Oct. 31, 1950 E. W. MENKE 2,528,158

METHOD AND APPARATUS FOR CONTROLLING THE POROSITY OF ELECTRICALLY PERFORATED SHEET MATERIAL

Filed Nov. 19, 1949 3 Sheets-Sheet 1

Fig. 1.

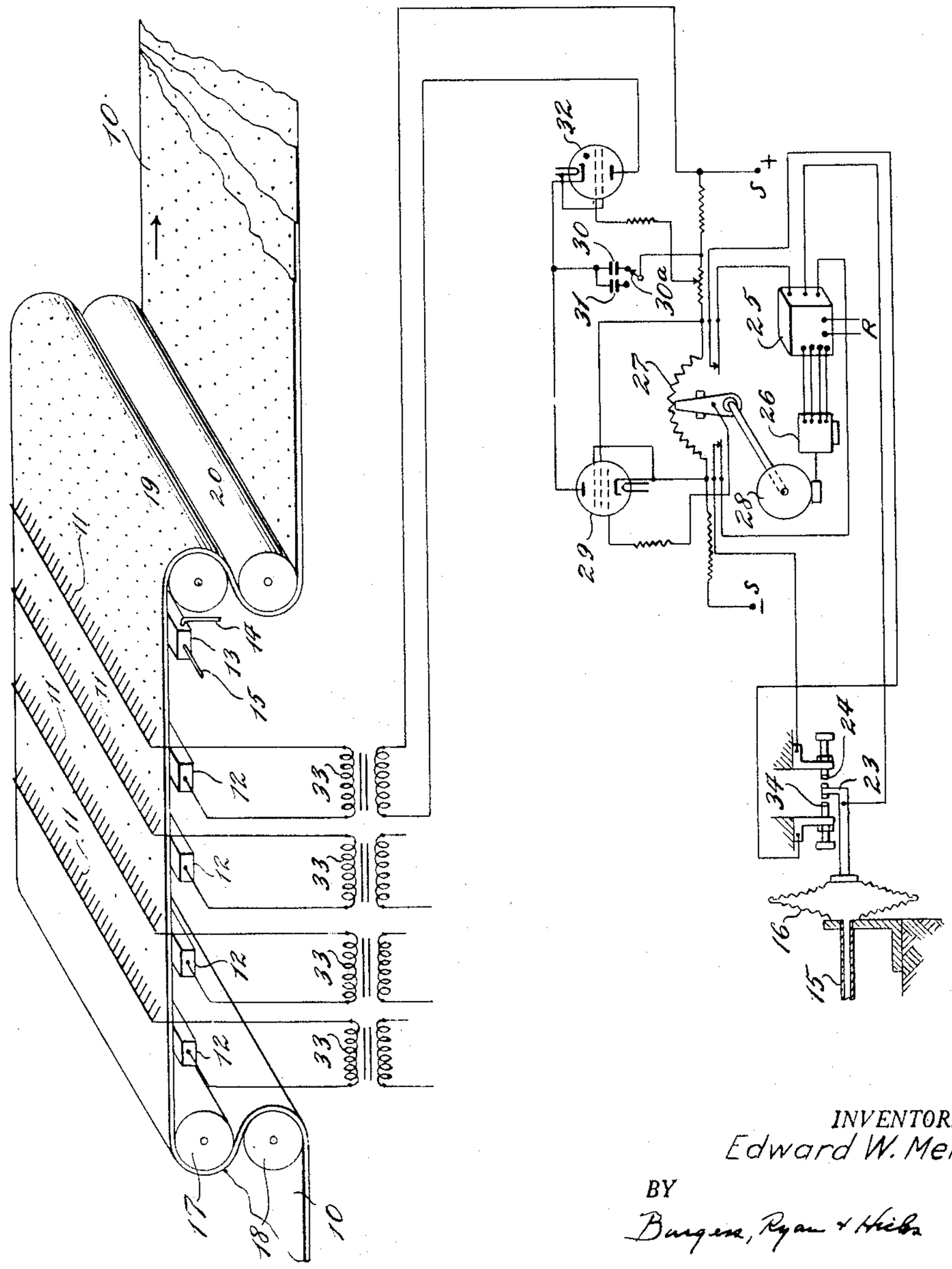

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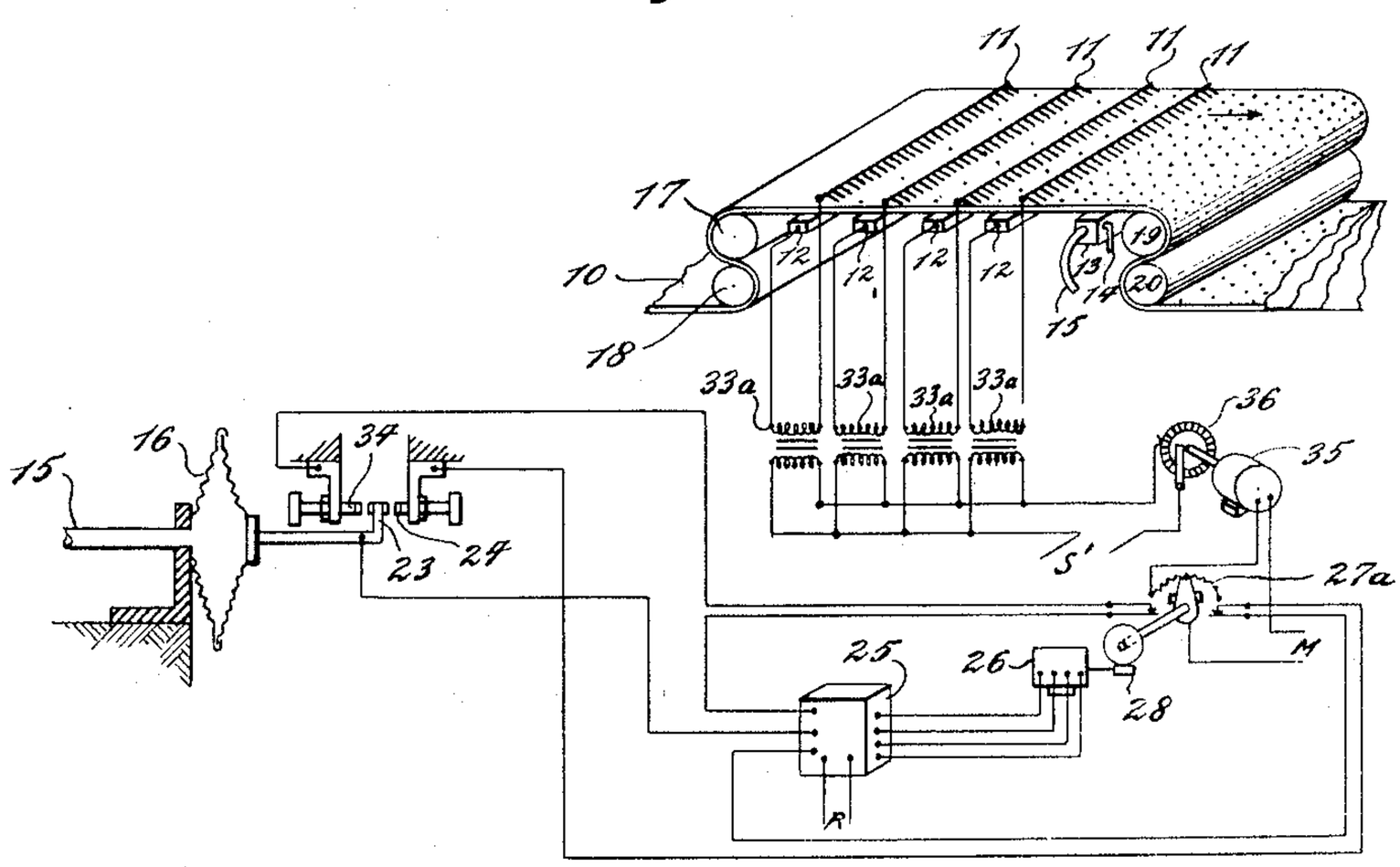
Fig. 2.



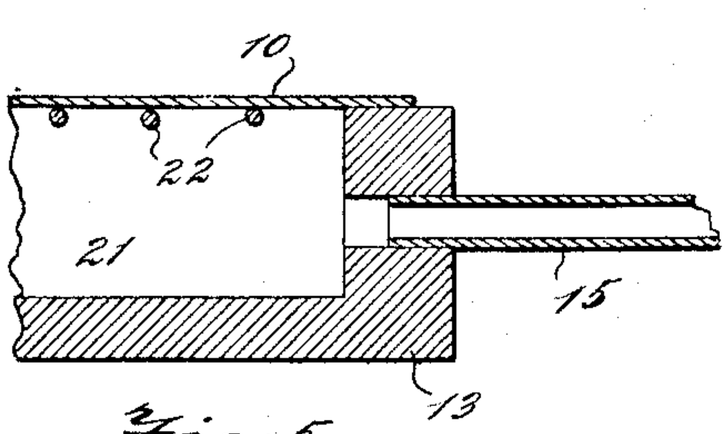


Fig. 5.

