Oct. 31, 1950 E. W. MENKE 2,528,157

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

Filed Nov. 19, 1949 2 Sheets-Sheet 1

Fig. 1.

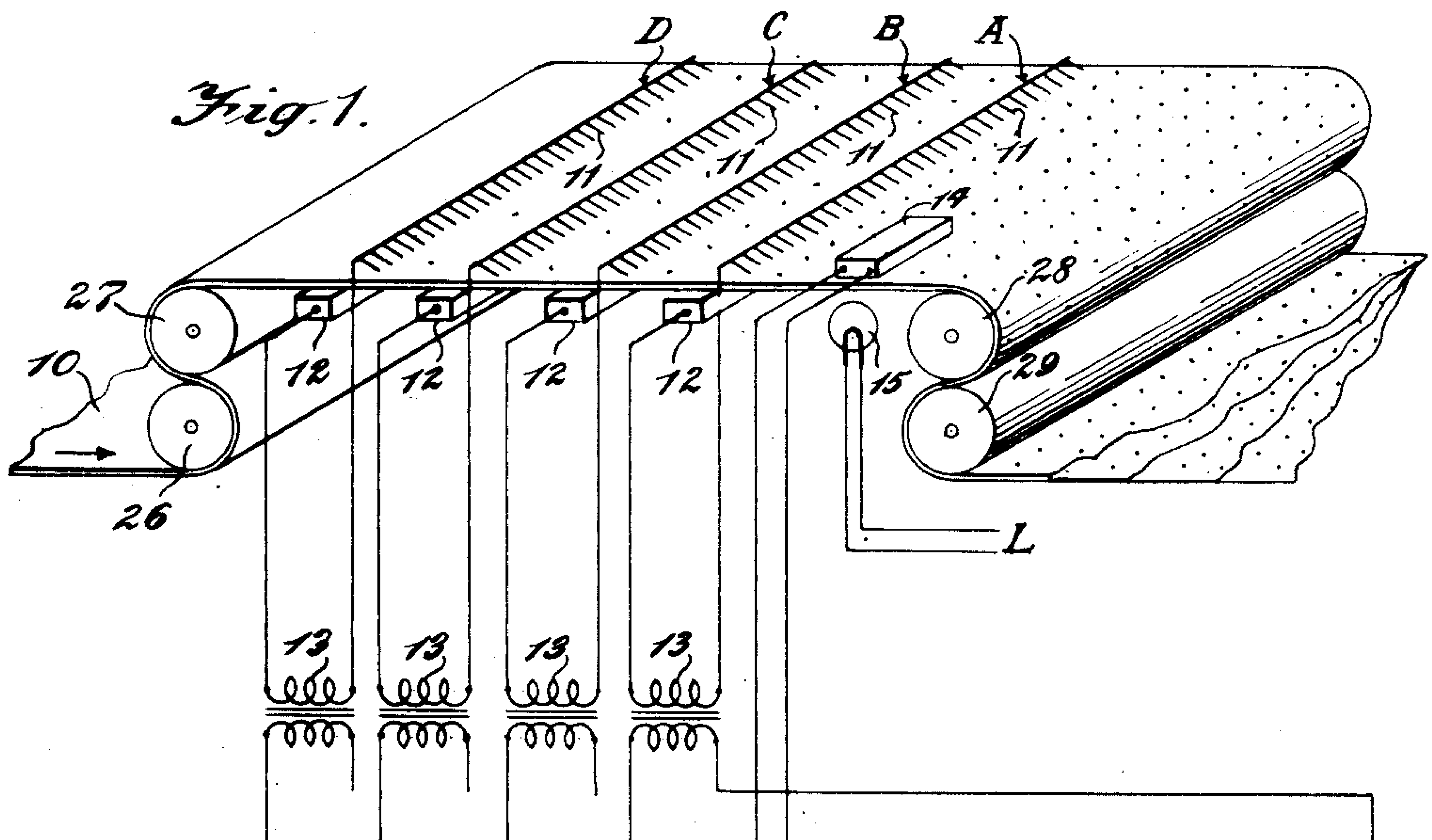
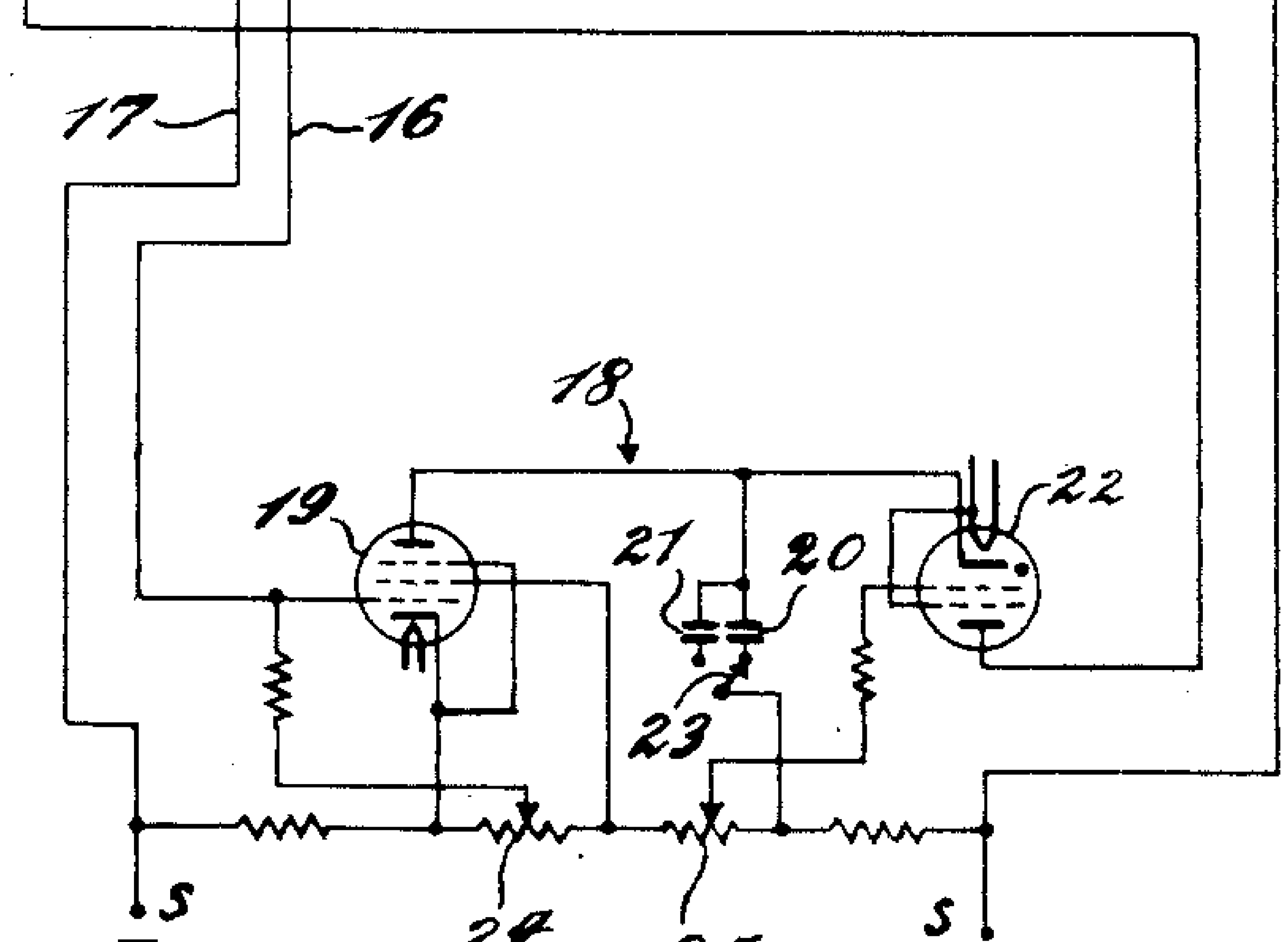



Fig. 5.

