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(54) Process and apparatus for the production of a dry, fibrous web comprising organic fibres and a binder.

(57) Process and apparatus for the production of a dry, binder-containing, fibrous web, wherein a liquid binder is applied to said web before the web is passed through a series of driers located on different levels, said web being supported by foraminous wires and hot air being passed through the web during the passage through each drier, the fibrous web being sucked against a foraminous wire during the passage from one level to another, said foraminous wire being supported by a roller having a perforated surface and the interior of said roller being connected with a source of vacuum.

By using the process and the apparatus of the invention, the risk of burst of the web is reduced and the production rate is substantially increased.

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Process and apparatus for the production of a dry, fibrous web comprising organic fibres and a binder.

This invention relates to a process for the production of a dry, fibrous web comprising organic fibres, preferably cellulosic fibres, and a binder, said process comprising the steps of applying to a fibrous web a liquid binder to form a wet binder-containing web, drying the wet, fibrous web by passing said web through a series of driers located on at least two levels, supporting the fibrous web by a foraminous wire during the passage through each drier, and passing a stream of hot air through the fibrous web during the passage through each drier in a direction substantially perpendicular to the direction of movement of said web.

US patent specification No. 3.849.904 discloses a drier system in which a wet, fibrous web is passed through four driers, each divided into an upper and a lower compartment by a foraminous wire supporting the web. In the prior art system hot air is supplied to the upper compartment of a drier and the air having passed through the fibrous web is sucked away from the lower compartment and is introduced in the upper compartment of the preceding drier.

It has been attempted to reduce the floor space necessary for such a drier system by mounting groups of driers of the above mentioned type on top of one another and by passing the fibrous web from a group of driers located on a high level under an essentially 180° turn to a group of driers located on a lower level and finally out of the last drier located on the floor level.

The introduction of the wet web into the driers located on the highest level and the removal of the dried web from a drier on the floor level is due to the fact that it is desired to apply the liquid binder to that side of the web which turns away from the apparatus during the first turn of the web in order to prevent that fibres are disengaged from the fibrous web in the turning zone.

When drying a fibrous web prepared by a dry-forming process in an apparatus of the above mentioned type, serious problems may arise. Thus, the fibres of such a fibrous web are loosely interconnected and the web is resistant to mechanical actions only after it has been dried and binder has set or optionally has been cured. Therefore, the fibrous web easily bursts during the movement from the place at which the binder is applied and to the place at which it is introduced into the first drier. Such bursts are fre quent in cases where the wet, fibrous web is passed from the floor level on which the binder preferably is applied to the first drier located in the highest group of driers of such a drier system.

When an aqueous binder is applied to the fibrous web, the latter tends to expand due to the absorption of water by the cellulosic fibres, and if the application of aqueous binder is non-uniform in the cross-machine direction, the expansion may lead to the formation of wrinkles or pleats. The formation of such wrinkles or pleats not only reduces the quality of the final dried, fibrous product but also increases the risk of bursts during the passage of the web through the driers.

These problems have made it necessary to provide zones within the apparatus in which large lengths of web material can be collected in case of bursts because some time inevitably lapses before the apparatus can be stopped after a burst of the fibrous web has been detected.

The risk of such bursts during the drying of wet, fibrous webs prepared by the dry-forming process has made it impossible to obtain the desired high production rates by such a dry-forming process.

In the commercial production of fibrous materials prepared from dry-formed, fibrous webs it has only been possible to reach production rates of 300-500 m/min., whereas the maximum production rate for wet-formed fibrous materials is about 2000 m/min., and this difference has significantly reduced the possibilities for having the dry-forming method which compared to the wet-forming method presents several advantages, e.g. with respect to quality and anti-pollution accepted as an alternative to the latter method.

The object of the invention is to avoid bursting of the fibrous webs when such webs are dried in the manner defined above.

A further object of the invention is to increase the production rate in the manufacture of dry, fibrous materials by the process in question and in which the fibrous web has been formed by a dry-forming process.

These objects and other objects which will appear from the following description are achieved by the process of the invention which is characterized in that the fibrous web is in contact with a support during its movement from one level to another, and that it is sucked against said support during at least part of said move ment.

The invention is based on the discovery that the risk of disengagement of fibres from the fibrous web can be essentially eliminated by sucking the fibrous web against the support supporting the fibrous web during its movement from one level to another, and that there is then no need for transporting the wet, fibrous web from floor level to the top of the drier. Instead thereof the fibrous web can be introduced into the first drier located on the floor level, and from the last drier of the group of driers located on said level it can be moved to a further group of driers located on a higher level and so on. When the fibrous web has passed through the upper group of driers, it has obtained a sufficiently high strength allow it to be moved down to floor level with no support for the fibrous web and with no risk of bursting.

As a result of the reduced risk of bursting it has been possible to increase the production rate significantly. Furthermore, the apparatus in which the process is carried out can be reduced in size.

The invention also relates to an apparatus for the production of a dry, fibrous web comprising organic fibres and a binder.

