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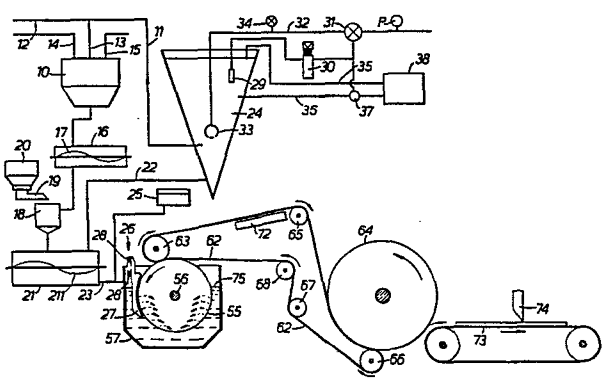
(54) Apparatus for making cement composite materials.

(57) To obtain satisfactory operation of apparatus, e.g. of the Hatschek, Magnani or Bell Flow-on types, for making cement composite materials reinforced with glass fibres, using an aqueous slurry of cement, glass fibre, pulverised fuel ash, finely divided amorphous silica, cellulose pulp, flocculant and water which is deposited on a foraminous surface such as the drum of a Hatschek machine or the felt belt of a Magnani or Bell Flow-on machine, the apparatus is provided with means for controlling the temperature of the slurry before and during deposition on the foraminous surface. The temperature control means may comprise means (30 to 38) for heating and for cooling the water in a reservoir (24) which supplies a slurry mixer (10).



APPARATUS FOR MAKING CEMENT COMPOSITE MATERIALS

This invention relates to apparatus for making cement composite materials reinforced with glass fibres.

For making cement composite materials reinforced with asbestos fibres, three principal types of machine are currently in use, namely the Hatschek, Magnani and Bell Flow-on machines. All of these machines comprise means for forming an aqueous slurry of cement, asbestos and water, and a foraminous surface on which a layer of the slurry can be deposited and through which water can be removed to de-water the cement composite material. In the Hatschek machine, a dilute slurry with a solids content of around 6 to 10% by weight is used and the foraminous surface is provided on the circumference of a rotating cylindrical drum which is partly submerged in a vat containing the slurry. The layer of slurry is deposited as a film on the surface of the drum through which a proportion of the water is removed and the film is transferred to a felt belt in contact with the emergent part of the drum, further de-watered by suction through the belt and transferred to an accumulator roller on which the desired thickness of cement composite material is built up. In the Magnani machine, a thick slurry of around 45 to 50% solids content by weight is deposited on a travelling felt belt by means of a reciprocating distributor and de-watered by suction through the belt. The Bell machine uses a slurry of a solids content intermediate between those used in the Hatschek and Magnani machines, which is fed to the surface of a travelling felt belt through the nip between one of the rollers around which the belt is trained and a superposed contra-rotating roller. The layer of slurry on the belt is de-watered by suction and transferred to an accumulator roller to build up the desired thickness.

The operation of these three types of machines with asbestos fibres as the reinforcement for the cement is dependent upon the property of the asbestos fibres to be wetted by the cement slurry and to retain the fine particles of cement.

The replacement of asbestos by glass fibres has long been recognised as desirable from the point of view of health, but it has been found to involve considerable process problems arising from the differences in behaviour between asbestos fibres and glass fibres, in particular the fact that glass fibres are not wetted by a conventional aqueous cement slurry and have a tendency to clump together, resulting in loss of fine cement particles when the material is de-watered and a non-homogenous structure in the composite material. The use of flocculants and other additives, such as cellulose pulp, in the slurry can improve the retention of fine particles, e.g. as described in our UK Patent Specification No. 1543951, so as to enable cement composite materials to be produced economically on apparatus designed primarily for production of asbestos cement products, but certain inconsistencies in the glass fibre reinforced cement composite materials have been found in practice.