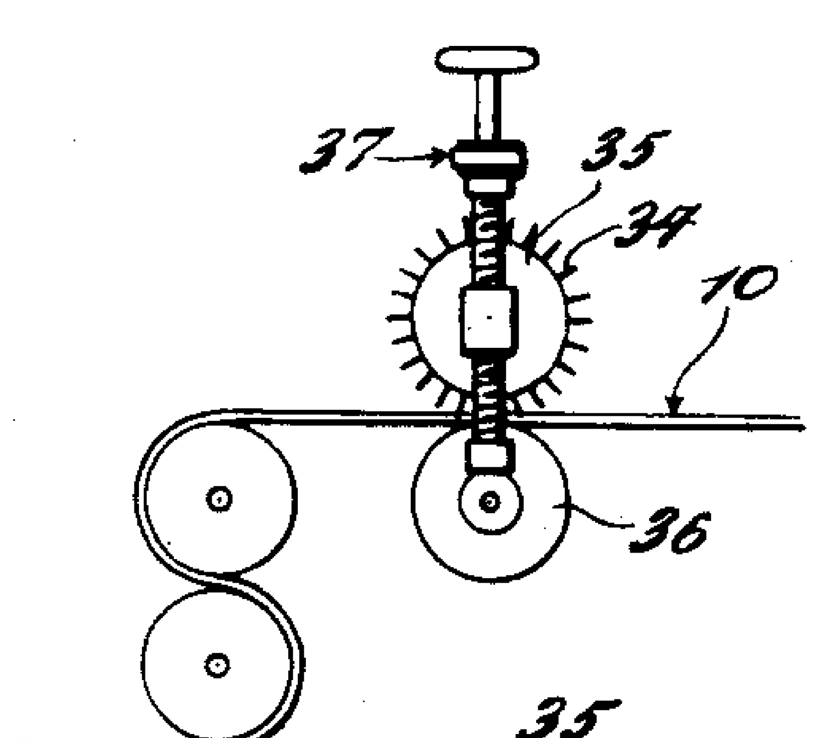
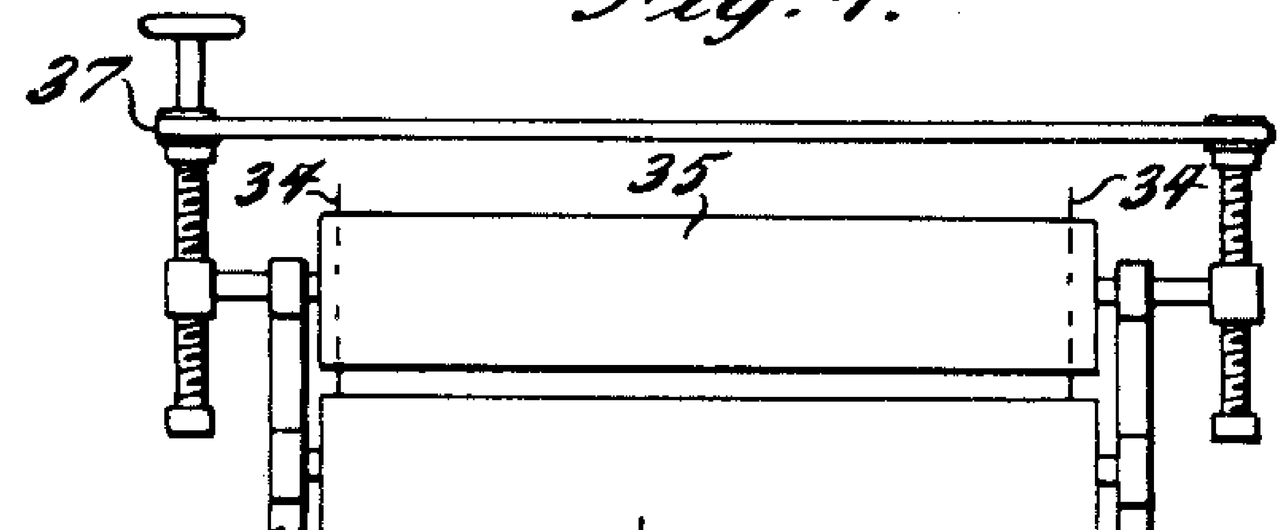


Fig. 4.