The apparatus of the invention comprises means for continuously advancing the fibrous web on a support, means for supplying liquid binder to the web during its movement on said support, driers located on at least two levels, foraminous wires for advancing the fibrous web through said driers, means for transferring the web from a drier mounted on one level to a wire mounted on another level, and means for generating a stream of hot air through the fibrous web during its movement through each drier, said stream of air being substantially perpendicular to the direction of movement of the web in said drier.

The apparatus of the invention is characterized in that it comprises means for supporting the fibrous web during its movement from one level to another and means for sucking the web against said support during at least part of said movement.

During the application of liquid binder to the fibrous web the latter is preferably supported by an endless, foraminous wire passing through a binder station. During the passage through said binder station, liquid binder, e.g. in the form of a mist, is sprayed onto the upper surface of the fibrous web and at the same time air is removed by suction from the zone below the foraminous, endless wire.

The application of binder is preferably effected by means of a row of orifices mounted in a row extending perpendicular to the direction of movement of the fibrous web.

Since the liquid binder may be unstable, it is desirable to avoid a mechanical pump system for the supply of liquid binder to the orifices and, therefore, one or more hydrophors connected with a source of compressed air having a pressure of e.g. 12-15 bars are preferably used. It is particularly advantageous to use two hydrophors mounted parallel, one of said hydrophors being filled with binder while the second hydrophor supplies binder to the orifices through a conduit which through suitable valves can be connected with one hydrophor or the other.

The liquid binder is preferably subjected to several successive filtrations by means of filters having decreasing mesh sizes, for example sizes of from 40 to 15 mesh. The final filtration is preferably effected short before the binder is atomized in the orifices.

The application of liquid binder to the fibres makes the web relatively heavy, and since the wet, fibrous web may adhere to the supporting wire, the transfer of the wet, fibrous web from the wire used for the support of said web during the application of binder to the foraminous wire supporting the web during the passage through the first drier may be critical. This is particularly the case in the manufacture of thin, fibrous webs, for example fibrous webs having a weight of below 50 g/m².

When an endless, foraminous wire is used to support the fibrous web during the application of binder, it is preferred that the fibrous web after being removed from said wire is introduced directly onto the wire which is to support the fibrous web during the passage through the first drier. It is preferable to direct a stream of air against the lower surface of the fibrous web and over its full width in the zone in which the wet web is removed from the wire. By using such a stream of air, the removal of the web from the wire is facilitated with no damage of the web.

The stream of air is preferably generated by using a hollow roller having a perforated roller wall and an internal compartment having means for supplying compressed air to the compartment and a discharge slot extending over the full length of the roller and opening in proximity of the perforated roller wall.

The foraminous wire supporting the fibrous web during the application of binder is for example a wire made from a plastics material.

When using such an endless wire, it is difficult to prevent that binder adheres to said wire and that adhering binder when contacting the fibrous web causes the web to adhere to the wire. Therefore, it is preferred to subject the endless wire to a cleaning operation when the fibrous web has been removed therefrom and before it is again contacted with fibrous material.

The cleaning of the endless, supporting wire is preferably effected by means of high pressure water optionally containing a detergent.

After having passed below orifices from which high pressure water is sprayed onto the wire, there will still be some water left in and on the wire, and these water residues are preferably removed by means of compressed air which is blown through the wire from alternating sides of said wire. Subsequently, the wire is contacted with two lips extending over the full width of the wire and each contacting one side of the wire. The purpose of such contact is to smooth out remaining liquid droplets so as to form a film which can be removed by suction in a suction box mounted in connection with each lip.

The above mentioned lips are preferably made from polyethylene which has a suitable wear-resistance.

In order to avoid contamination of the environment with binder residues, the liquid fractions obtained during the cleaning operation are preferably collected and purified. The purified liquid can then be passed into the sewer.

The drying of the wet, fibrous web is preferably effected in groups of driers mounted on the same level and close to one another. Each drier preferably consists of two zones, viz. an upper and a lower zone, separated by the foraminous wire.

The drying air is preferably introduced into the upper zone in which the pressure preferably is superatmospheric, and moisture-containing air is removed from the lower zone. The air which is introduced into the first drier typically has a temperature of 200-220°C and the outlet air preferably has a temperature of 105-120°C. The hot air which is introduced in the subsequent drier optionally has a temperature which is lower than the above mentioned temperature.

A perforated plate extending parallel with the foraminous wire is preferably provided both in the upper and in the lower zones in order to make the drying as uniform as possible.

The heating of the air which is to be supplied to a drier is preferably effected by means of a gas burner provided in a pipe attached to a feed pipe for hot air. The air which has passed through the fibrous web and the wire located below said web is sucked away and part of said air is recycled to the feed pipe for hot air.

The feed pipe for hot air preferably terminates in the upper zone of the drier at the inlet end of said drier, and the air which has passed through the fibrous web is preferably discharged at the outlet end of the lower zone.

During at least part of the movement of the fibrous web from one level to a higher level it is preferably sucked against a foraminous wire by means of a hollow rotating cylinder having a perforated cylinder wall and by maintaining a subatmospheric pressure within said cylinder. In this manner the movement of the fibrous web can be effectively controlled.

