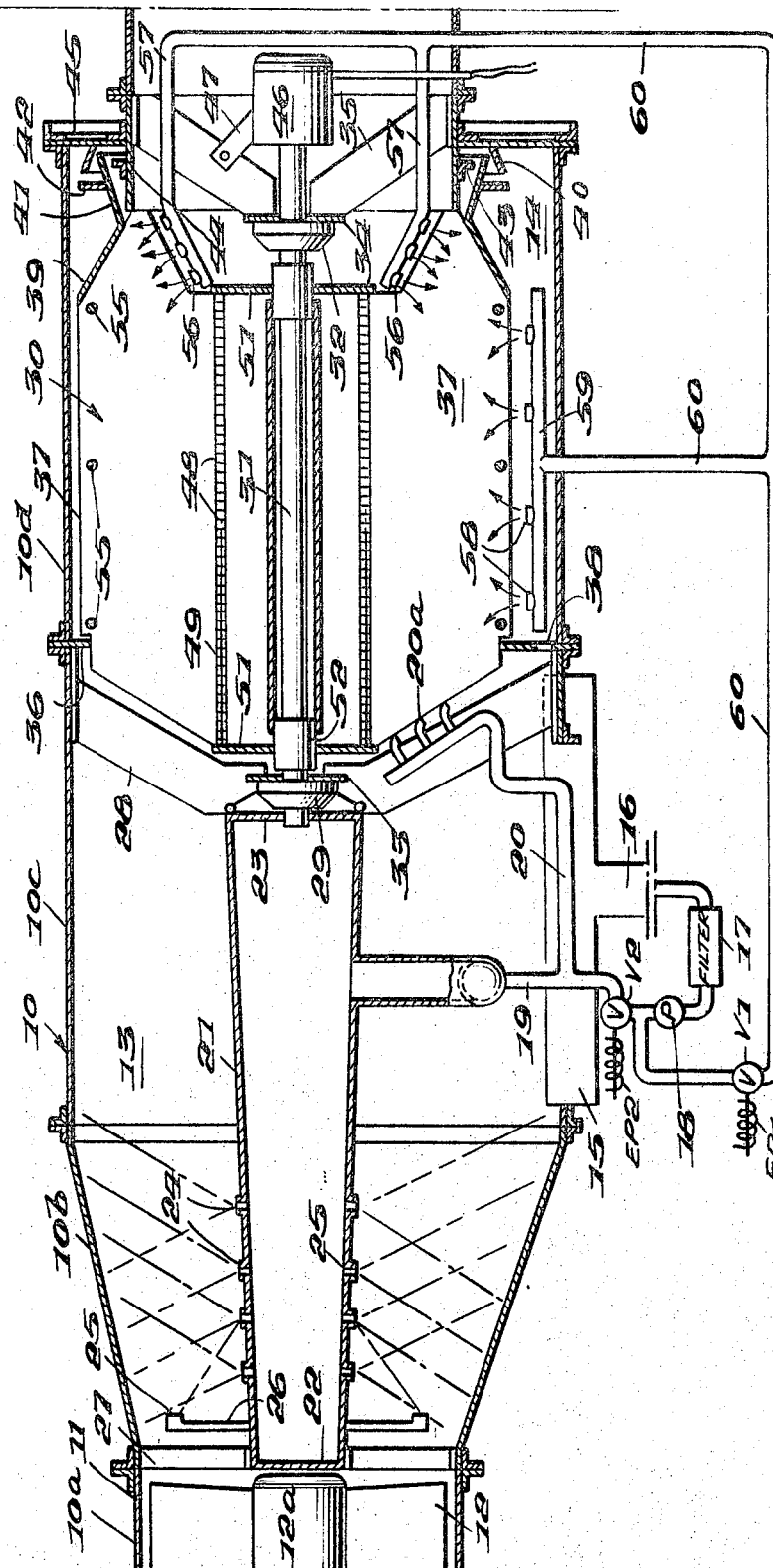
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ROTATING ELIMINATOR

Filed Aug. 23, 1966

2 Sheets-Sheet 1

Fig. 1.