We have now discovered that these inconsistencies arise from temperature variations which affect the production process when using slurries containing flocculant. In particular, if the slurry temperature is too low, flocculation does not take place effectively and excessive quantities of fine materials pass through the foraminous surface and block it so that filtration ceases. If the temperature is too high, the flocculated particles tend to become over-large, resulting in an open porous structure in the composite material and excessive retention of water, resulting in poor green strength and a lower final strength of the composite material.

The present invention accordingly provides apparatus for making cement composite materials reinforced with glass fibres, comprising:-

(a) means for forming an aqueous slurry comprising cement, glass fibre, pulverised fuel ash, finely divided amorphous silica, cellulose pulp and water,

(b) a foraminous surface on which a layer of the slurry can be deposited and through which water can be removed to de-water the cement composite material,

(c) means for adding a flocculant to the slurry adjacent to the foraminous surface, and

(d) means for controlling the temperature of the flocculant-containing aqueous slurry before and during deposition on the foraminous surface.

Preferably the means for forming the aqueous slurry comprises a water reservoir from which water can be supplied to a slurry mixer, and the means for controlling the temperature of the flocculant-containing slurry comprises means for heating and for cooling the water in the reservoir. The means for heating the water in the reservoir may comprise a steam generator connected through a regulator valve which is controlled by a temperature controller to a pipe opening into the water in the reservoir, while the means for cooling the water in the reservoir may comprise a pump controlled by the temperature controller and arranged to circulate water from the reservoir to and from a cooling lagoon. The means for controlling the temperature of the slurry may further comprise a temperature sensor in the reservoir, connected to the temperature controller.

In a particular embodiment of the invention, the slurry mixer is arranged to supply a relatively thick slurry comprising water and cement to a blender provided with means for introducing glass fibres into the slurry, the blender being in turn arranged to supply the glass-fibre-containing slurry to a holding vessel which is connected to the water reservoir for supply of water for diluting the slurry and is also connected to the vat of a Hatschek type machine for feeding the diluted slurry thereto, a tank for containing flocculant solution being connected to the line between the holding vessel and the vat.

A specific embodiment of the invention, as applied to a Hatschek type machine, and to a Bell Flow-on machine, will now be described by way of example and with reference to the accompanying diagrammatic drawings in which:-

FIGURE 1 illustrates the layout of a Hatschek machine and the supply of temperature-controlled slurry thereto, and

FIGURE 2 illustrates a Bell Flow-on machine in schematic side elevation.

As shown in Figure 1, a conventional Hatschek-type machine comprises a horizontal, hollow wire mesh cylindrical sieve 55 mounted for anti-clockwise rotation about its cylindrical axis 56 in a slurry-containing vat 57.

Above the sieve 55 is a continuous moving woven felt 62 which is kept in firm contact with the sieve 55 by means of a rotatably mounted heavy roller 63 and is trained around further rollers 65, 66, 67, 68. The felt 62 passes from the sieve 55 to an accumulator roller 64 on to which a film of slurry can be transferred as described below. The ends of the sieve 55 are fitted with seals (not shown) so that water from the slurry can only flow through the wire mesh and out through discharge ports mounted through the seals. In operation, the sieve 55 is rotated with a surface speed of the order of 45 metres/min. and a thin, even film of slurry is deposited on its wire mesh surface while the major part of the water is removed. The thickness of the film depends upon the slurry level in the vat 57, its consistency, and the speed of rotation of the sieve 55.

The thin film of glass fibre containing cement slurry which is collected on the wire mesh of the sieve 55 is transferred to the woven felt 62. The film is then processed in the same manner as is used in forming asbestos cement products by Hatschek machinery, by passing it over at least one vacuum box 72 which draws additional water from the film. The film is then passed under the iron or steel accumulator roller 64, further removal of water being caused by compression between rollers 64 and 66, and is transferred in a continuous operation to the accumulator roller 64 until a sheet is built up on the roller 64 to a desired thickness. The sheet can be knifed along a groove in the accumulator roller 64 and peeled from it on to a conveyor table 73, and subsequently trimmed and cut to desired lengths by saws 74.

