

July 28, 1936.

H. G. CRAM

2,049,050

EVACUATION OF CONDENSATE

Filed June 13, 1934

3 Sheets-Sheet 1

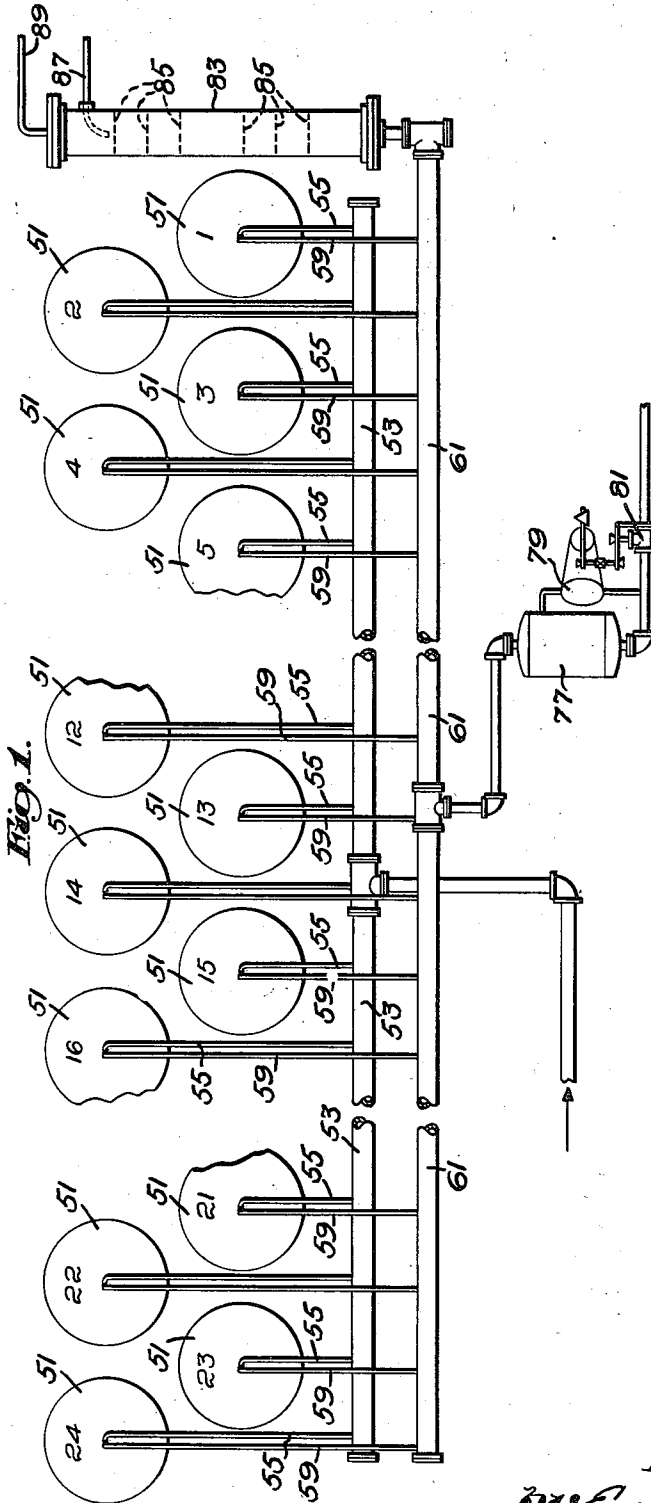
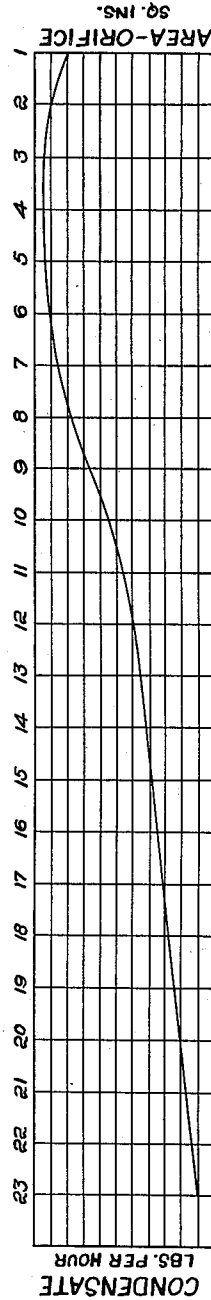


Fig. 2.