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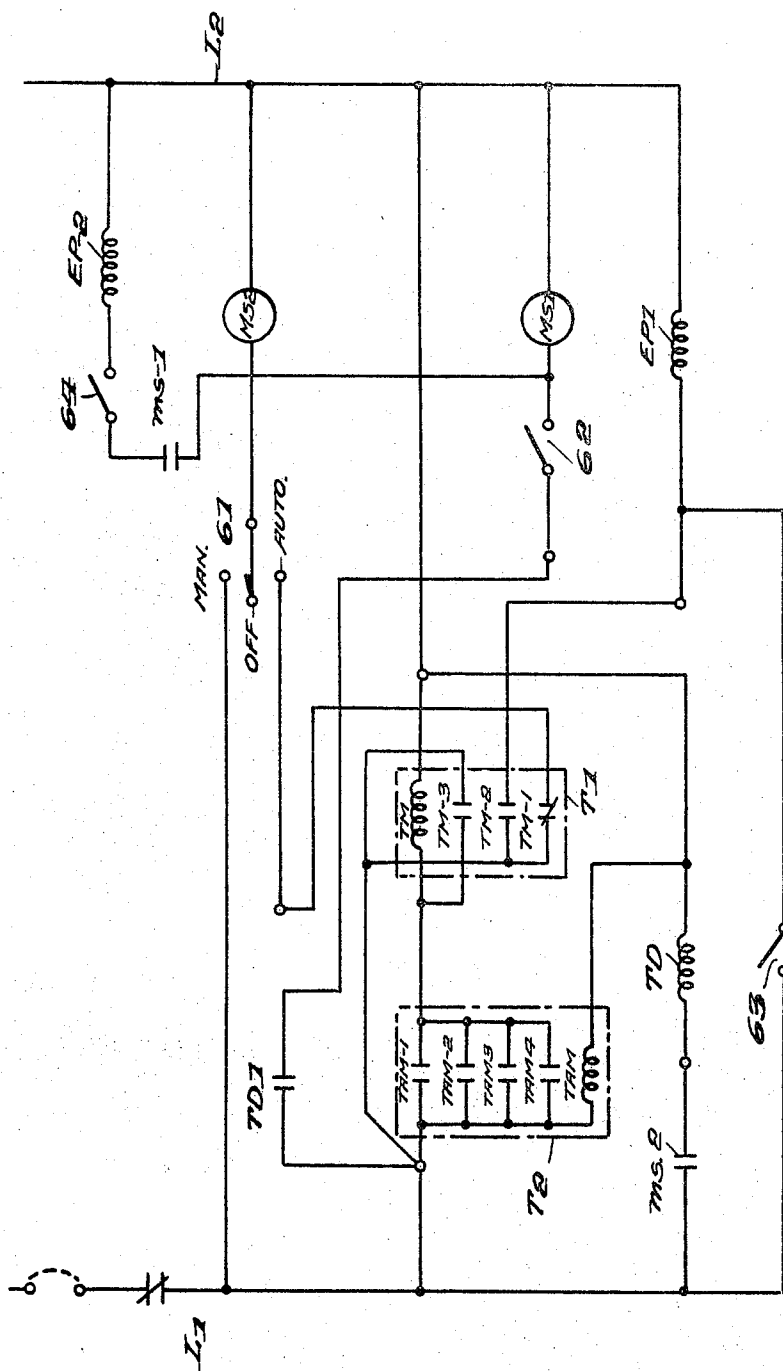
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ROTATING ELIMINATOR

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7 Claims. (Cl. 55—227)

This application relates to an improvement in rotary bladed apparatus for eliminating moisture droplets entrained in air which has been washed, and is a continuation-in-part of application Ser. No. 351,418, filed Mar. 12, 1964, now patent number 3,282,032, issued Nov. 1, 1966, which was a continuation-in-part of application Ser. No. 264,473 filed Mar. 5, 1963, now abandoned, which in turn was a continuation-in-part of application Ser. No. 169,432, filed Jan. 29, 1962, also now abandoned.