The operation described so far is conventional for production of cement composite materials on a Hatschek machine.

In the present invention, the slurry for supply to the vat 57 is formed by first mixing a relatively thick slurry of cement, pulverised fuel ash, volatilised silica, cellulose pulp and water, with a solids content of 40 to 60%. The slurry is mixed in a high shear mixer 10 of conventional design, to which water and a supply of aqueous cellulose pulp are fed through lines 11, 12 and 13, while cement and pulverised fuel ash are supplied through line 14 and an aqueous slurry of volatilised silica is fed through line 15. Volatilised silica is a form of finely divided amorphous silica produced as a by-product in the electro-reduction process for production of silicon. If any solid processing additives are to be incorporated, they are dispersed in the cement/pulverised fuel ash mixture supplied through line 14. The resultant thick slurry is fed to an interim storage tank 16 where it is kept under agitation by means of a rotating mixer blade 17.

Alkali-resistant glass fibres, e.g. as described and claimed in our UK Patent Specification No. 1,290,528, are mixed into batches of the thick slurry in a blender 18. The glass fibres are fed by a vibrating feeder 19 from a hopper 20 and folded into the slurry by rotary and vertical circulation in the blender 18.

The batches of thick fibre-containing slurry are transferred to a large holding vessel 21 which contains a low shear rotary agitator 211 and in which the slurry is diluted to a solids content of 6 to 10%, typically 7.5%, by weight, by water supplied through line 22. Line 22 receives the dilution water from a main conical reservoir 24 which also supplies the water through line 11 to the high shear mixer 10. The dilute slurry is supplied from vessel 21 through line 23 to the vat 57. Flocculant solution from tank 25 is added to the slurry in line 23 so that the flocculant is mixed into the slurry just before it passes into the vat 57.

The vat 57 is provided with an agitator 26 in the form of a series of similar parallel blades 27 (only one of which can be seen in the Figure) disposed in vertical planes perpendicular to the axis 56 of the sieve 55 and spaced from one another across the width of the vat. The blades are mounted on wheels 28 so that they can be reciprocated parallel to the axis of the sieve for producing the desired agitation of the slurry.

For controlling the temperature of the slurry, a sensor 29 is provided in the conical reservoir 24 and connected to a thermostat device 30 which controls a valve 31 in a steam supply line 32 which has an outlet 33 in the reservoir 24. A non-return valve 34 is provided in the steam line 32 to vent the line 32 when the steam supply is cut off.

For cooling the water in the reservoir 24 when necessary, inlet and outlet lines 35, 36 and a pump 37 are provided for circulating the water to an external cooling lagoon 38, again under the control of the thermostat device 30.

As an alternative to the heating arrangement described above, employing direct supply of steam through line 32 into the reservoir 24, a heat exchanger could be incorporated in the line 23 before or after its junction with the supply from the flocculant-containing tank 25, using recirculated steam or hot water as the heating medium. Furthermore, the sensor 29 could be located in the vat 57 instead of in the water reservoir 24.

In specific examples of production of glass fibre reinforced cement composite materials on the apparatus described above and illustrated in Figure 1, a slurry was used having a solids content of 7.5% by weight, the solids comprising, in weight percentages:-

Ordinary Portland Cement	60.5%
Pulverised fuel ash	24.5%
Volatilised silica	8.0%
Dispersible chopped glass fibre strands	3.5%
Cellulose pulp	2.0%
Processing aids (dispersing agents, flocculating agent)	0.5%

The temperature of the slurry in the vat 57 was gradually increased from a temperature of 15°C. At this low temperature, it was not possible to collect material on the rotating sieve 55 because the flocculating action was ineffective and excessive quantities of fine cement particles passed through the sieve. As the temperature was increased, it became possible to collect material from the drum but it was clearly of inferior quality and the amount of solids passing through the drum remained at an unacceptably high level until the temperature of the slurry reached 20°C. At this temperature, the process began to run well, in the manner described above, and the product was of good quality, the best properties being achieved with the slurry temperature around 23°C. Above 25°C, the quality began to deteriorate and as the temperature was increased beyond 27°C the product was found to have a porous character and when cured gave a low final strength.