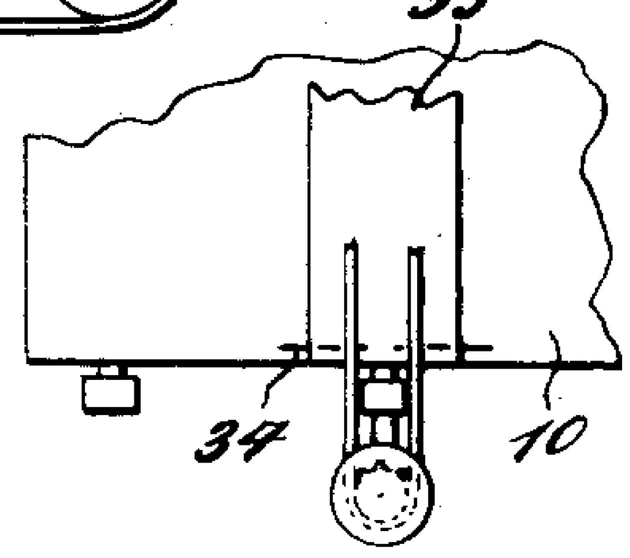


Fig. 6.

INVENTOR.
Edward W. Menke

BY

Burgess, Ryan & Hicks

ATTORNEYS

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

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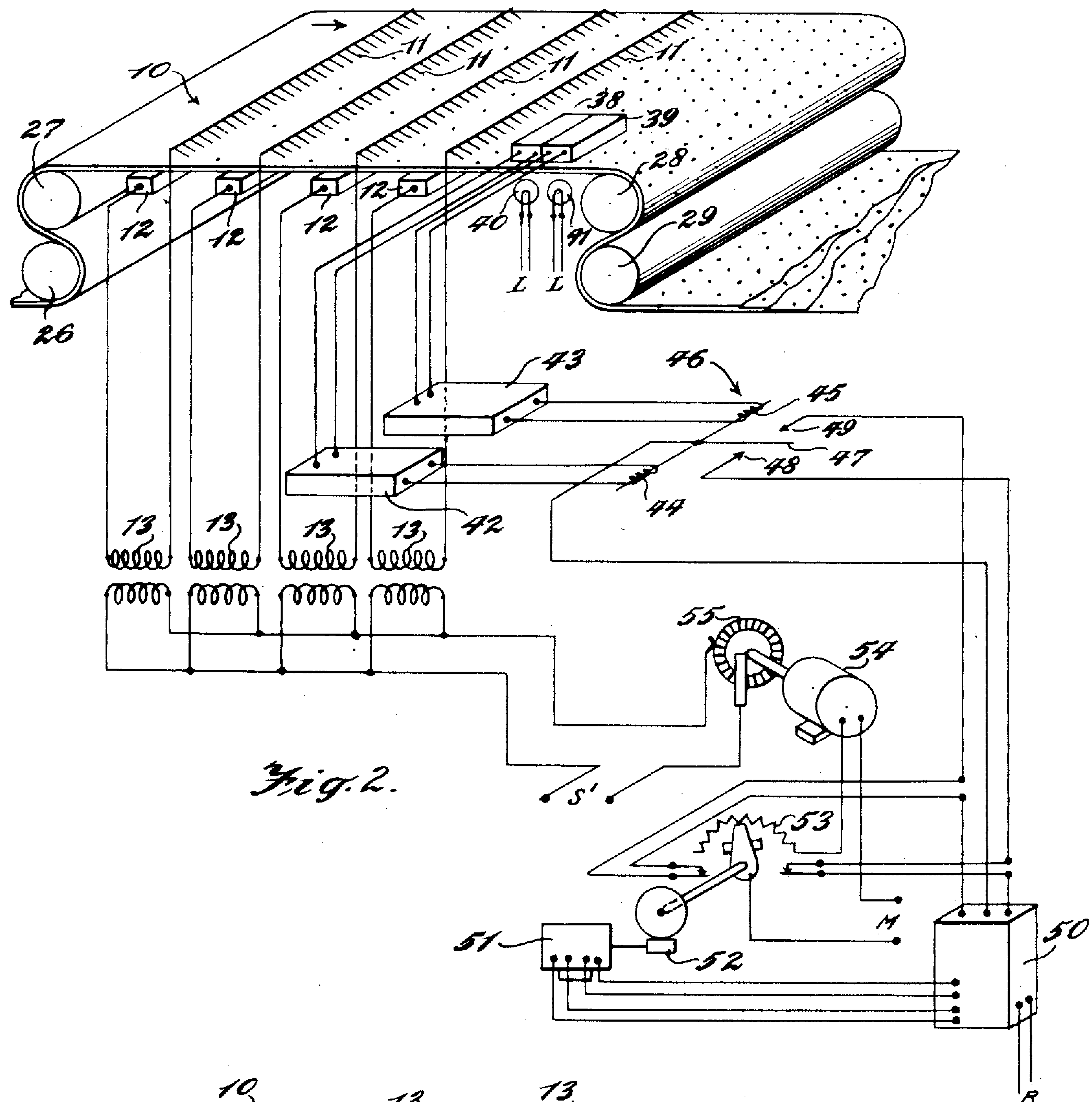