The present invention is directed to an improved construction for a rotary bladed eliminator and has for its principal object to provide an improved arrangement for removing from the eliminator structure any lint and other particles entrained in the air stream and which may be caught up and deposited upon the surfaces of the blades, as well as in the spaces between blades. Collection of lint and other particles on and between the surfaces of adjacent blades not only lowers the ability of the eliminator to perform its function properly but also is reflected by a corresponding increase in the pressure drop through the eliminator which increases the cost of operating the apparatus since correspondingly more power is required to drive the air through the eliminator section of the complete air washer equipment.

More particularly, the desired objective of the invention is attained by use of flooding nozzles arranged adjacent the blading on the eliminator and from which comparatively high velocity jets of water are discharged into the spaces between the blades to wash off and remove any foreign particles such as lint and the like which may have become jammed in the blading. The flooding nozzles are located adjacent the radial edges of the blading at the discharge end of the eliminator structure and can also be located adjacent the longitudinally extending edges of the blading, i.e. at the periphery of the eliminator structure.

In accordance with a further feature of the invention, operation of the flooding nozzles to clean off the blading is programmed so as to take place at timed intervals. The cleaning sequence operates on a given cycle with the aid of timer motor means and the necessary switching devices controlled by the timer which will switch the various operating components on and off at the proper times and in the correct sequence. Thus, for example, the cleaning cycle can be set up to provide for automatic control over a pump or valves which control supply wash water to the air washer unit, and the air blower located ahead of the rotating eliminator so as to shut down these components while the flooding nozzles are operating to clean off the blading of the eliminator, and also to automatically cut off the rotary drive for the eliminator so that the latter will slow down during operating of the flooding nozzles. Also, the flooding nozzles can be arranged at such an angle to the blading as to produce a slight turbine action sufficient to effect rotation of the blading at a relatively low speed past the flooding nozzles during the clean-off operation.

The foregoing as well as other objects and advantages inherent in the invention will become more apparent from the following detailed description of one suitable embodiment and from the accompanying drawings wherein:

FIG. 1 is a view in central longitudinal section of a complete air washer including a rotating bladed elimi-

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nator section together with means for cleaning off the eliminator blading; and

FIG. 2 is a schematic wiring diagram of a programmer by which to obtain a periodic clean-off of the eliminator blading according to a given operating cycle for the entire air washer.

With reference now to the drawings and to FIG. 1 in particular, the improved high-velocity, low static pressure air washer and eliminator assembly is seen to include an elongated casing 10 through which the air is passed for washing and for thereafter eliminating all or a desired portion of the water droplets which become entrained in the air stream after leaving the washer section of the assembly. The casing 10 thus includes a cylindrical entrance chamber 11 seen at the extreme left in FIG. 1 in which a fan 12 is located, the function of the fan being to force the incoming dirt and lint laden air to be treated through the washer chamber 13 and thereafter through the eliminator chamber 14. A truncated conical section 10b of the casing which diverges in the direction of air flow therethrough is connected to the cylindrical entrance section 10a, and conical section 10b is followed by a cylindrical section 10c, the casing sections 10b and 10c serving to establish the washer chamber 13. The cylindrical casing part 10c has a rectangular opening cut into the under portion thereof and a sump 15 is welded to the wall of this opening. A drain pipe 16 is welded to an opening in the bottom wall of this sump so that it can drain away the water which is fed to the washer and which is not evaporated. This drain water is preferably used on a recirculating basis in the washer so that pipe 16 is a gravity drain back to a filter unit 17 to remove foreign particles washed away from the air stream so that the clean water can then be directed from the filter through a pump 18 which returns the water via a valve V2 controlled by solenoid EP2 and piping 19 to a water inlet header which is constituted by an elongated tube 21 that extends centrally and generally horizontally within the casing sections 10b, 10c. The water header tube is closed at the opposite ends thereof by walls 22 and 23. The diameter of the water header tube 21 at the end wall 22 adjacent fan 12 is preferably the same as the hub portion of the fan blades so that tube 21 not only functions as a header but also serves as an air directing means for the air stream which flows through the washer chamber 13. Water header tube 21 which is pressurized by the water admitted to the same from pump 18 is provided with a plurality of outlet nozzles 24, eight of which are seen in FIG. 1, which are secured directly into the wall of the header tube 21 so that their spray pattern is directed outwardly toward the conical wall section 10b. The number of nozzles can be selected as necessary to establish the required water flow for the washer and they are preferably located in a helical path around the periphery of the water header so that their spray patterns overlap. In addition, each full circle of nozzles is preferably spaced so that no two nozzles lie along the central axis of header tube 21 but there is a symmetry between the rows of nozzles to achieve a more complete coverage of the area of the washer which is near the center line.