Before the fibrous web is introduced into a drier or the first drier on the higher level, a further amount of binder is preferably applied to that side of the fibrous web which has not previously been treated with a binder. In this manner, the strength of the fibrous web is further increased, and the risk of bursting is reduced. An endless, foraminous wire can be used for the support of the fibrous web during the application of further binder. This wire is preferably supported by the above mentioned hollow cylinder having a perforated cylinder wall, such that the fibrous web from the time at which it is lifted from the supporting wire on the lower level, and during the application of binder and until it is introduced onto a foraminous wire on which it is introduced into the drier on the higher level, is constantly in contact with said wire.

The drying of the fibrous web on the higher level and the transfer of the further dried fibrous web to a still higher level, if any, is preferably effected in the same manner as described above. However, it is ordinarily unnecessary to apply further amount of binder when binder has been applied to both sides of the fibrous web.

A third group of driers is preferably used when the binder is thermocuring and when it is then necessary to effect a final heat treatment of the fibrous web. Such heat treatment is preferably effected at a temperature which is as high as possible without risking a discolouration of the fibrous web. The temperature is typically about 180-220°C.

After the heat treatment to cure the binder the fibrous web has a strongly reduced moisture content, for example of below 2% by weight, and it is therefore ordinarily necessary to readjust the water content of the web, for example by spraying water onto said web. In this manner the moisture content is increased, for example to about 8% by weight which is sufficient to obtain a stable product.

During the application of water which as mentioned above preferably is effected by spraying and during the movement of the fibrous web thus treated to a reeling station, the fibrous web may optionally be supported by an endless wire.

The invention will now be described in further detail with reference to the drawings, in which

Fig. 1 schematically illustrates a preferred embodiment of an apparatus according to the invention in a side view,

Fig. 2 shows a vertical, sectional view through that part of an endless wire for the support of the fibrous web during the application of binder which is adjacent to the front end of the endless wire for the support of the fibrous web during the passage through the first drier,

Fig. 3 shows a vertical, sectional view through a roller and part of the endless wire for the support of the fibrous web during its movement from one level to a higher level,

Fig. 4 shows a side view of the roller and the endless wire illustrated in Fig. 3,

Fig. 5 shows a schematic, perspective view of a drier with some parts removed, and

Fig. 6 shows a top view of a drier corresponding to the drier illustrated in Fig. 5.

The apparatus illustrated in Fig. 1 comprises three sections, viz. a section in which a fibrous web 1 is consolidated and binder is applied thereto, a drying and curing section consisting of a number of driers and a conditioning and reeling section.

The first of these three sections comprises a roller set 2 for the consolidation of the fibrous web 1 which for example has been prepared by a dry-forming process, i.e. a process in which a suspension of fibres in air is directed against an air-permeable forming surface so as to deposit a dry fibre layer on said forming surface.

After having been consolidated, the fibrous web 1 is introduced onto an endless, foraminous wire 3 which is supported by rollers 4 and which carries the fibrous web through a station 5 for the application of binder onto the upper surface of the fibrous web 1. The application of binder is effected by means of one or more orifices 6 issuing a stream of binder droplets. The station 5 also comprises a suction box 7 which is mounted below the wire 3 and from which air is removed with a fan 8. The return run of the wire 3 passes through a cleaning station 9 in which residues of fibres and binder are removed to prevent adherence between the fibrous web 1 and the wire 3 when they again are contacted with one another. The bindercontaining fibrous web 1 is removed from the wire 3 and is introduced onto an air-permeable drying wire 10 supporting the fibrous web during the passage through driers 11 and 12 mounted in series. The wire 10 is supported by rollers 12a. The transfer of the bindercontaining fibrous web 1 from the wire 3 to the drying wire 10 is illustrated in Fig. 2.

As will appear from Fig. 2 the wire 3 passes over a roller 4 comprising an axially extending inner compartment 13 which can be rotated about the shaft of the roller and which has an axially extending slot 14 provided in close proximity of the surface 15 of the roller which is air-pervious. The inner compartment 13 is connected with a fan 16 capable of establishing a superatmospheric pressure in the compartment 13. The roller 4 is mounted close to a roller 12 supporting the drying wire 10, such that the fibrous web 1 is unsupported only over a short distance.

The fan 16 which generates a superatmospheric pressure in the compartment 13 and a stream of air in the slot 14 contributes to the removal of the fibrous web 1 from the wire 3. When said stream of air is directed against the underside of the fibrous web 1, the latter is lifted from the wire 3. As mentioned above, the angular position of the compartment 3 is adjustable and, therefore, it is possible to determine the optimum position of the slot 14 under the given operational conditions.

The drier 11 is divided into an upper section and a lower section by the wire 10 and hot, drying air is supplied to the upper section and moist air discharged from the lower section.