Fig. 2.

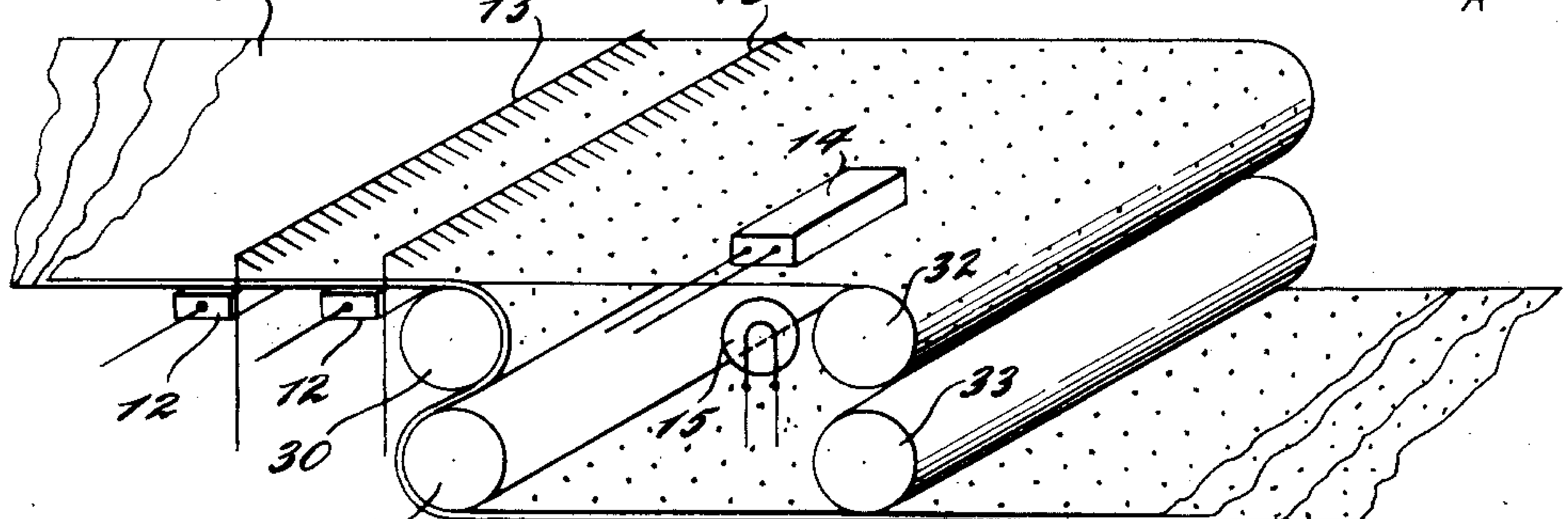

Fig. 3.