In addition to the nozzles 24, other nozzles 25 which can be in any appropriate number for the size of the washer, are elevated on header pipes 26 which extend radially outward from header tube 21 to the approximate center line between the transition wall part 10b and header tube 21. These nozzles 25 are directed downstream of the air flow to help fill in any gaps which possibly may have been left by the nozzles 24. This 90° overlapping of the water issuing from the individual nozzles assures complete coverage of the washing space within the washer chamber 13 and provides an optimum condition for obtaining a higher saturation efficiency for the unit.

Water header 21 is maintained in its proper position inside of the washer chamber 13 by four struts in the form of plate 27 located 90° apart at the entrance to the conical transition section 10b and by a similar arrangement of four plate-like struts 28 placed at the junction between the washer section 13 and eliminator section 14. These latter struts also serve to support the front bearing 29 for the front end of the rotating eliminator assembly 30 which will be described later in further detail.

Washer chamber 10 is provided with another water supply header 20 which connects with pipe 19. This header 20 is mounted rigidly to the lower support 28 to maintain a spaced parallel relation to the tapered front surface of the blades 37 of the eliminator assembly 30, and is provided with a plurality of nozzles 20a which are so positioned as to direct high-velocity low-volume jets of water substantially parallel to the upstream face of the eliminator assembly. Although the nozzles 20a are located on only one header and spray preferably downwardly toward the sump 15, each eliminator blade 37 will have its upstream edge scrubbed by the water jets issuing from nozzles 20a as the blades 37 individually rotate past the water jets. The scrubbing action of the water jets from nozzles 20a is preferably included on an air washer of the type described if long fiber material such as cotton is being washed from the air flowing through the washer because some of the fibers drape across the edge of the blade, half of their length on one blade side and the other half on the blade opposite side in such a manner as to not be easily removable.

Air washer saturation efficiency is determined partially by how much water is added to the air stream as it moves through a chamber such as chamber 10, and control of such a washer is generally accomplished by throttling the sprays from the primary nozzles such as the nozzles 24, 25. This action reduces the water flushing action on eliminator blades 37 but does not diminish the lint being drawn through the washer to contaminate the eliminator. As a result, the continuous jet sprays from nozzles 20a are necessary to remove the lint which is caught on the entrance edges of the eliminator. The more usual procedure is to supply high-volume, low-pressure water from many nozzles facing directly into the eliminator and these are normally termed flooding nozzles. However, it has been found that this procedure allows the saturation efficiency of the washer to drop only to approximately 50% even through the primary nozzles have been closed off. The improved arrangement which has been described featuring the set of nozzles 20a allows the washer saturation to fall to approximately 20% since a very carefully directed high-pressure, low-volume water cleaning spray is used.