DRYER NUMBER



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3 Sheets-Sheet 2

Fig. 3.

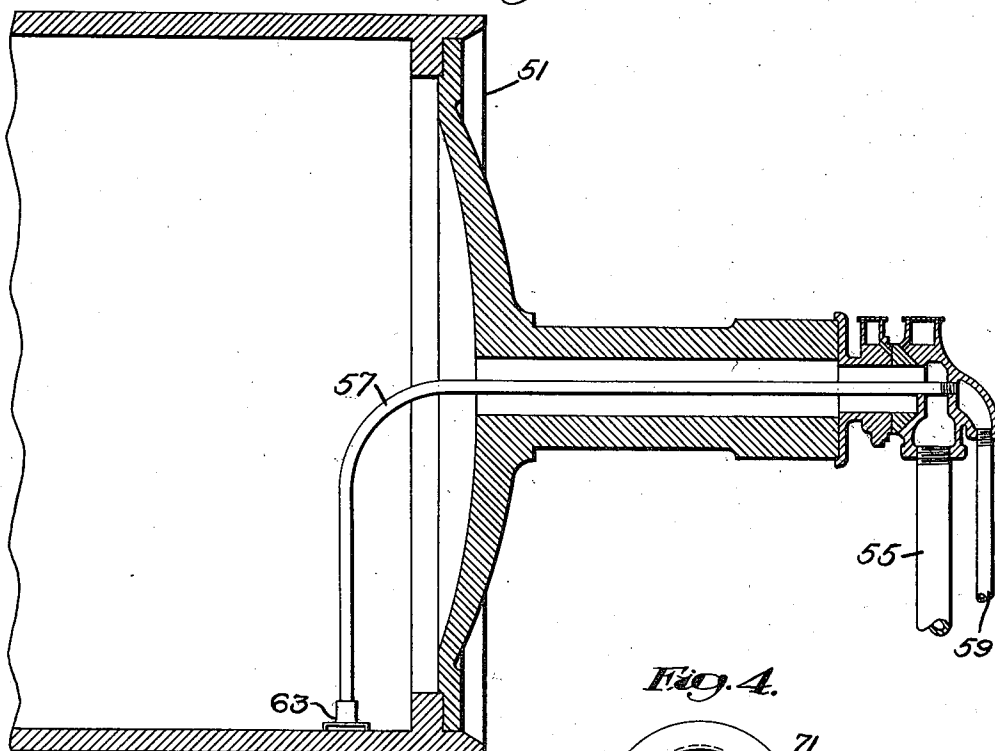


Fig. 4.

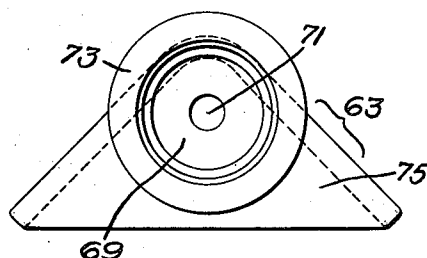


Fig. 5.

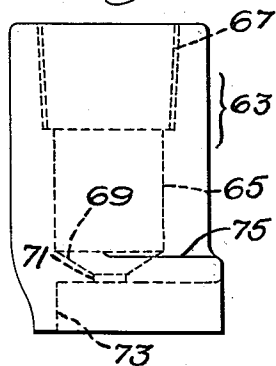
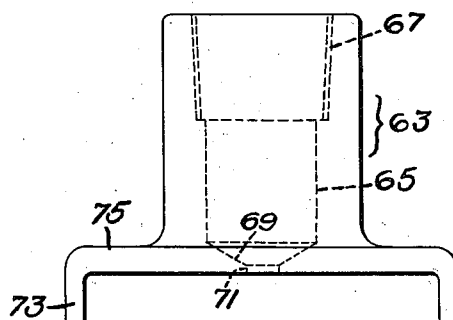


Fig. 6.