The construction of the driers is described in detail in connection with Fig. 5. In the embodiment illustrated therein part of the air is recycled. Thus, part of the moist air discharged from the lower section is recycled through a pipe 17 and a fan 18 to the upper section of the drier after being reheated by means of a burner 19. A smaller amount of the moist air is discharged through a branch pipe 20 which is connected with a common outlet pipe 21 from which the air can be liberated to the surrounding atmosphere through a fan 22.

After being passed through the second drier 12 which is constructed in the same manner as the drier 11, the fibrous web is contacted with an endless wire 23 supported by a roller 24 and a number of additional rollers 25. While the fibrous web 1 is in contact with the wire 23, it is carried up to a higher level and on said higher level it is passed through two driers 26 and 27 mounted in series and constructed in the same manner as the drier 11. During the movement of the fibrous web through the driers 26 and 27 it is placed on an endless, air-permeable drying wire 28 supported by rollers 29.

The roller 24 is preferably constructed as shown in Fig. 3 and Fig. 4. As will appear from these figures, it comprises a perforated cylinder wall and the interior of said roller is divided into two compartments 30 and 31 by means of a separating plate 32. The compartment 31 is located adjacent to the portion of the cylinder wall which supports the wire 28 and the fibrous web during the vertical movement of the web and is connected with a fan 33 via a centrally provided suction pipe 34. A subatmospheric pressure is maintained within the compartment 31 by means of the fan 33, and the sub-atmospheric pressure has the effect of sucking the fibrous web against the wire 28 during its critical turning movement from the lower level towards the higher level. As a result of this suction arrangement the turning movement can be effected even at very high speeds of the wire 28.

After having reached the higher level, binder is applied on that side of the fibrous web which was opposite to the orifice or orifices 6 during the first application of binder. The additional application of binder is effected with one or more orifices 35 mounted in a compartment 36 having a lower portion functioning as a suction box and being connected with a fan 37. The return run of the endless wire 23 passes a cleaning station 38 serving to remove adhering binder and fibres. After having passed through the drier 27, the fibrous web is introduced into a compartment 40 in which it is contacted with a further endless, air-permeable wire 41 which carries the fibrous web up to a higher level and on that level through three driers 42, 43 and 44 mounted in series. The wire 41 is supported by a roller 45 which like the roller 24 has a perforated cylinder wall and whose interior is connected with a fan 46, and a number of additional supporting rollers 47. Air which has been sucked away from the interior of the roller 45 with the fan 46 is reintroduced into the compartment 40 and the heat content of said air is used for a heating of the fibrous web 1 before it is introduced into the driers 42-44 in which the temperature preferably is higher than in the remaining driers so as to allow the binder to be cured.

A perforated distribution plate 50 is provided in the compartment 40 to uniformly distribute the air which is reintroduced into said compartment.

After having passed the row of driers 42-44 in which the binder is cured, the fibrous web has a low moisture content. Therefore, it is introduced onto a further endless, air-permeable wire 51 supported by rollers 52 and carrying the fibrous web 1 through a conditioning station 53 in which it is sprayed with water from one or more nozzles 54, and in which air is sucked away from its lower part by means of a fan 55. After having been conditioned so as to obtain a desired moisture content, the fibrous web is reeled at 56.

The drier illustrated in Figures 5 and 6 comprises an upper section having means for supplying hot, drying air to said section and a lower section from which moisture-containing air is discharged. The supply of air is effected through a duct 60 mounted at the upstream end and the discharge of air through another duct 61 mounted at the downstream end. Thus, the dry air is forced to move both along and perpendicularly to the fibrous web 1.

The drier also comprises two perforated plates 62 and 63 mounted at a short distance above and below the endless wire 10 in order to provide a uniform distribution of air in both the longitudinal and the lateral direction of the drier.

The duct 60 and the adjacent zone of the upper section comprise angular guide plates 64 which divide the duct into smaller ducts 65 so as to further improve the distribution of the drying air over the width of the fibrous web. Each of these smaller ducts comprises a damper 66 which is rotatable about a vertical axis, and with which the opening can be adjusted as desired.

The duct 61 and the adjacent part of the lower section comprise similar angular guide plates 67 forming four smaller ducts 68, each comprising an adjustable damper 69.

Claims

1. A process for the production of a dry, fibrous web comprising organic fibres and a binder, said process comprising the steps of applying to a fibrous web a liquid binder to form a wet binder-containing web, drying the wet, fibrous web by passing said web through a series of driers located on at least two levels, supporting the fibrous web by a foraminous wire during the passage through each drier, and passing a stream of hot air through the fibrous web during the passage through each drier in a direction substantially perpendicular to the direction of movement of said web, **characterized** in that the fibrous web is in contact with a support during its movement from one level to another, and that it is sucked against said support during at least part of said movement.

2. A process as in claim 1, wherein the fibrous web is supported by an endless, foraminous wire during the application of the liquid binder, **characterized** in that the fibrous web after being removed from said wire is passed directly to the foraminous wire supporting the fibrous web during the passage through the first drier.

3. A process as in claim 2, **characterized** in directing one or more streams of air against the lower side of the endless wire in the zone in which the web is removed from said wire.