INVENTOR.
Edward W. Menke

BY
Burgess, Ryan & Hicks

ATTORNEYS

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

Edward W. Menke, Nutley, N. J., assignor to Henry C. Hay, New York, N. Y.

Application November 19, 1949, Serial No. 128,392

15 Claims. (Cl. 219—19)

This invention relates to improvements in method and apparatus for controlling the porosity of electrically perforated sheet material and relates more particularly to a method and apparatus for automatically controlling the porosity that is obtained by electrical perforation of a multiple-ply sheet material having at least one opaque ply.

An object of the invention is to provide a method and apparatus that will automatically maintain the porosity that is obtained by electrical perforation of sheet material at a desired value regardless of the speed at which the sheet material is traveling during its perforation or other factors affecting the electrical perforation of the sheet material. Reference may also be made to my copending application Serial No. 128,393, filed November 19, 1949, entitled "Method and Apparatus for Controlling the Porosity of Electrically Perforated Sheet Material," which deals with subject matter related to the present invention.

Other objects and advantages of the invention will be apparent and best understood from the following description and the accompanying drawings in which:

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

Fig. 2 is a schematic view illustrating a modification of the apparatus embodying and capable of carrying out my invention;

Fig. 3 is a schematic view illustrating a modification of a portion of the apparatus illustrated in Figs. 1 and 2; and

Figs. 4, 5 and 6 are end, side and plan views, respectively, of another modification of a portion of the apparatus illustrated in Figs. 1 and 2.

Referring now to the drawings in detail there is a moving web of sheet material 10. As illustrated in Fig. 1, the sheet material 10 may consist of a plurality of plies of paper with at least one of the plies being opaque. Such multi-ply paper is commonly used in the manufacture of bags for the packaging of cement or other pulverized or granular commodities. In order to permit the air to escape from such a bag as it is being filled with a commodity such as cement, it has been found advantageous to perforate the sheet material, preferably by electric discharge, so as to provide a perforated container such as described and claimed in United States Letters Patent No. 2,340,546 issued February 1, 1944, to John W. Meaker. However, it will be understood that the present invention applies to single sheet as well as the sheet consisting of multiple plies.

Generally speaking, the perforation of the sheet material 10 may be most economically carried out immediately prior to the sheet material 10 entering the tube portion of a bag making machine or in conjunction with some other operation in the manufacture of the sheet material or bag where a separate handling of the sheet material for the purposes of perforation is not required. However, when the perforation of the sheet material is carried out in conjunction with other operations such as the tube forming operation in a bag making machine, the speed at which the sheet material is moving may vary considerably due to factors other than those involved in the perforating operation. For example, the speed at which the sheet material moves through the bag-forming machine may vary from 200 feet per minute to 600 feet per minute under ordinary operating conditions for various reasons. Consequently, if the perforating apparatus is designed to produce a total area of perforations in the sheet material that is required to give the desired porosity at one speed, the total area of perforations will then produce a porosity that is above that desired if the speed at which the sheet material is moving is reduced or a porosity that is below that desired if the speed at which the sheet material is moving is increased. As a result, in either case, the desired porosity is not obtained in the sheet material.

As will be described, the present invention insures that the total area of perforations required to produce the desired porosity will be obtained regardless of the speed at which the sheet material travels and also, regardless of other factors such as variations in the dielectric strength, thickness or other characteristics of the sheet material.