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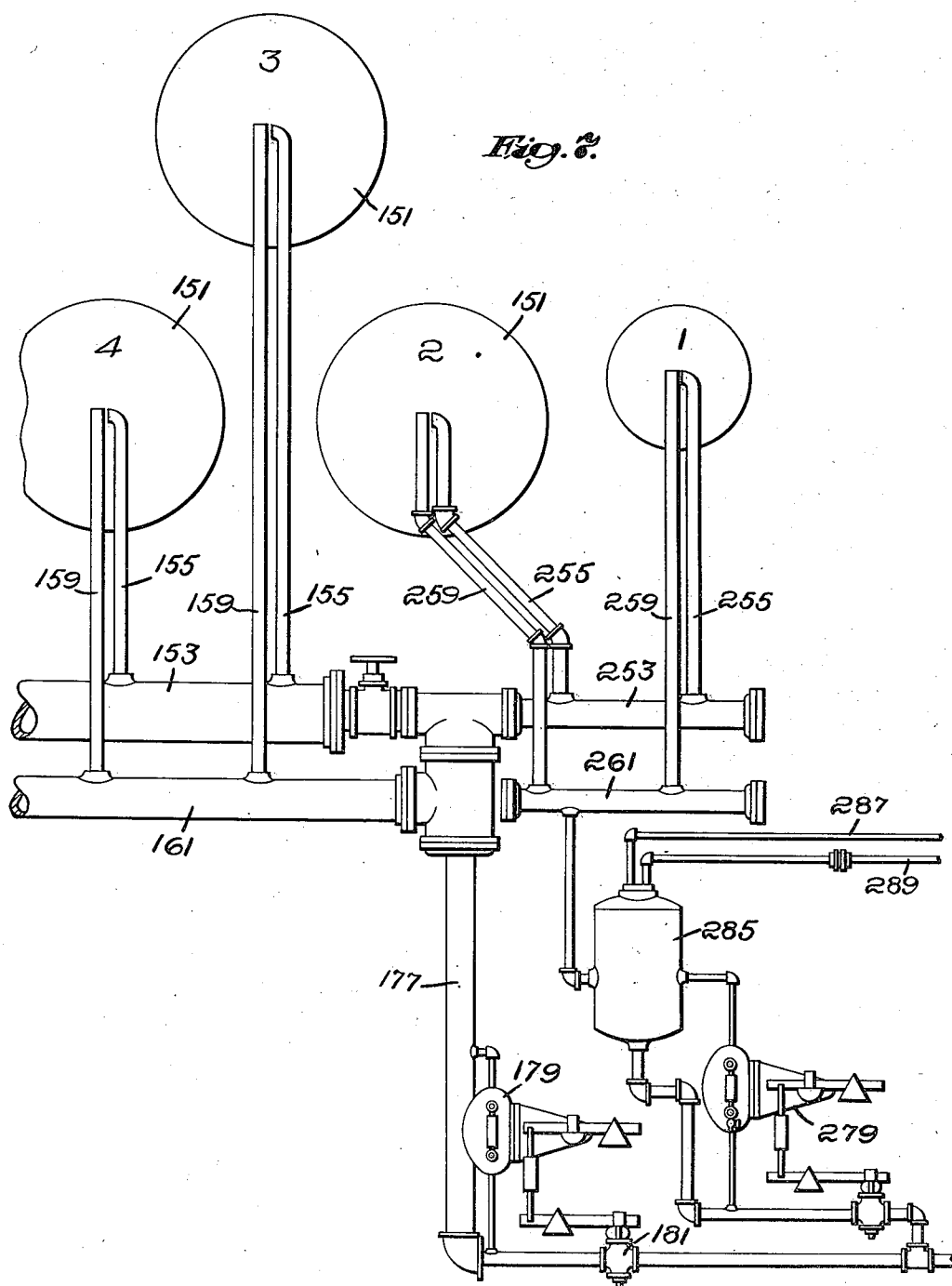
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EVACUATION OF CONDENSATE

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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

2,049,050

EVACUATION OF CONDENSATE

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Application June 13, 1934, Serial No. 730,450

12 Claims. (Cl. 34—48)

This invention relates to evacuation of the condensate from internally steam-heated cylinder driers such as are utilized in connection with paper making machines, and the object is to provide inexpensive, simple and efficient facilities for effecting such evacuation.