The same apparatus for supplying slurry and controlling its temperature (items 10 to 25 and 29 to 36 in Figure 1) was also used in conjunction with a Bell Flow-on machine modified for use with glass fibre as described in our co-pending British Patent Application No. 84 00226 filed 5th January 1984.

As shown in Figure 2, the modified Bell Flow-on apparatus comprises a vessel 40 for holding an aqueous fibre-containing cement slurry, and an endless water-pervious felt belt 42, which is arranged to be driven around a series of guide rollers 43, 44, 45. Slurry is delivered to the vessel 40 continuously during operation through a supply pipe 46 corresponding to the line 23 of Figure 1. The right hand end of the vessel 40 is defined partly by the upper surface of the belt 42 as it passes around the guide roller 43 and partly by a superposed roller 47, which is driven in the opposite sense to the sense of rotation of the guide roller 43. A small gap between the upper surface of the belt 42 and the lowermost part of the periphery of the roller 47 constitutes the outlet from the vessel 40 and permits a thin layer 49 of the cement slurry to be deposited on the belt. In accordance with normal practice, a rotary agitator 50 is disposed in the vessel 40 to cause turbulence in the slurry.

The layer 49 of fibre-containing cement slurry on the belt 42 is de-watered in known manner through the belt using drainage chambers 51. After de-watering, the layer 49 becomes a cohesive web 52 of fibre-reinforced cement which is picked up from the belt 42 and wound on to a rotatable pivotally mounted receiving roller 53. When a sufficient thickness of fibre-reinforced cement has been built up on the surface of the roller 53, it is cut axially of the roller and taken off for pressure de-watering and curing.

An additional agitator is provided in the vessel 40, extending into the nip between the roller 47 and the belt 42, and formed by a series of similar parallel curved blades 41 which are disposed in vertical planes parallel to the direction of movement of the belt 42 (i.e. at right angles to the axes of the rollers 43, 47) and spaced from one another across the width of the vessel 40. The blades 41 are secured to a horizontal carriage 48 which extends across the width of the vessel 40 and which is horizontally reciprocable by a motor (not shown) between pairs of upper and lower rollers 54.

Similar tests to those made on the Hatschek machine of Figure 1 were made on a Bell machine of Figure 2. A slurry composition was made up to have a solids content of 30%, and the solids had the following composition:

Ordinary Portland Cement	61%
Pulverised fuel ash	25%
Volatilised silica	9%
Dispersible chopped glass fibre strands	3%
Cellulose pulp	2%
Dispersing agents, flocculating agents	0.1%

It was found that at temperatures of the order of 15 to 16°C, there was very poor flocculation, and due to the fine cement materials clogging or blinding the felt belt 49, it was extremely difficult to collect any material. With a temperature of 18 to 19°C, cement composite material was collected on the accumulator roller 53 but the water retention was excessive. With a slurry temperature in the region of 20 to 25°C, the machine operated at maximum speed with good de-watering and the felt belt remained clean, while the properties of the cement composite material were satisfactory. With a slurry temperature of 27°C the properties of the material were found to deteriorate due to porosity.

It is believed that the nature of the flocculant used influences to some extent the appropriate temperature for operation. It is clear, however, that the provision of means for controlling the temperature of the flocculant-containing aqueous slurry before and during deposition on the foraminous surface, in accordance with the invention, enables consistent production of satisfactory cement composite material to be achieved.

The glass fibre used is preferably in the form of chopped strands of filaments sized with a size composition such that the strands separate or filamentise into individual filaments in the slurry as in the foregoing Examples, but strands which retain their integrity may be used instead of or in addition to the dispersible fibres.