The sheet material may be electrically perforated in the usual manner by passing it between one or more sets of opposed electrodes, as indicated at characters A, B, C, and D, between which electrical discharges take place. Each set of the electrodes A, B, C, and D consists of a series of upper electrodes 11 and a series of lower electrodes 12 extending across the width of the sheet material. The electrodes 11 and 12 of each set are connected, respectively, to opposite sides of the secondary of a transformer 13 that is capable of delivering an electrical current to the electrodes at a voltage sufficient to cause an electrical arc discharge to take place between the electrodes and through the sheet material passing between them. The electrodes 11 and

12 may be of any suitable type and each series of electrodes may be interconnected in any suitable manner. Also, where more than one set of electrodes is used, the electrodes in each set may be staggered across the width of the sheet material so that as it passes between the various sets of electrodes different areas of the sheet are covered by the respective set of electrodes. An example of a suitable arrangement of electrodes and the connections therefor is shown and described in United States Patent No. 2,372,508 issued March 27, 1945 to John W. Meaker.

After passing between the various sets of electrodes and being perforated thereby, the perforated sheet material 10 passes between an electrically responsive, light-sensitive element in the form of a photo-electric cell 14 and a source of light in the form of a lamp 15 that is connected to a source of electrical energy L. The beam of light from the lamp 15 is directed by a suitable optical system against one side of the moving sheet material 10 and a portion of the beam of light is permitted to pass through the sheet material by the openings or perforations therein. This portion of the beam of light will impinge on the electric cell 14 and the output of the cell will vary in response to variations in the amount of light striking it. The output of the photo-electric cell 14 is connected by leads 16 and 17 to the input of an electronic control circuit 18 that controls the frequency at which pulsations of direct current are delivered to the primary of the transformer 13 in accordance with variations in the output of the photo-electric cell 14. By controlling the frequency of the current flowing in the primary of the transformer 13, the frequency of the electrical discharges taking place between the opposed electrodes 11 and 12 and the total area of the perforations in the sheet material is also controlled. Similar control circuits may be provided for each of the transformers 13, if desired, but since these circuits will correspond to the one illustrated, they need not be described or illustrated herein.

The electronic control circuit 18, illustrated in Fig. 1, includes an amplifier tube 19 of the pentode type and the output of photo-electric cell 14 is connected to the control grid thereof. The output of the amplifier tube 19 is connected to a condenser 20 or 21 that is connected across the control elements of a thyratron tube 22. The condensers 20 and 21 are of different capacities and are arranged so that either one may be connected across the thyratron tube 22, as desired, by a switch 23.

If the light passing through the perforations in the sheet material decreases, indicating that the porosity of the sheet material is below a desired value, the output of the photo-electric cell 14 will decrease. A decrease in the output of the photo-electric cell 14 changes the bias of the grid in the amplifying tube 19 so that more current is permitted to flow from the cathode to the plate of the tube 19 thus increasing the output current flowing from the amplifying tube to the condenser 20 (or 21). When the output current from the tube 19 is increased, it causes the condenser 20 (or 21) to charge and discharge more rapidly so that the thyratron tube 22 is rendered conductive at more frequent intervals. During the intervals that the thyratron tube 22 is conductive, current from a source of direct current S flows through it to the primary of the transformer 13. As the frequency of the intervals during which the direct current flows through the primary of the transformer 13 increases, a corresponding increase in the frequency of the discharges between the electrodes 11 and 12 that are connected to the secondary of the transformer 13 takes place.

The converse of the foregoing takes place if the amount of light passing through the perforations in the sheet material increases indicating that the sheet material has a greater porosity than desired and the frequency of the pulsations of current flowing through the thyratron tube 22 to the primary of the transformer 13 is decreased.

The rate at which the charging and discharging of the condenser 20 (or 21) takes place may also be varied by manually adjusting a variable resistance 24 that is connected between the grid of the amplifying tube 19 and the negative side of the source of direct current S. In addition, a variable resistance 25 that is connected between the negative side of the source of direct current S and a control grid of the thyratron tube 22 may also be varied to regulate the voltage required for the thyratron tube to become conductive.