My invention will be well understood by reference to the following description taken in connection with the accompanying drawings, wherein:—

Fig. 1 is a broken diagrammatic view in side elevation of a drier;

Fig. 2 is a graph;

Fig. 3 is a fragmentary longitudinal section through one of the drying cylinders showing the eduction pipe;

Fig. 4 is an enlarged plan view of the tip of the pipe;

Fig. 5 is a side elevation thereof;

Fig. 6 is a front elevation; and

Fig. 7 is a fragmentary diagrammatic side view of another form of installation.

Referring to the drawings, I have shown in Fig. 1 in diagrammatic fashion a paper machine drier of well known type embodying a battery of cylinders, herein indicated as being twenty-four in number, about which the web coming from the paper making machine is trained. Steam is introduced from a steam header 53 by means of the branch pipes 55 extending to the trunnions of the cylinders as seen in Fig. 3. Water of condensation is removed from the interior of the cylinders by means of eduction pipes 57 extending through the trunnions and communicating with the pipes 59 which herein lead to a common header 61. Referring to Fig. 3, the eduction pipes are broadly similar to those in common use and usually called "syphons" in that they bend downwardly within the cylinder and have their ends presented in close opposition to the lower portion thereof to take up condensate accumulating at the bottom of the cylinder. I utilize, however, a novel form of eduction pipe preferably of a construction hereinafter to be more fully described. As is customary steam is supplied to the drier cylinders at a low pressure, say about two pounds per square inch gage.

From one point of view it might be considered that the best thermal efficiency would be provided if all the steam in each cylinder were condensed to water which was evacuated as such with no steam passing through the eduction pipes 57 to the condensate header 61. Apart from the practical difficulties, which will be appreciated, this, however, would tend to entrap air in the

cylinders and decrease its thermal efficiency. I therefore discharge a small amount of steam with the condensate to exhaust the air which is entrained with the steam, and in accordance with my present invention I effect an efficient and balanced operation of the drying cylinders by proper control of and through the surplus steam thus utilized. It will further be understood that for economical reasons it is not practical to exhaust the steam and condensate to atmosphere through the eduction pipes. In the customary operation of these so-called syphons hitherto they have communicated with a condensate-receiving system from which the condensate might be delivered to the boiler plant for boiler feed water or to some process wherein the heat contained could be utilized to advantage. With this arrangement the condensate accumulated in the drier cylinders until the inlets of the syphons became sealed. Thereafter some condensation of the surplus steam in the condensate header took place by radiation in the pipes, traps, etc., until such time as a sufficient amount of steam had been condensed to effect a decrease in pressure in the condensate header and thereby a differential in pressure between the interior of the drier and the header such as to force the accumulated condensate in the drier to pass up the syphon pipe and discharge to the condensate header. This caused a syphoning action, the condensate continuing to pass out of the driers until the seal at the inlet of one or more of the syphons was broken. When the seal was thus broken, any differential in pressure was, of course, equalized, and while theoretically the syphoning action should continue in other cylinders containing a greater amount of condensate, my practical observation has led me to believe that this would not in fact take place although I am unable to explain why. In any event, assuming that the various cylinders were thus emptied, no further discharge would take place until all the syphon pipes were sealed. As the rate of condensation in the battery of cylinders varied among the several cylinders, this resulted in the fact that at the wet end of the machine, that is, the point nearer the paper-making machine proper, a considerable quantity of condensate accumulated before the syphons at the dry end were sealed. This resulted in stagnation of circulation of steam through the driers, especially on the wet end, effected a collection of air therein detrimental to the conduction of heat from the steam to the drier wall and promoting rusting on the inside of the drier

rolls. Moreover, the accumulation of condensate materially increased the power required to rotate the drier cylinders especially when the latter were rotated at considerable speed. On the other hand, if a vacuum were maintained artificially in the condensate header, clearly when certain syphon pipes were unsealed a wasteful discharge of steam through the driers and inefficient thermal operation of the same resulted because of the large carrying capacity of the pipes. Certain ameliorations of the process have been effected in practice by subdividing the battery of cylinders into sections and discharging steam serially therethrough, but these arrangements in turn are subject to certain criticisms and obviously entail a multiplication of equipment which in itself is expensive and otherwise objectionable.