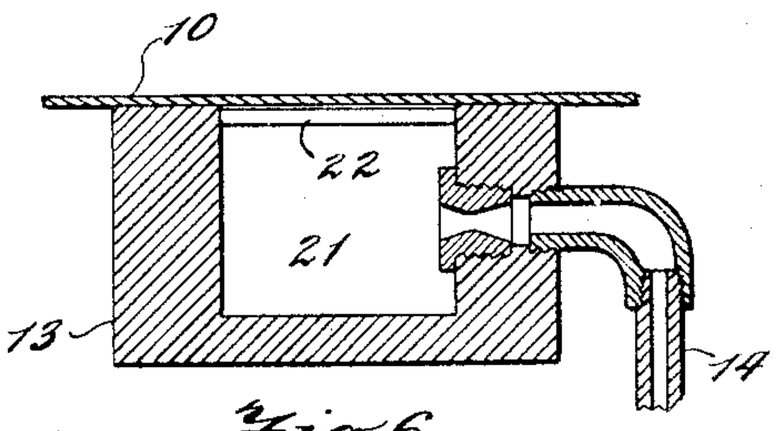


Fig. 6.

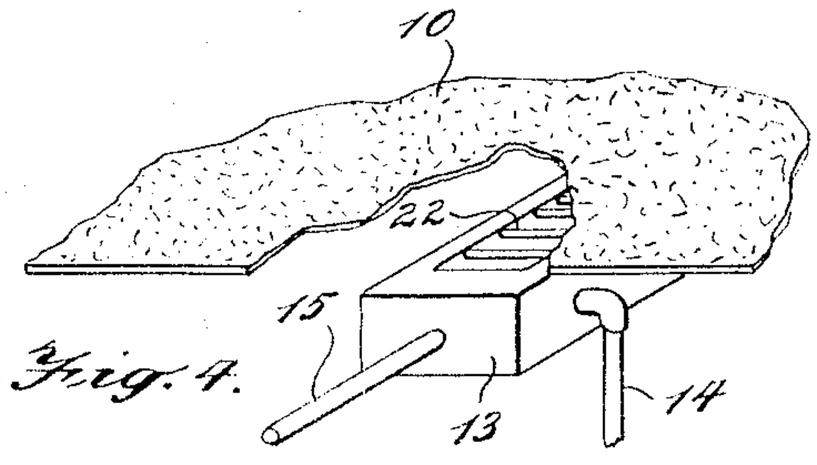


Fig. 4.