4. A process as in claim 1, **characterized** in using a foraminous wire supported by at least one hollow, rotatable roller having a perforated surface for the transfer of the fibrous web from one level to another, and maintaining a subatmospheric pressure within said roller.

5. A process as in claim 1, **characterized** in applying a binder to the fibrous web on two different levels and on opposite sides of the web.

6. An apparatus for the production of a dry, fibrous web comprising organic fibres and a binder, said apparatus comprising means for continuously advancing the fibrous web on a support, means for supplying liquid binder to the web during its movement on said support, driers located on at least two levels, foraminous wires for advancing the fibrous web through said driers, means for transferring the web from a drier mounted on one level to a wire mounted on another level, and means for generating a stream of hot air through the fibrous web during its movement through each drier, said stream of air being substantially perpendicular to the direction of movement of the web in said drier, **characterized** in that it comprises means for supporting the fibrous web during its movement from one level to another and means for sucking the web against said support during at least part of said movement.

7. An apparatus as in claim 1, in which the support for the fibrous web during the application of binder is an endless, foraminous wire supported by rollers, **characterized** in that said endless wire is supported by a roller having a perforated surface at that end at which the fibrous web is removed from said endless wire, and that it further comprises means for generating one or more streams of air directed against the underside of the fibrous web in the zone in which it is removed from said endless wire.

8. An apparatus as in claim 1, **characterized**in that the means for generating one or more streams against the underside of the fibrous web comprises a compartment having an exit slot which is angularly adjustable.

9. An apparatus as in claim 6, **characterized**in that it comprises an endless, foraminous wire for supporting the fibrous web during its movement from one level to another, said foraminous wire being supported by a rotatable roller

having a perforated surface and that it further comprises means for establishing a vacuum within said roller.