The operation of a system in accordance with my invention may be understood from the following description of the manner of its application to an existing machine. Given a machine such as shown in Fig. 1 with twenty-four drier cylinders, it will be appreciated that the condensation effected in each of the cylinders will not be the same because the web enters on cylinder 1 in a moist condition and emerges at 24 relatively dry. I have determined that the rate of condensation in the individual cylinders is determined by its location in the battery. A change in the weight of the sheet, in the speed of the machine or the like causes a change in the rate of condensation, but this rate of change will be relatively the same for all cylinders. As a matter of fact the nature of the paper machine is such that the drying conditions are almost constantly changing as the weight of sheet at best is not exactly uniform, nor is the moisture content therein, but the sheet usually passes so rapidly through the machine that these changes are felt substantially simultaneously throughout the system. In Fig. 2 I have shown a typical graph indicating in pounds per hour the condensation of such a machine as is diagrammed in Fig. 1.

In applying my system to an existing machine equipped with condensate evacuating means of one kind or another I actually measure the condensate from each individual cylinder as by installing a trap at the outlet pipe of each drying cylinder. From the data so obtained such a graph as is shown in Fig. 2 may be produced. It will be understood that while more efficient eduction devices might vary the rate of condensation and that the nature of the sheet being dried would also cause a change in the figures, the change would be sensibly uniform and under other conditions the curve would parallel that shown in Fig. 2.

With these data as a guide, the eduction system is constructed in accordance with the following principles.

The eduction devices which I prefer to use may be formed from pipes of any suitable or usual form provided with tips by means of which the discharge therethrough is controlled and which conveniently and preferably may be of the form shown in Figs. 4, 5, and 6 which embody the principles and advantages of the device shown in my Patent 1,919,416 although also substantially differing therefrom in their manner of operation. These tips 63 as herein shown may take the form of a bronze casting having a bore 65 of the same internal diameter as the pipe 57 and a coupling section 67 by means of which they may be screwed on to the end of the pipe

in the manner of an ordinary pipe fitting. The lower end of the tip corresponding to the end of the pipe has a transverse wall or septum 69 which is pierced by a small port or orifice 71. As will hereafter appear, the size of this orifice may vary, but for ordinary drying cylinders of an interior diameter of 4 feet and 100 inches in length I have obtained good results from orifices of a diameter of about $\frac{1}{4}$ of an inch, as will hereinafter be more fully explained. The length of the orifice is short, preferably less than the diameter. Outwardly of this orifice the end of the pipe is preferably provided with a depending wall 73 partially surrounding the same and which is herein shown as extending divergently beyond the pipe, the extended portion being provided with the top wall 75, the wall 73, however, defining an area open at the bottom and presented to the wall of cylinder 51 in use. The depending wall 73 as in my prior Patent 1,919,416, above referred to, serves to create a turbulence in the water collecting in the bottom of the cylinder, permitting it to be picked up by the steam escaping through restricted orifice 71 at greatly increased velocity and discharged therewith through the eduction pipe 57. It will be noted that the effective area of the orifice is not changed if the end of the pipe is more or less distant from the cylinder wall.

The sizes of the various orifices 71 are graduated throughout the battery of drying cylinders. The discharge of fluid through an orifice of this nature when measured by weight varies with the area of the orifice and with the square root of the differential in pressure tending to discharge the fluid therethrough, in other words, with the square root of the head. If a given cylinder condenses a certain number of pounds per hour, as indicated by test, this many pounds of water must, if it is to be discharged through eduction pipe 57 through the trunnion of the cylinder, be raised a distance equal substantially to the internal radius of the cylinder. I proportion the orifice of that particular cylinder so that it would discharge that amount as liquid at a fixed rate throughout the given time in question under a head somewhat exceeding this necessary lift. I have obtained good results in practice by making this additional lift equivalent to from 6 inches to a foot. As a foot of water is equivalent somewhat less than a half-pound per square inch pressure, this may be otherwise expressed by saying that the excess head is in the order of a fraction of a pound. This excess head is provided to permit and insure the discharge of a limited amount of surplus steam through the driers to obviate stagnation therein and to provide for control of the system in the manner hereinafter to be described.