Since there are no air straightener vanes behind the blades of the fan 12 and the air will be leading at a vector angle relative to the velocity of the air through the washer and the rotational speed of the fan, struts 27 are preferably slanted relative to the longitudinal axis of the washer chamber 13 so that they will not interfere with the discharge helix angle since the air swirl tends to centrifuge the washer water out towards the walls 10b, 10c of the washer chamber and thereby eliminate much of the water which could possibly have to be eliminated in the straight bladed, rotating eliminator assembly 30. The other struts 28 could also be slanted in the same manner as struts 27 but since the former are so close to the rotating eliminator assembly 30 and because of some practical difficulty in slanting these larger plate members, they are installed parallel with the longitudinal axis of the washer.

The rotating eliminator assembly 30 is mounted for rotation on shaft 31 which is supported near each end by ball bearing assemblies 29, 32 which are bolted to plates 33 and 34 respectively. Plates 33 and 34 are welded respectively onto the struts 28 for the front bearing assembly and struts 35 for the rear bearing assembly which are similar in number and position to the struts 28. The two sets of eliminator bearing support struts 28 and 35 are secured

to reinforced wall portions of the overall casing structure 10.

An annular air seal baffle plate 36 is secured between the connecting flanges of the washer and eliminator wall sections 10c, 10d of the casing and the inner edge of this baffle extends to the periphery of the blades 37 of the rotating eliminator assembly 30 to prevent high velocity air from traveling through the annular space defined by the wall 10d of the eliminator section and the outer edges of the eliminator blades 37.

The longitudinal axis of the rotating eliminator assembly 30 is offset slightly upward from the longitudinal axis of the eliminator section 14 of the apparatus so that there is a larger space underneath the rotating eliminator assembly than above it, this space being used to contain water in such quantity that the slight pressure head developed will force the water back through a scupper 38 and back into sump 15 from whence it can drain through pipe 16.

The air exit end of the rotating eliminator assembly 30 is surrounded by a seal assembly of solid sheet metal which consists of a truncated conical section 39 rigidly attached to the blades 37 of the eliminator assembly. A reversely extending truncated conical section 41 is rigidly attached to section 39 and extends rearward away from the eliminator. An annular shaped baffle plate 42 extending radially is secured to the truncated section 41. The truncated conical sections 39, 41 and the annular baffle plate 42 constitute the rotating components of the air seal at this end of the eliminator assembly. The stationary parts of the seal are comprised of an annular baffle plate 43 extending radially outward from a cylindrical wall section 44 which extends axially of the eliminator assembly 30 and lies inwardly of the truncated section 41. The cylindrical section 44 is fitted into a circular opening in the end wall plate 45 of casing 10 for the rotating eliminator assembly. A truncated conical baffle 40 is rigidly attached to this end plate 45 and extends into the area lying between the rotating conical section 41 and baffle plate 42. The drive shaft 31 of the rotating eliminator assembly terminates in a gear motor 46 which is mounted directly on the shaft. This gear motor has a torque arm 47 attached to the motor case and secured to one of the rear struts 35 so that it can effect rotation of shaft 31.

The rotating eliminator is comprised of an assembly of the radially extending planar blades 37 arranged in planes parallel with the axis of rotation and which rotates with the motor driven shaft 31. In the illustrated embodiment the radially inner edge portions of the blades 37 are cut and bent outward from the plane of the plate in opposite directions to form a series of axially spaced loops 48 or piano hinge parts at each side of the blade. The hinge parts 48 of adjacent blades are interlinked and held together by means of rods 49 which pass through the hinge parts 48 and are made slightly longer than the length of the eliminator blades so as to project from each end thereof. The opposite end portions of the rods 49 are passed through apertures in end plates 51 which are secured fast to hubs 52 which are fitted onto shaft 31 and secured thereto such as by keying.

In order to substantially form a sealed cylindrical surface extending circumferentially under all of the eliminator blades 37 to prevent the flow of water laden air into and through the practically hollow hub portion of the rotating eliminator assembly 30, the interfitted laterally turned radially inner edge portions of adjacent blades also serve to close the separation between adjacent planar surfaces of the blades in addition to their function as hinge parts.