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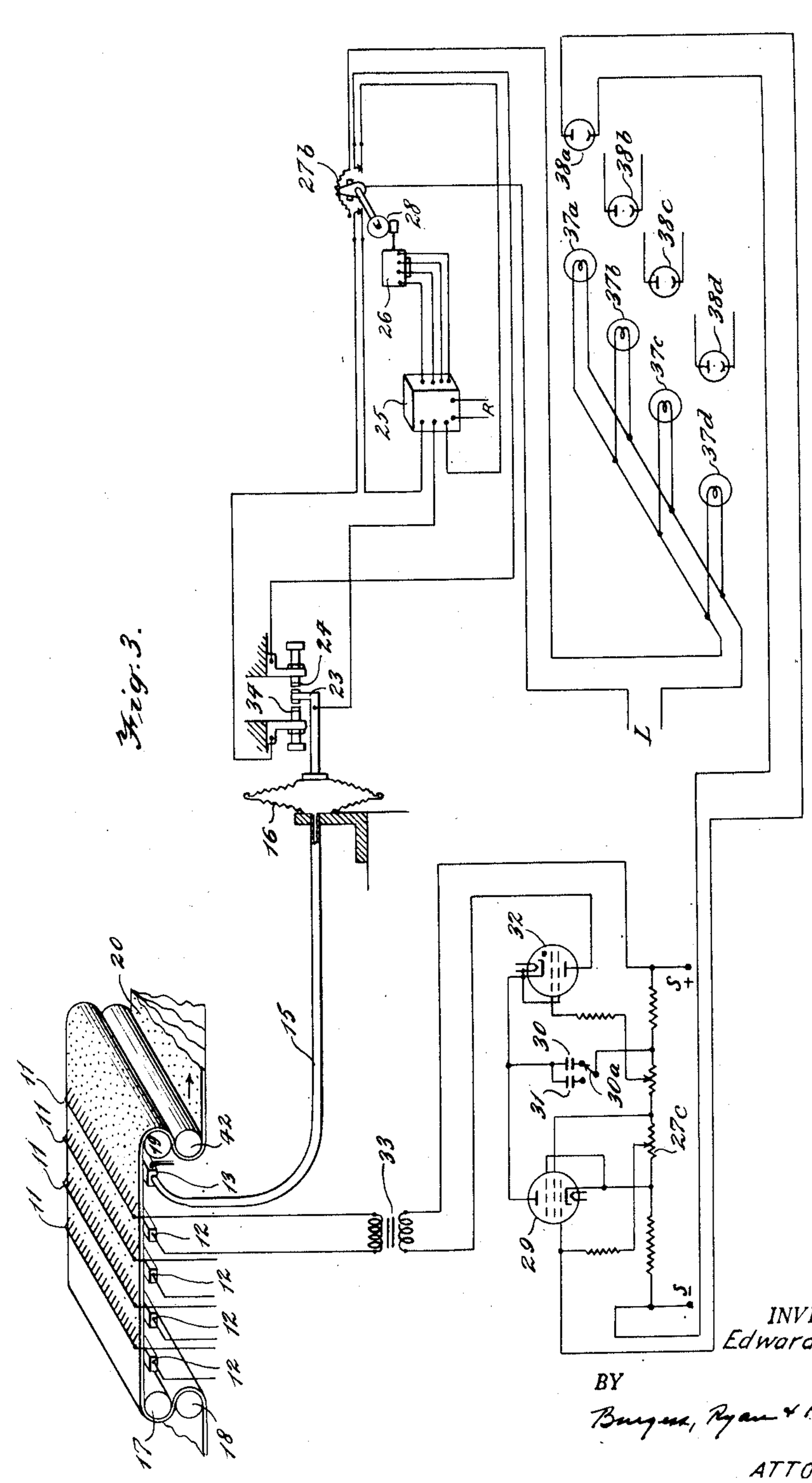

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METHOD AND APPARATUS FOR CONTROLLING THE POROSITY OF ELECTRICALLY PERFORATED SHEET MATERIAL

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Application November 19, 1949, Serial No. 128,393

12 Claims. (Cl. 219—19)

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This invention relates to improvements in method and apparatus for controlling the porosity obtained by electrically perforating sheet material and relates more particularly to a method and apparatus for maintaining the porosity obtained by electrically perforating sheet material at a predetermined value.

Certain features of the present application are shown and described in my copending application Serial No. 128,392 filed November 19, 1949, entitled "Method and Apparatus for Controlling The Porosity of Electrically Perforated Opaque Sheet Material," and reference may be made thereto for a detailed description of such features.

An object of the present invention is to provide a method and apparatus whereby the total area of electrical perforations that are required to produce a desired porosity in an electrically perforated sheet of material, either opaque or transparent, will be automatically maintained regardless of the speed at which the sheet material is traveling during its perforation or other factors that might affect the electrical perforation of the sheet material. Other objects and advantages of the present invention will be apparent and will be best understood from the following description and the accompanying drawings in which:

Fig. 1 is a schematic drawing illustrating an apparatus embodying and capable of carrying out my invention;

Fig. 2 is a schematic drawing illustrating a modified apparatus embodying and capable of carrying out my invention;

Fig. 3 is a schematic drawing illustrating another modification of the apparatus embodying and capable of carrying out my invention;

Fig. 4 is a perspective view illustrating a portion of the apparatus embodying my invention; and

Figs. 5 and 6 are side and end elevations in section, respectively, of the portion of the apparatus illustrated in Fig. 4.

Referring now to the drawings in detail, there is a web of sheet material 10 that is moved in the usual manner between one or more sets of opposed electrodes 11 and 12. The sheet material 10 may consist of one or more layers or plies and it may be an opaque material such as an ordinary kraft paper that is commonly used for bags or it may be a translucent or transparent material such as regenerated cellulose.