Since an orifice of this nature under like conditions of head and pressure will pass the same weight of fluid independently of its volume and whether in the form of liquid or in the form of gas, it is immaterial whether the condensate is being discharged as a liquid column or commingled with surplus steam. That is, the orifice will discharge under a given differential a certain number of pounds of water and/or steam. If a certain number of pounds is represented by condensation water, we therefore know the weight of surplus steam which will also be discharged which because of the minute size of the orifices is maintained at a low figure, as contrasted with the weight of steam which would pass through a pipe having an open end. In the case of a drier hav-

ing cylinders 4 feet in diameter and 100 inches long I have obtained good results where the cross sectional areas of the orifices were less than .1 of a square inch in order both to obtain the balanced discharge from the various cylinders as herein-
 5 after will appear and to effect this with proper economy of steam, although larger orifices, if properly differentiated or graduated among the various cylinders of the battery, might effect a
 10 balanced operation at a greater steam consumption and in the case of larger cylinders the orifices would generally be of a larger size.

A proper differential between the interior of the cylinders and the condensate header 61 is maintained by condensation of the surplus steam which is discharged from the cylinders because of the increased head provided which permits a certain amount of steam to pass over through the orifice of each cylinder in addition to the condensate accumulating in that cylinder. In Fig. 1 the condensate accumulating in the header 61 discharges to a tank 77 wherein it is maintained at a constant level by means of a liquid level controller 79, surplus being discharged through valve
 15 81. The surplus steam passes to a condensing device 83 adapted to effect condensation thereof at a uniform rate. As shown in Fig. 1, this unit comprises a chamber containing a series of horizontal perforated plates 85. Cooling water of uniform temperature is delivered to the top of the chamber through pipe 87 and sprayed to the top perforated plate and percolates down through the entire series of plates. Steam entering the chamber at the bottom and passing upward
 20 through the plates is condensed by its direct contact with the cooling water and the cooled plates. A small vacuum line 89 having a very small fixed orifice therein is connected to the top of the condensing device 83 for the removal to the atmosphere of any air that may collect in the top of the chamber. With the equipment installed a required pressure differential between the inside of the dried cylinders and the condensate header 61 is obtained by adjusting the rate of supply of cooling water to the condensing device 83. This adjustment is made during normal operation and thereafter is not changed. Very little cooling water is necessary in the condenser as it is required to condense only the surplus steam from the driers when the eduction pipes are operating efficiently, that is, when they are removing condensate with just enough surplus steam to serve as a medium of control of the differential between the inside of the driers and the condensate header in the manner next to be described.

If now due to any change in conditions the rate of condensation in the drying cylinders increases, a greater proportion of water comes over through the eduction pipes as compared with steam, since the weight which can be discharged through the orifices is constant, and the volume discharged to the header 61 is lowered. As steam is there condensed at a constant rate, the pressure in the header is decreased and the differential increased.
 60 This corresponds in effect to an increase in the size of the orifice and permits and provides for correspondingly greater discharge from the drying cylinders. This discharge is proportionate among the several cylinders of the battery. Conversely if condensation decreases and a greater proportion of steam is delivered to the condensate header, since only a fixed amount is condensed by the condenser 85, pressure in the header increases, decreasing the differential and decreasing the flow of condensate until a normal con-
 75

dition is restored and the rate of flow of surplus steam to the condensate header is that originally determined upon corresponding substantially to the rate of condensation of the condenser 84 plus any radiation from pipes, etc., which latter is practically uniform. In other words, the rate of flow of surplus steam is instantly adjusted to correspond to the rate of condensation of the uniform rate condenser and waste of steam is avoided. It will be apparent that the system is very flexible in that with the paper off the machine and with practically no condensing action in the driers the differential may automatically be reduced to zero, whereas if a sudden increase in condensation were effected by a maximum increase in the weight
 15 of paper over the driers, an increase in differential would automatically result between the inside of the driers and the condensate header which might equal several times the normal differential.