CLAIMS

1. Apparatus for making cement composite materials reinforced with glass fibres, comprising means for forming an aqueous slurry of cement, glass fibre, pulverised fuel ash, finely divided amorphous silica, cellulose pulp and water; a foraminous surface on which a layer of the slurry can be deposited and through which water can be removed to de-water the cement composite material; and means for adding a flocculant to the slurry adjacent to the foraminous surface; characterised by the provision of means for controlling the temperature of the flocculant-containing aqueous slurry before and during deposition on the foraminous surface.

2. Apparatus according to Claim 1 characterised in that the means for forming the aqueous slurry comprises a water reservoir from which water can be supplied to a slurry mixer, and the means for controlling the temperature of the flocculant-containing slurry comprises means for heating and for cooling the water in the reservoir.

3. Apparatus according to Claim 2 characterised in that the means for heating the water in the reservoir comprises a steam generator connected through a regulator valve which is controlled by a temperature controller to a pipe opening into the water in the reservoir.

4. Apparatus according to Claim 3 characterised in that the means for cooling the water in the reservoir comprises a pump controlled by the temperature controller and arranged to circulate water from the reservoir to and from a cooling lagoon.

5. Apparatus according to Claim 3 or 4 characterised in that the means for controlling the temperature of the slurry further comprises a temperature sensor in the reservoir, connected to the temperature controller.

6. Apparatus according to any one of Claims 2 to 5 characterised in that the slurry mixer is arranged to supply a relatively thick slurry comprising water and cement to a blender provided with means for introducing glass fibres into the slurry, the blender being in turn arranged to supply the glass-fibre-containing slurry to a holding vessel, which is connected to the water reservoir for supply of water for diluting the slurry and is also connected to the vat of a Hatschek type machine for feeding the diluted slurry thereto, a tank for containing flocculant solution being connected to the line between the holding tank and the vat.