Preferably, the radially outer portions of the eliminator blades 37 are held in spaced relation by means of rubber spacers 55.

When motor 46 is energized thus causing shaft 31 and hence also the assembly of eliminator blades 37 to rotate, air washed in the washer chamber 13 and any water drop-

lets entrained therein entering the channels formed between adjacent blades 37 will be caused to move in a helical path as it travels from one end of the eliminator blade assembly to the other. As explained, the pitch of the helical path taken by the air will be determined by the velocity of the air and by the rotational speed of the eliminator blade assembly. During the time the water laden air is enclosed within the blades of the eliminator it is being rotated at a reasonably high speed and each particle of water and other particles having mass are propelled by centrifugal force toward the outer edges of the eliminator blades. In addition to this centrifugal separation of the water from the air there also exists a collateral scrubbing action between the blades 37 which helps to film the water out upon the surfaces of these blades so that it can come up to rotational speed more quickly. Water removed from the air by the rotating eliminator assembly is collected in the lower portion of the casing section 10*d* and is returned to the sump 16 for recirculation in the water header 21 after being passed through the filter 17 and pump 18.

During operation of the eliminator, it is possible that some dirt, lint and other particulate material may become stuck on the surfaces of the blades, and in the gaps between adjacent blades thus interfering with proper operation of the apparatus and increasing the static pressure losses. While dirt accumulation and clogging are not serious factors in the improved eliminator structure due to the fact that the blades are essentially planar throughout their area of contact with the air being passed through the eliminator, some dirt and clogging may occur and hence, it is advantageous if arrangements are made for conveniently cleaning off the blades. FIG. 1 illustrates one suitable arrangement wherein it will be seen that one or more rows of flooding nozzles 56 mounted on header pipes 57 are located at the discharge end of the bladed eliminator assembly 30, the nozzles being so directed as to discharge streams of water under considerable pressure in a backward, i.e. generally upstream direction into the space between adjacent blades and thus flush out any particulate matter which may have become lodged on and between the blades. The present embodiment also makes use of other flooding nozzles 58 located adjacent the periphery of the blading and extending longitudinally along the same for directing streams of clean-out water in a generally radially inward direction. These nozzles 58 are mounted on header pipes 59. Besides their cleaning function, the nozzles 58 can be so positioned as to direct their discharge at a slight angle to a true radial direction so as to create a turbine effect which can be used to effect a comparatively slow rotation of the eliminator assembly during cleaning. The header pipes 57, 59 are connected back through a common pipe 60 and valve V1 controlled by solenoid EP1 to the outlet from pump 18 and, as will be explained later, automatic control over operation of the flooding nozzles is such that when the discharge from pump 18 is put through valve V1, the other valve V2 controlling flow of water to the air washer nozzles 24, 25 and nozzles 20*a* is cut off.

The invention provides a program type of control for effecting periodic operation of the flooding nozzles to clean out the eliminator, thus assuring an essentially continuous operation of the eliminator at optimum efficiency. The programmer is illustrated in electrical schematic form in FIG. 2. Here it will be seen that a slave timer T1 operated by a timer motor TM includes three sets of contacts TM-1, TM-2 and TM-3. A master timer T2 operated by a timer motor TAM and controlling four sets of contacts TAM-1 to TAM-4 is correlated to operation of the slave timer T1 to establish the desired interval between cleaning cycles.

The starter MS-2 for motor 12*a* which drives fan 12 is connectable across its power supply lines L1 and L2 through a selector switch 61 containing an "off" position, a "manual" position, and an "automatic" position. In

the "off" position the fan motor starter is simply off from its power supply lines. In the "manual" position, fan motor starter MS-2 may be energized at any time by direct connection to its power supply lines, by-passing the timer control. In the "automatic" position, control over the fan motor starter is established through contacts TM-1 on slave timer T1.