In Fig. 7 I have shown a slightly different installation and in this figure parts are indicated by three digit reference numerals. Where the last two digits are identical with numerals applied to the arrangement shown in Fig. 1, it indicates that the parts correspond and in many instances a detailed description is unnecessary. In the form of the invention shown in Fig. 1 one or more cylinders, herein cylinders 1 and 2, at the wet end of the machine are treated separately from the remaining cylinders which constitute a battery in themselves and cylinders 1 and 2 take their steam supply from the condensate header 161 of the remaining cylinders and constitute in effect a part of a condenser for these cylinders. Liquid in condensate header 161 is discharged to leg 177 under control of liquid level controller 179 and the steam passes to the auxiliary steam header 253 supplying cylinders 1 and 2 through the pipes 255. The eduction pipes 259 from cylinders 1 and 2 open to a condensate header 261 which discharges to a tank 285 which combines the functions of the tank 77 and condenser 85 in Fig. 1, maintaining a level of condensate through a liquid level controller 279 and providing for a uniform rate of condensation of steam discharged from the cylinders 1 and 2 by means of cooling water supplied through the pipe 287.

It will be understood that the orifices or ports of the various eduction pipes supplying the pipes 159 are graduated throughout the battery of driers as hitherto described and that the two cylinders 1 and 2 together with the condenser 285 constitute a condensing unit for the other cylinders and control the differential in header 161. The orifices of the eduction pipes discharging to pipes 259 are also suitably designed and the condenser 285 controls the flow of steam through these cylinders as in the case of the twenty-four cylinders of the machine shown in Fig. 1. While this arrangement requires a certain duplication of mechanism, for example, two controllers 179 and 279, the condenser 285 may be made exceedingly small with this arrangement and a somewhat more rapid circulation of steam through the latter cylinders of the drier may be effected which may be advantageous for some purposes.

As an indication of the advantages of my system I present the following comparison of identical machines in the same plant after one of them had been equipped as herein described in accordance with the arrangement illustrated in Fig. 7. As contrasted with the other machines having evacuation devices of conventional form with eduction pipes of substantially uniform capacity and without the provision of a condensing unit 75

285, the machine with the arrangement such as herein described was speeded up to a surface speed of 1226 feet per minute as contrasted with 1027 feet for the otherwise identical machines, yet the steam consumption for drying purposes dropped from 7200 pounds per hour to 6200 pounds per hour while the number of horse power required to rotate the cylinders decreased from 315 to 111.

I am aware that the invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof, and I therefore desire the present embodiment to be considered in all respects as illustrative and not restrictive; reference being had to the appended claims rather than to the foregoing description to indicate the scope of the invention.

I claim:

1. A drier system for webs comprising a battery of internally steam-heated cylinders having eduction pipes opening to a common condensate-collecting system, said pipes having ports substantially individually proportioned to pass to said collecting system the normal volume of condensate for each cylinder for a determined differential of pressure between the cylinders and the collecting system, means to retain a fixed volume of condensate in the collecting system and means associated with the collecting system to condense steam therein at a substantially fixed rate.

2. A drier for webs comprising a battery of internally steam-heated cylinders having condensate eduction pipes opening freely to a common water and steam offtake system, each pipe having adjacent the intake end thereof a permanently mechanically unobstructed port determining its discharge capacity under a given differential of pressure, the sizes of the ports being substantially graduated throughout the battery to correspond to the actual heat exchange effected by the cylinders on a moist web passing serially thereover, and means effective to vary the differential of pressure between the cylinders and the offtake system in proportion to the rate of condensation.

3. A drier for webs comprising a battery of internally steam-heated cylinders having condensate eduction pipes, each pipe having a port determining its discharge capacity under a given differential of pressure, the sizes of the ports being substantially graduated throughout the battery to correspond to the actual heat exchange effected by the cylinders on a moist web passing serially thereover, and means to vary the differential of pressure between the cylinders and the offtake sides of said ports proportionately to the rate of condensation comprising a device for condensing at a fixed rate steam delivered through said pipes.

4. In combination with a steam-heated drying cylinder, an eduction pipe entered through the journal and extending toward the bottom thereof having a permanently mechanically unobstructed port leading to the exterior of the cylinder, said port being substantially of a capacity which during a given time would pass a volume of liquid equal to the normal condensation effected by the cylinder in use for such time at a uniform rate under a head slightly exceeding, as by about a fraction of a pound, the lift of said pipe.