FIG.1

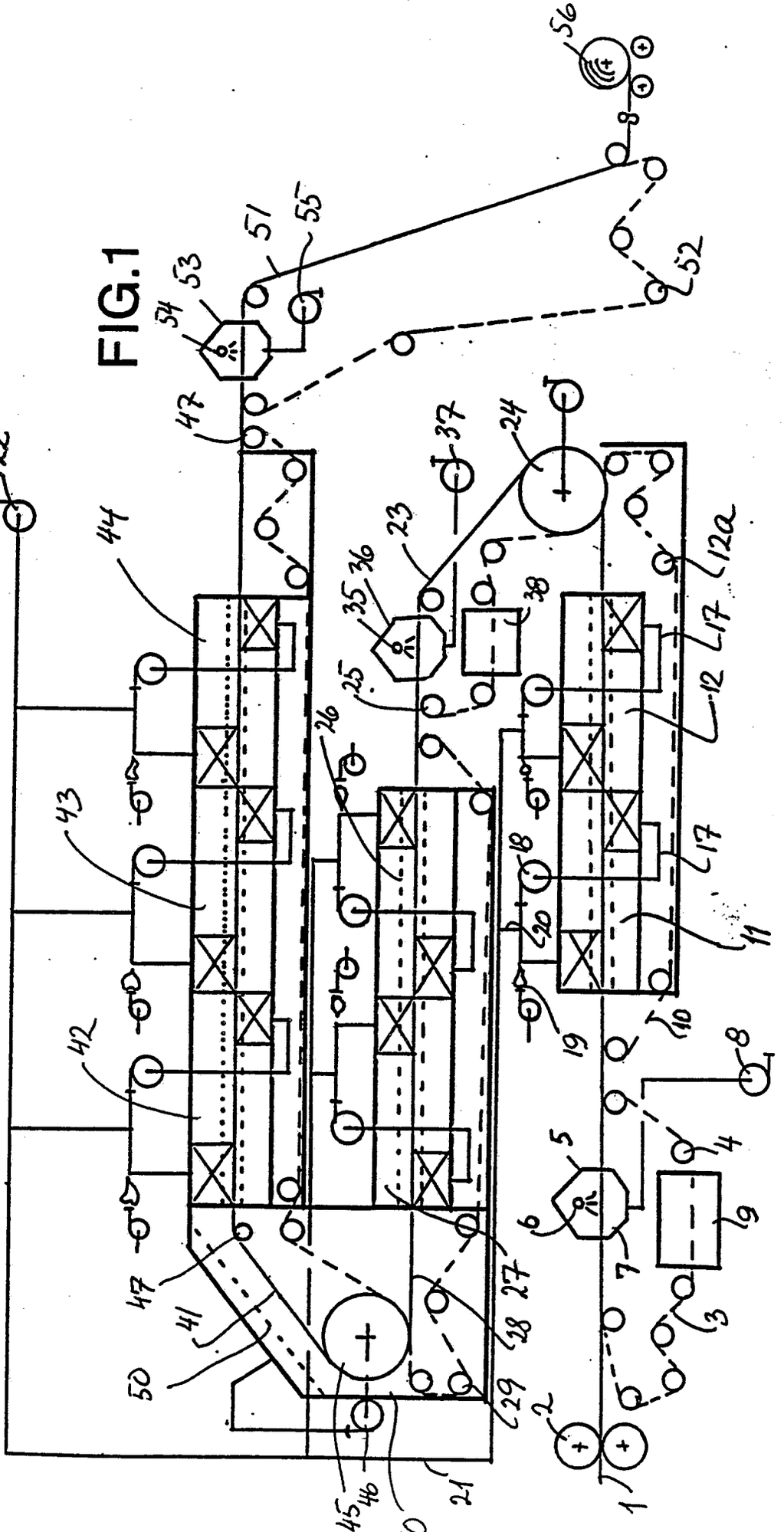
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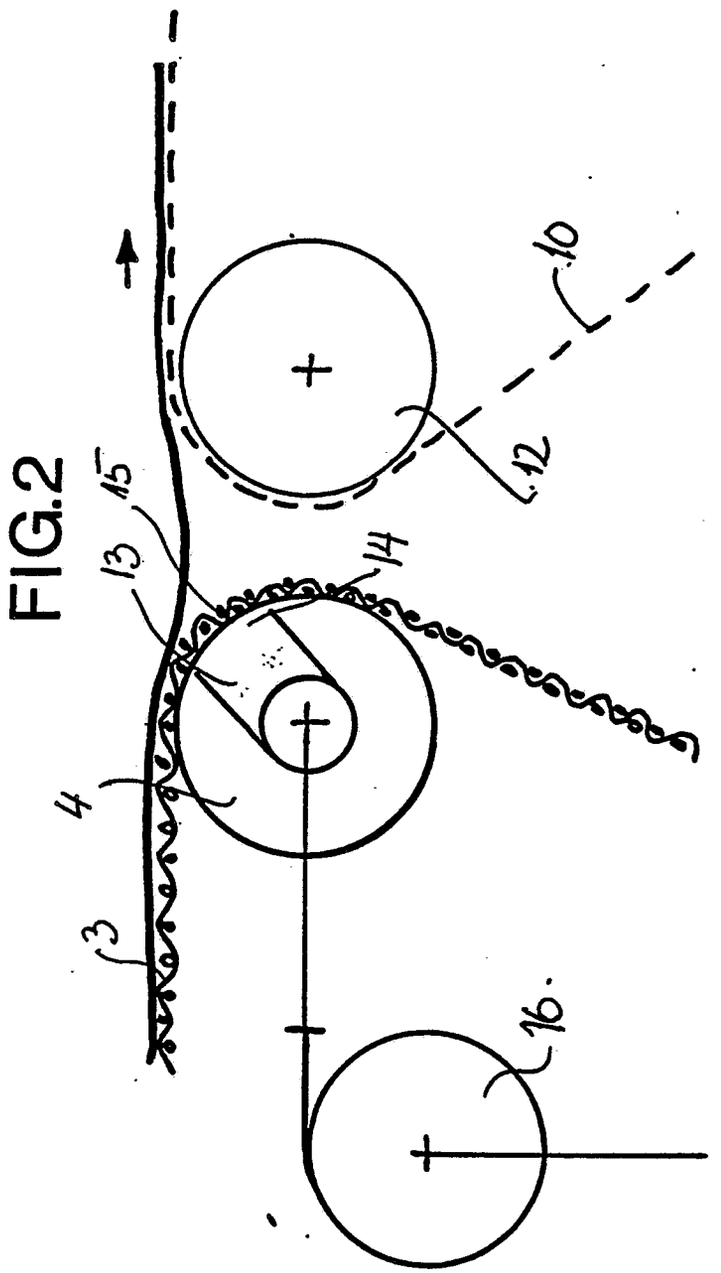
FIG.2