The electrodes 11 and 12 may be of any suitable type and the electrodes in each series of electrodes may be connected in a suitable manner such as that illustrated and described in United States Letters Patent No. 2,372,508 issued March 27, 1946, to John W. Meaker.

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After passing between the electrodes 11 and 12 and being electrically perforated, the sheet material 10 passes over a vacuum chamber 13 that extends at least part way across the width of the sheet material. The vacuum chamber 13 communicates through a pipe 14 with a vacuum pump (not shown) and also communicates through a pipe 15 with a flexible metal bellows or diaphragm 16. If the sheet material 10 consists of more than one layer, the plies thereof may be held against movement relative to each other in order to keep the sheets in register and the perforations in the various plies in alignment by reeving the sheet material around a set of rolls 17 and 18 engaging with the sheet in advance of the electrodes and around a set of rolls 19 and 20 engaging with the sheet after it has passed over the vacuum chamber 13.

As shown best in Figs. 4–6, the vacuum chamber 13 is hollow as indicated at 21 with an opening along its upper face. A series of rods or wires 22 extend across the opening in the upper face of the vacuum chamber 13 and support the sheet material 10 as it passes over the vacuum chamber. The vacuum pump to which the vacuum chamber is connected by the pipe 14 is of a type that will maintain a constant degree of vacuum in the recess 21 of the vacuum chamber 13 under a given set of conditions. The bellows 16 is arranged so that when the total area of perforations in the sheet material produces the desired degree of porosity in the sheet material, the vacuum that is maintained in the vacuum chamber 13 and is transmitted through the pipe 15 to the diaphragm 16 holds the diaphragm 16 at a neutral or static position. However, the vacuum that is maintained in the vacuum chamber 13 will increase if total area of perforations in the sheet material decreases and will decrease if the total area of perforations in the sheet material increases. The changes in the vacuum in the vacuum chamber 13 are transmitted through the pipe 15 to the bellows 16 and will cause the bellows to move. If the vacuum decreases due to an increase in the total area of the perforations per unit of area in the sheet material, the flexible bellows 16 will expand and conversely if the vacuum increases, the flexible bellows will contract.

The bellows 16 carries a movable contact 23

and the expansion of the bellows moves the contact 23 into engagement with a fixed contact 24. The closing of the contacts 23 and 24 completes a circuit through a control box 25 connecting a reversible electric motor 26 to a source of electrical energy R. The electric motor 26 when thus connected drives the contact arm of a variable resistance 27 through a reduction worm and gear drive 28 in a direction to decrease the resistance 27.

The resistance 27 connects the grid of a pentode type amplifying tube 29 to one side of a source of direct current S. When the resistance is decreased, the bias of the grid in the tube 29 relative to the cathode therein is increased and the output of the amplifying tube is correspondingly reduced. The output of the amplifying tube 29 is connected to condensers 30 and 31 either of which may be connected across a thyratron tube 32 by a switch 30*a*. When the output of the tube 29 is reduced, the rate at which the condenser 30 (or 31) is charged is reduced and the thyratron tube 32 is rendered conductive at less frequent intervals. The thyratron tube 32 is connected in a circuit connecting the primary of a transformer 33 to the source of direct current S and delivers pulsations of the direct current to the primary of the transformer 33. The voltage of the pulsating direct current is increased by the secondary of the transformer to a voltage that is capable of creating a discharge between the electrodes 11 and 12 and through the sheet material moving between the electrodes. The frequency or the number of such discharges between the electrodes 11 and 12 will vary with the frequency of the pulses of current delivered to the electrodes through the thyratron tube 32. Thus, if the frequency of the pulses of current delivered by the thyratron tube 32 is reduced, the total area of the perforations in the sheet material and the porosity of the sheet material will be likewise reduced.

The opposite effect takes place when the vacuum in the vacuum chamber 13 increases indicating that the porosity of the sheet material is below a desired value. In such event, the vacuum acting on the bellows 16 causes the bellows to contract and the contraction of the bellows moves the contact 23 into engagement with a second fixed contact 34. When the contacts 23 and 34 are closed, the motor 26 is driven in the reverse direction and increases the resistance 27 which reduces the bias applied to the grid in the amplifying tube 29 increasing the output current flowing from the tube 29. This increases the rate at which the condenser 30 (or 31) is charged and renders the thyratron tube 32 conductive at more frequent intervals. The end result of this is to increase the frequency at which the electrical discharges take place between the electrodes and the total area of the perforations produced in the sheet material 10.