5. In combination with a steam-heated drying cylinder, an eduction pipe entered through the journal and extending toward the bottom thereof having adjacent its end a septum pierced by a permanently mechanically unobstructed orifice having a diameter which during a given time

would pass a volume of liquid equal to the normal condensation effected by the cylinder in use for such time at a uniform rate under a head slightly exceeding, as by about a fraction of a pound, the lift of said pipe.

6. In combination with a steam-heated drying cylinder, an eduction pipe entered through the journal and extending toward the bottom thereof having adjacent its end a septum pierced by a permanently mechanically unobstructed orifice having a diameter which during a given time would pass a volume of liquid equal to the normal condensation effected by the cylinder in use for such time at a uniform rate under a head slightly exceeding, as by about a fraction of a pound, the lift of said pipe, and means projecting outboard of the septum for creating adjacent said orifice a turbulence in condensate accumulating in the cylinder.

7. A drier system for webs comprising a battery of internally steam-heated cylinders over which the web is serially passed and having condensate eduction pipes entered through the journals and extending toward the bottoms thereof, the pipes having ports each substantially of a capacity which would pass at a uniform rate under a head slightly exceeding, as by about a fraction of a pound, the lift of said pipe a volume of liquid equal to the normal condensation effected by the particular cylinder in use and thus being graduated throughout the battery, said eduction pipes opening to a common condensate-collecting system, and means associated with the said collecting system to condense at a substantially fixed rate steam delivered thereto through said pipes.

8. A drier system for webs comprising a battery of internally steam-heated cylinders over which the web is serially passed and having condensate eduction pipes entered through the journals and extending toward the bottoms thereof, the pipes having ports each substantially of a capacity which would pass at a uniform rate under a head slightly exceeding, as by about a fraction of a pound, the lift of said pipe a volume of liquid equal to the normal condensation effected by the particular cylinder in use and thus being graduated throughout the battery, said eduction pipes opening to a common condensate-collecting system, one or more cooperating cylinders over which the web likewise passes and having eduction pipes with ports of a size similarly determined, means to supply steam from the condensate-collecting system of the first mentioned battery to said cylinders, a condensate-collecting system for the latter and means associated with the last mentioned system for condensing steam therein at a substantially fixed rate.

9. An eduction pipe for a steam-heated drier cylinder having across its end a septum pierced with an orifice of relatively small diameter as compared with the pipe and outwardly thereof a depending wall partly encircling the same and defining an open area at its lower end.

10. An eduction pipe for a steam-heated drier cylinder having across its end a septum pierced with an orifice of relatively small diameter as compared with the pipe and outwardly thereof a depending wall partly encircling the same and having its ends extending divergently beyond the pipe and a top wall connecting said diverging portion, the wall defining an open area at its lower end.

11. A drier for webs comprising a battery of internally steam-heated cylinders having con-

5 condensate eduction pipes, each pipe having a port
determining its discharge capacity under a given
differential of pressure, the sizes of the ports
being substantially graduated throughout the
battery to correspond to the actual heat ex-
change effected by the cylinders on a moist web
passing serially thereover, means to deliver steam
to certain of said cylinders, means for delivering
steam discharged therefrom to other cylinders
10 and means controlling the differential of pressure
between the latter cylinders and the offtake side
of the ports thereof proportionately to the rate
of condensation therein comprising a device for
condensing at a fixed rate steam delivered there-
15 from.

12. A drier for webs comprising a battery of
steam-heated cylinders having condensate edu-
ction pipes, means for supplying steam to a set

of said cylinders, a water and steam offtake sys-
tem common thereto in open communication
therewith, means for delivering steam exhausted
to said system through the eduction pipes of said
set to one or more other cylinders, each pipe of
said set having at the intake end thereof a per-
manently mechanically unobstructed port deter-
mining its discharge capacity under a given dif-
ferential of pressure, the sizes of the ports be-
ing substantially graduated throughout the bat-
tery to correspond to the actual heat exchange
effected by the cylinders on a moist web passing
serially thereover, and means effective to vary
the differential of pressure between the interiors
of said other cylinders and the discharge side
15 of the eduction pipes thereof in proportion to
the rate of condensation of the said cylinders.

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