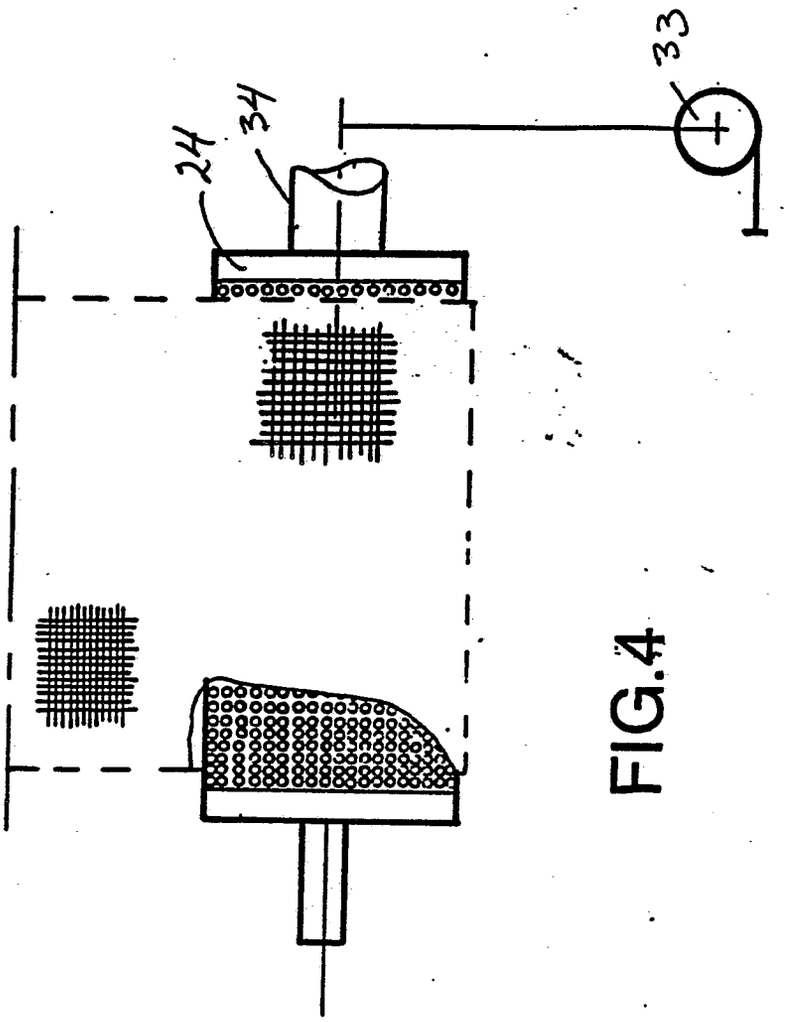


FIG.4

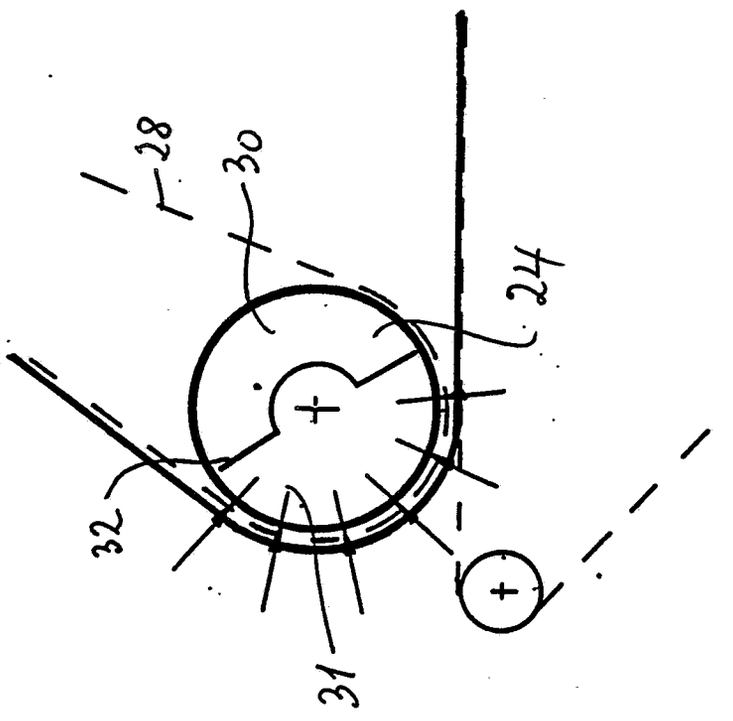


FIG.3