In the modification illustrated in Fig. 2, a variable resistance 27*a* is connected in circuit with a motor 35 driving a commutator element 36 to a source of electrical energy M. The commutator element 36 is in a circuit that connects the primaries of a series of transformers 33*a* to a source of direct current S'. The rotation of the commutator element 36 opens and closes the circuit to the primaries of the transformers and thereby induces an increased voltage in the secondaries of the transformers and the speed at which the commutator rotates controls the frequency at which the electrical discharges between

the electrodes and through the sheet material takes place. Thus, when the porosity of the sheet material falls below the desired value, the contacts 23 and 24 are closed and the reversible motor 26 is driven in a direction to reduce the resistance 27*a* and increase the speed of the motor 35. Conversely, if the porosity of the sheet material exceeds the desired value, the contacts 23 and 24 are closed and the reversible motor 26 is driven in a direction to increase the resistance 27*a* and reduce the speed of the motor 35.

In the modification illustrated in Fig. 3, a variable resistance 27*b* is in a circuit connecting a series of lamps 37*a* and 37*d* to a source of electrical energy L. The light from each of the lamps 37 is directed respectively on to photoelectric cells 38*a* to 38*d*. Each of the photoelectric cells 38 is connected to the control grid of an amplifying tube 29 in an electronic control circuit similar to that shown in Fig. 1 and described in conjunction therewith. However, in this instance a variable resistance 27*c* that is manually adjustable is connected to the control grid of the tube 29 rather than the resistance 27 with the motor drive.

In all of the embodiments of the invention herein described and illustrated the total area of the electrical perforations is maintained within predetermined limits so that the porosity of the perforated sheet material will also be maintained within predetermined limits. It will be understood that pressure from a constant source of pressure other than a negative pressure (vacuum) may be connected to the pressure chamber 13 and applied to the perforated sheet of material. However, in the case of applying a vacuum to the moving web of perforated sheet material and the increasing or decreasing of the frequency of the electrical discharges taking place between the electrodes will be inverse with respect to the increases and decreases in the vacuum in the chamber 13 resulting from changes in the total area of the perforations in the sheet material.

Also, in the case of multiple-ply sheet material, it may be found desirable to separate one ply of the perforated sheet material from the other plies prior to applying a vacuum from the vacuum chamber 13 to the perforated material in order to prevent a shifting of the plies blocking the perforations. This can be done in the manner illustrated and described in my copending application previously referred to herein.

It will be understood that other forms of pressure actuated switches may be used in place of the bellows 16 and the movable contact 23 carried thereby and other changes and modifications can be made in the embodiments of the invention described and illustrated herein without departing from the scope of the claims appended hereto.

I claim:

1. The method of maintaining the porosity produced in sheet material by electrical perforations within predetermined limits which comprises electrically perforating the sheet material by passing a moving web of sheet material between a set of opposed electrodes and causing electrical discharges to pass between the electrodes and through the moving sheet material, then applying pressure from a constant source of pressure to the moving web of perforated sheet material and varying the frequency of the electrical discharges passing between the opposed electrodes and through the sheet material in

response to changes in the pressure resulting from changes in the total area of the perforations in the sheet material.

2. The method of maintaining the porosity produced in sheet material by electrical perforations within predetermined limits as defined in claim 1 wherein a negative pressure is applied to the perforated sheet material and the frequency of the electrical discharges is varied inversely with respect to changes in the negative pressure resulting from changes in the total area of the perforations in the sheet material.

3. The method of maintaining the porosity produced in multiple-ply sheet material by electrical perforations within predetermined limits which comprises electrically perforating the sheet material by passing a moving web of the sheet material between a set of opposed electrodes and causing electrical discharges to pass between the opposed electrodes and through the moving web of sheet material, then applying pressure from a constant source of pressure to the moving web of perforated sheet material, maintaining the plies of the sheet material in register during the perforation of the sheet material and while the pressure is applied thereto, and then varying the frequency of the electrical discharges passing between the opposed electrodes and through the moving web of sheet material in response to changes in the pressure resulting from changes in the total area of the perforations in the sheet material.