The starter MS-1 for motor 46 which drives the eliminator assembly 30 is connectable across the power line conductors L1, L2 through a manually operated switch 62 which is usually kept closed but which can be opened at any time, thus by-passing the timer control in order to stop the eliminator assembly in the event of an emergency, or for any other necessary reason. Also connected in this starter circuit for the eliminator motor are contacts TD-1 of the delay timer, the motor TD of which is connected in series with auxiliary contacts *ms*-2 on the fan motor starter MS-2 so that the motor TD of the delay timer runs only when the fan motor starter MS-2 is energized.

Solenoid EP-1 controlling valve V1 is connectable across its power supply L1, L2 through a manually controllable switch 63 which is usually kept open and is connected automatically to the power supply through contacts TM-2 of the slave timer T1.

The circuit for energizing solenoid EP-2 from supply lines L1, L2 and controlling operation of valve V2 includes a manually operated switch 64 which is usually kept closed, and auxiliary contacts *ms*-1 on starter MS-1 for the eliminator motor, as well as manually operated switch 62 and contacts TD-1 of the delay timer.

The program control over operation of the complete washer and eliminator structure operates in the following manner. The motor TAM of master timer T2 runs continuously and controls the four separate sets of paralleled contacts TAM-1 to TAM-4. By a proper phasing of these four separate sets of contacts, it is possible to establish almost any repeatable time cycle up to and including one operation every twenty-four hours. Master timer T2 in turn, through one of its four sets of contacts TAM-1 to TAM-4 when closed, energizes motor TM of slave timer T1 which, once started, continues through its entire sequence and then turns itself off to await the next impulse from master timer T2. Slave timer T1 controls three sets of contacts of which the contact sets TM-1 and TM-2 control various sequenced events, and contact set TM-3 serves as a holding contact to cause the timer to operate through one complete cycle which may, for example, be thirty minutes.

On the assumption that the manual, spray valve switch 64 is closed, fan starter switch 61 is turned to "auto," eliminator switch 62 is closed, and the flooding or backwash switch 63 is open, the operating sequence is as follows:

(1) Master timer T2 indicates that a timed cleaning cycle should be started by a closure of one of its four sets of contacts. This operation energizes the motor TM of slave timer T1 which, after a few seconds, closes its own holding contacts TM-3 which holds this timer in continuous operation for a total period of thirty minutes.

(2) Three minutes after slave timer T1 starts, contact TM-1 breaks its circuit which removes the power from starter MS-2 for fan motor 12*a* and hence, the fan begins to slow down and ultimately stop. When this happens, normally open auxiliary contacts *ms*-2 on motor starter MS-2 close and effect energization of the motor TD of the delay timer which, after approximately one minute, breaks the circuit by means of its internal contact set TD-1 to the eliminator motor starter MS-1 and also to the solenoid EP-2 which is required to be energized in order to keep valve V2 open. Thus, valve V2 moves to a closed position and cuts off the supply of wash water to the spray nozzles 24, 25 in the washer and also to the nozzles 20*a*.

(3) Approximately four minutes after slave timer T1

starts its cycle, switch contacts TM-2 close and complete a circuit for energizing solenoid EP-1 thus moving valve V1 controlled by it to open position and directing water from the discharge side of pump 18 through piping 60, 59, 57 to the backwash nozzle groups 56 and 58 which then function to clean out any foreign matter lodged in the spaces between adjacent blading on the eliminator assembly as well as the surfaces of the blades themselves. At this moment, all movable components of the washer-eliminator structure are stopped, with the exception of the two timers, the backwash sprays from the nozzle groups 56, 58, and the rotating eliminator which is being driven only by the weight of backwash water from the side-mounted flushing headers 58, which as previously explained, can be so directed as to effect a slight amount of turbine action. The cleaning operation continues for approximately three minutes after which slave timer contacts TM-2 open to thus break the energizing circuit to solenoid EP-1 which causes valve V1 to close and cut off further water flow to back-washing nozzle groups 56, 58.