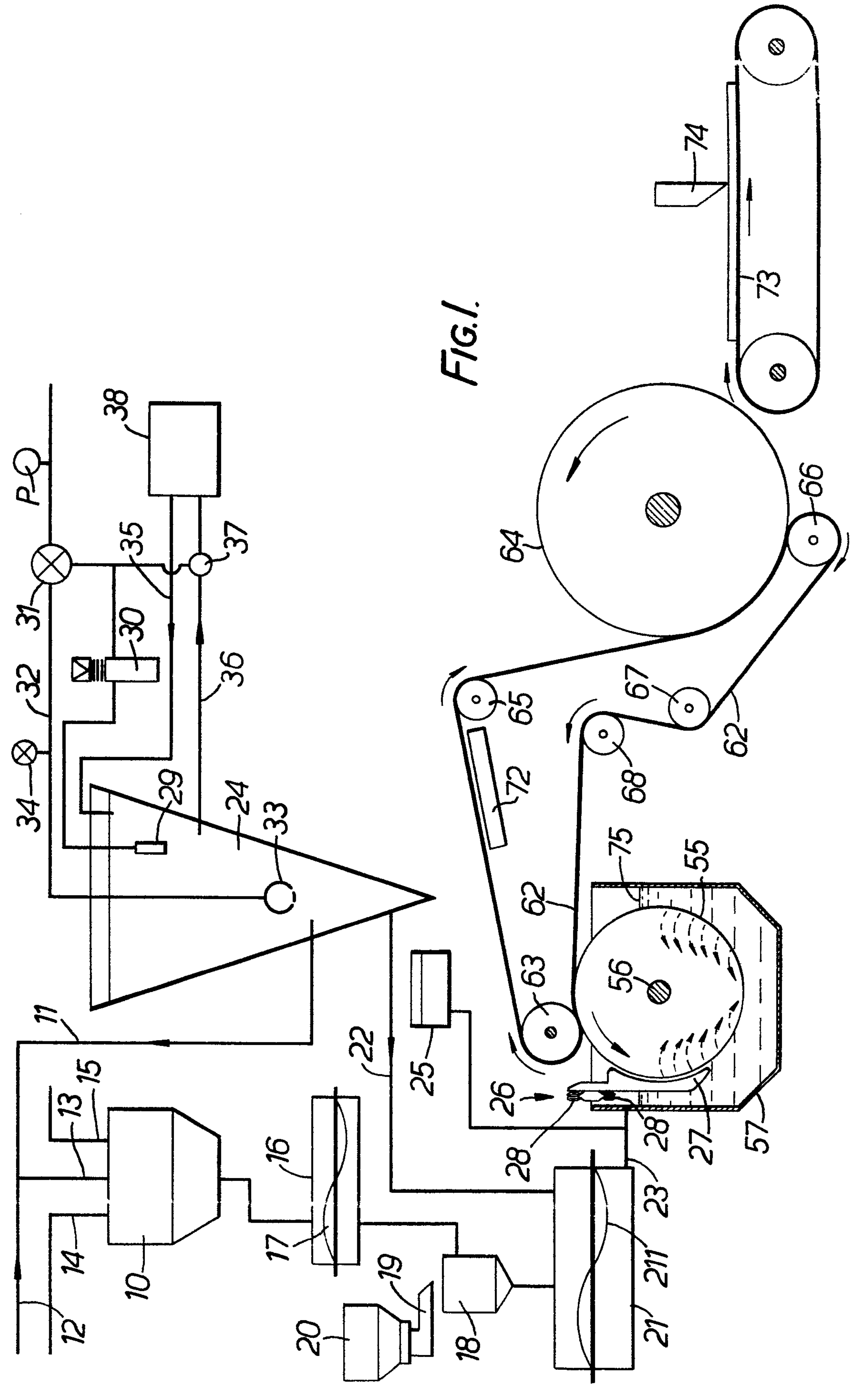


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FIG.1.

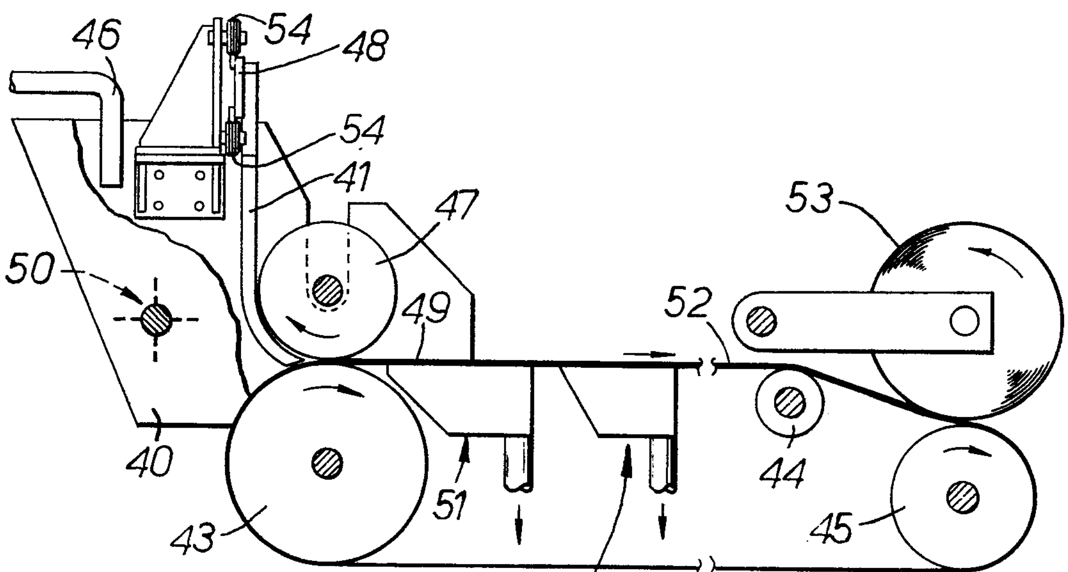

FIG.2.