4. The method of maintaining the porosity produced in sheet material by electrical perforations within predetermined limits which includes moving a web of the sheet material between a set of opposed electrodes, passing electric discharges between the opposed electrodes and through the moving web of sheet material, then passing a portion of the moving web of perforated sheet material over an opening in a chamber that is connected to a source of constant pressure to said chamber, and then varying the total area of perforations being produced in the sheet material by the electrical discharges by varying the frequency at which the electrical discharges take place between the opposed electrodes and through the sheet material in response to changes in the pressure in said chamber.

5. The method of maintaining the porosity produced in sheet material by electrical perforations within predetermined limits as defined in claim 4 wherein the pressure applied to the moving web of perforated sheet material is a negative pressure and the frequency of the electrical discharges is varied inversely with respect to changes in said negative pressure.

6. In an apparatus for maintaining the porosity produced in sheet material by electrical discharges within predetermined limits, the combination of a set of opposed electrodes between which a moving web of the sheet material is adapted to pass, means for delivering an electric current to said electrodes at a voltage capable of causing a discharge between the electrodes and through the moving web of sheet material, a pressure chamber contacting with a portion of one surface of the moving web of perforated sheet material at a point following the passage of the sheet through the electrodes, said chamber having an opening across which the moving web of perforated sheet material passes and being connected to a source of constant pressure, and means for varying the frequency of the discharges between the opposed electrodes, said means being connected to the pressure chamber and acting in response to changes of the pressure therein.

7. In an apparatus for maintaining the porosity produced in sheet material by electrical discharges within predetermined limits, the combination as defined in claim 6 wherein the means for varying the frequency of the discharges between the opposed electrodes includes a pressure actuated switch, said switch being connected to and movable in response to changes in the pressure in the pressure chamber, and circuits controlled by said switch for varying the frequency of the discharges in response to changes in the pressure in the pressure chamber.

8. In an apparatus for maintaining the porosity produced in a multiple-ply sheet material by electrical discharges within predetermined limits, the combination of a set of opposed electrodes, said electrodes being arranged to receive a moving web of the sheet material there between, means for delivering an electrical current to said electrodes at a voltage capable of causing a discharge between the electrodes and through the moving web of sheet material, a pressure chamber contacting with a portion of one surface of the moving web of perforated sheet material following its passage between the electrodes, said chamber having an opening across which the moving web of perforated sheet material passes and being connected to a source of constant pressure, means engaging with the moving web of sheet material for maintaining the plies thereof in register during the movement of the sheet material between the electrodes and across the pressure chamber, a pressure actuated switch connected to said pressure chamber and circuits controlled by said pressure actuated switch for varying the frequency of the discharges between the electrodes in response to changes of pressure in the pressure chamber.

9. In an apparatus for maintaining the porosity produced in sheet material by electrical discharges within predetermined limits, the combination of a set of opposed electrodes between which a moving web of the sheet material is adapted to pass, means for delivering an electric current to said electrodes at a voltage capable of creating a discharge between the electrodes and through the moving web of sheet material, a vacuum chamber located at a point following said electrodes, said chamber being connected to a source of constant vacuum and having an opening therein abutting against a portion of one surface of the moving web of perforated sheet material, a pressure actuated switch connected to said chamber, and circuits controlled by said switch for varying the frequency of the electrical discharges between the opposed electrodes in response to changes of the vacuum in said chamber.

10. In an apparatus for maintaining the porosity produced in sheet material by electrical discharges within predetermined limits, the combination as defined in claim 9 wherein the means for delivering an electric current to the electrodes includes a variable resistance and the circuits controlled by the pressure actuated switch include a reversible electric motor, said motor having driving connections to said variable resistance.

11. An apparatus for maintaining the porosity produced in sheet material by electric discharges within predetermined limits wherein a

moving web of sheet material is passed between a set of opposed electrodes and electric discharges are passed between the opposing electrodes and through the moving web of sheet material which includes a pressure chamber engaging with one side of the moving web of sheet material at a point following the electrodes, said chamber being connected to a source of constant pressure and having an opening therein across which the perforated sheet material passes, a pressure actuated switch connected to said chamber, and circuits controlled by said switch for varying the total area of the electrical perforations being produced in the moving web of sheet material by varying the frequency of the electrical discharges passing between the electrodes and through the sheet material.

12. An apparatus for maintaining the porosity produced in sheet material by electrical discharges within predetermined limits as defined

in claim 11 wherein the frequency at which electrical discharges pass between the opposed electrodes is controlled by a variable resistance and the circuits controlled by the pressure actuated switch include a reversible electric motor, said motor having driving connections to said variable resistance.

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