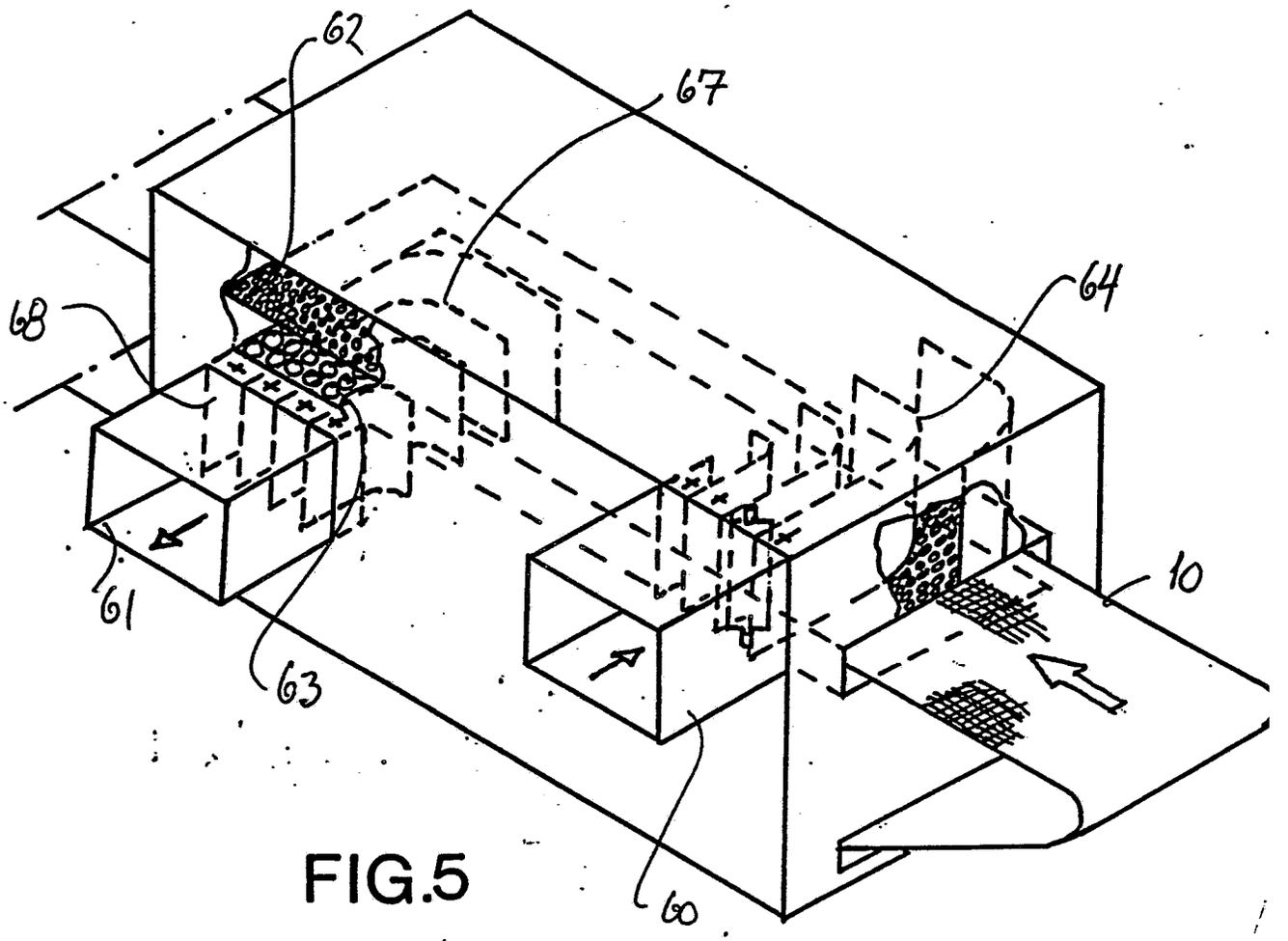


FIG.5

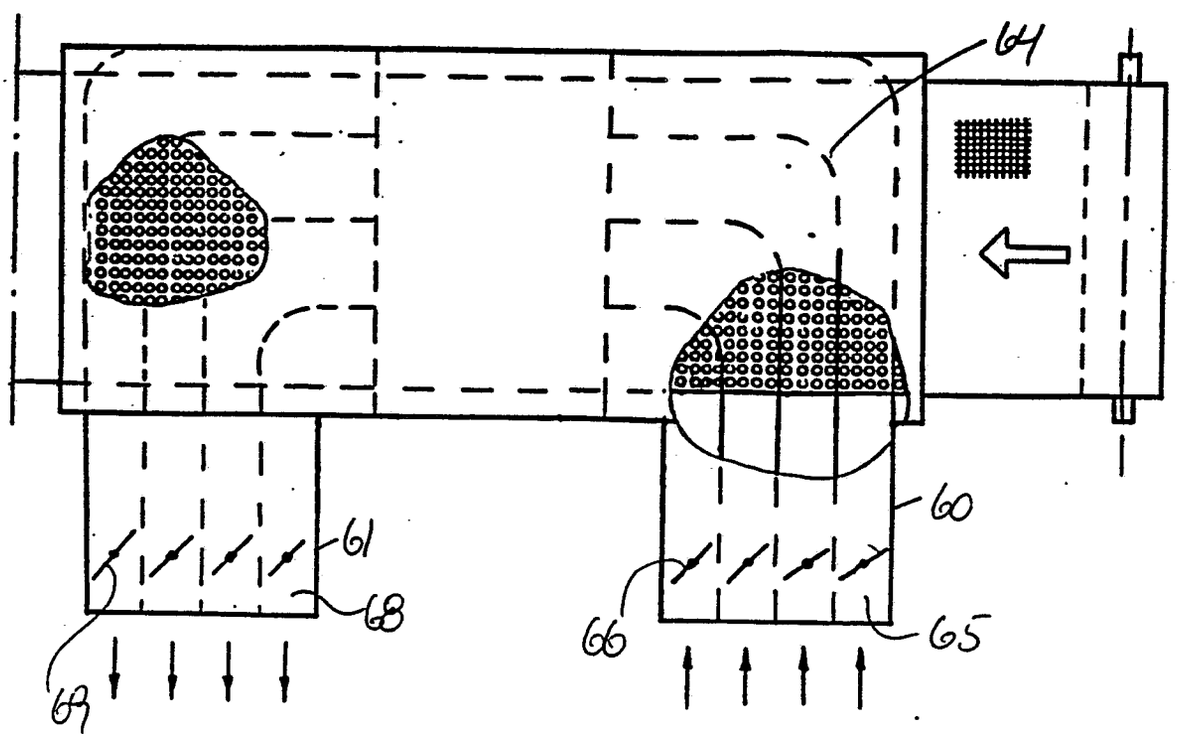


FIG.6