(4) After one additional minute, which gives the eliminator a slight amount of time for draining purposes, contacts TM-1 of the slave timer close which in turn causes motor starter MS-2 for the air handling fan 12 to pull in and thus start this fan to running again. The ensuing flow of air through the eliminator assembly 30 will serve to bring the eliminator up to approximately one-half normal running speed with no electrical power being delivered to its drive motor 46. This is advantageous since it provides a means for gradually overcoming the extremely high starting inertia of the comparatively heavy eliminator assembly 30.

(5) When fan 12 is started by operation of its starter MS-2, motor TM of the delay timer is also started but it then operates through a delay sequence so that power is not applied to the eliminator drive motor 46 until the eliminator assembly 30 has had a chance to gain an initial speed as explained above.

(6) At the end of approximately nine minutes after the cleaning cycle starts, contacts TD-1 of the delay timer again close which then effects energization of starter MS-1 for the eliminator drive motor 46, and also re-energizes solenoid EP-2 of valve V2 to thus re-open this valve and turn the washer spray nozzles 24, 25 and nozzles 20a back on.

We claim:

1. In a combined air washer and eliminator, the combination comprising a casing having an air inlet at one end and an air outlet at the other end, a fan for moving the air to be treated through said casing between said inlet and outlet, a first electric motor operatively associated with said fan for driving said fan, a washer chamber located within said casing and including water spray means for effecting contact of water with the air, an eliminator chamber located within said casing on the downstream side of said washer chamber, a rotatably mounted bladed eliminator assembly located within said eliminator chamber and which comprises a plurality of radially extending blades for producing a centrifugally induced helical outward flow path of the liquid droplets separated out of the air stream, a second electric motor operatively associated with said eliminator assembly for rotatably driving said eliminator assembly, back flooding nozzles arranged adjacent the edges of the blades of said eliminator assembly, pump means having an inlet and an outlet, conduit means connecting the inlet of said pump means with the lower part of said eliminator chamber for recirculating water collected in said eliminator chamber, selectively operable valve means located at the outlet of said pump means and operatively associated with said pump means outlet for directing the water selectively to

said water spray means in said washer chamber and to said back flooding nozzles located in said eliminator chamber, and timer means programming operation of said air washer and eliminator assembly over a sequential cycle which includes firstly cutting off the electric power to said first and second electric motors, secondly operating said valve means to cut off the water to said water spray means substantially concurrently with the cutting off of said second electric motor and to thereafter cut on the water to said back flooding nozzles thereby to clean off the surfaces of the blades of said eliminator assembly, thirdly operating said valve means to cut off the water from said back flooding nozzles, fourthly, restoring the electric power to said first motor and thereafter to said second motor and lastly operating said valve means to restore the flow of water to said water spray means.

2. A combined air washer and eliminator as defined in claim 1 wherein said timer means includes a continuously running master timer establishing a plurality of time-spaced operating cycles for said air washer and eliminator and a slave timer controlled from said master timer at time spaced intervals established by the latter, the supply of electric power to said first and second electric motors and the control of said valve means being established during each operating cycle through said slave timer.

3. A combined air washer and eliminator as defined in claim 1 wherein said valve means includes a first solenoid operated valve connecting the pump outlet with said water spray means in said washer chamber and a second solenoid operated valve connecting the pump outlet with said back flooding nozzles in said eliminator chamber.

4. A combined air washer and eliminator as defined in claim 1 wherein said back flooding nozzles are so oriented in relation to the blades of said eliminator assembly as to impart a rotary motion to the latter as the water is ejected from the nozzles.

5. A combined air washer and eliminator as defined in claim 1 wherein said back flooding nozzles are located longitudinally along the eliminator chamber and adjacent the periphery of the blades.

6. A combined air washer and eliminator as defined in claim 1 wherein said back flooding nozzles are located adjacent the downstream discharge edges of the blades.

7. A combined air washer and eliminator as defined in claim 1 wherein said back flooding nozzles include one group of nozzles located longitudinally along the eliminator chamber and adjacent the periphery of the blades and also a second group of nozzles located adjacent the downstream discharge edges of the blades.

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