When the sheet material 10 consists of multiple plies with at least one of the plies being opaque, the plies must either be maintained in register during and following their perforation so that the perforations in the plies will be aligned as the plies pass between the photo-electric cell 14 and the lamp 15, or the opaque ply must be separated from the other plies before it passes between the photo-electric cell 14 and the lamp 15. As shown in Fig. 1, the plies of the sheet material 10 may be maintained in register while it is being perforated and as it passes between the photo-electric cell 14 and the lamp 15 by reeving the sheet material 10 around a pair of rolls 26 and 27 located in advance of the perforating electrodes and then around a pair of rolls 28 and 29 following its passage between electric cell 14 and the lamp 15.

An arrangement for separating a single ply of opaque material from the other plies of the sheet material 10 is illustrated in Fig. 3. In this arrangement, the lower plies of the sheet material 10 are separated from the top ply immediately following the perforation of the sheet material by passing these plies around rolls 30 and 31. The top ply, which in this case is the opaque ply, passes between the photo-electric cell 14 and the lamp 15 after which it passes around rolls 32 and 33 and rejoins the lower plies.

As illustrated in Figs. 4, 5 and 6, the plies of sheet material 10 may also be held in alignment by pins 34 that are carried on a roller 35 located in advance of the perforating electrodes. The roller 35 and the pins 34 carried thereon are positioned so that the pins will penetrate through the plies of the sheet material 10 and into a rubber roll 36. The distance between the pin-carrying roller 35 and the rubber roller 36 may be adjusted through a handwheel and gearing 37 associated with the pin-carrying roller. The pins 34 should be spaced about the roller 35 so that one or more of the pins are positioned at their maximum penetration through the sheet material while other pins are entering and still others are leaving the sheet material. The plies of a multiple ply sheet material may also be maintained in register by spot pasting the plies together when the sheet material is fabricated.

Fig. 2 illustrates a modification of the apparatus illustrated in Fig. 1. In this arrangement, after the moving web of sheet material 10 has been perforated, it passes between a pair of photo-electric cells 38 and 39 and their respective light lamps 40 and 41 directed through the perforations onto the respective photo-electric cells. The outputs of the photo-electric cells 38 and 39 are connected, respectively, through amplifying devices 42 and 43 to coils 44 and 45 of a double-throw relay 46. The photo-electric cell 38 is set so that when the amount of light transmitted through the perforations in the sheet material 10 by the light source 40 decreases (indicating a decrease in the porosity of the sheet material below a desired value) the coil 44 acts to close the relay contact 47 with a fixed contact 48. When the light transmitted through the perforations in the sheet material 10 by the light source 41 increases (indicating an increase in porosity of the sheet material above the desired value) the current from the photo-electric cell 39 causes the coil 46 to act to close the relay contact 47 with a second fixed contact 49.

The closing of relay contact 47 with the contact 48 when the porosity of the sheet material decreases completes a circuit through a control box 50 to a reversible electric motor 51 and causes the motor 51 to drive a worm 52 in a direction to decrease a variable resistance 53 that is in a circuit connecting an electric motor 54 to a source of electrical energy M. The electric motor 54 drives a commutator 55. The commutator 55 is connected in a circuit connecting the primaries of the transformers 13 to a source of direct current S' so that when the resistance 53 is varied in this manner, the speed of the motor 54 will be changed and the frequency of the pulsations of current flowing to the primaries of the transformers 13 will also be varied. If the speed of the motor 54 is increased, the frequency at which electric discharges between the electrodes 11 and 12 is increased and the total area of perforations and the porosity that is produced by such perforations in sheet material 10 is also increased.

The speed of the motor 54 will be gradually increased until the desired degree of porosity has been obtained and at that time contact between the relay contact 47 and the fixed contact 48 will be opened. If the porosity of the sheet material exceeds the desired value, then the current flowing from the photo-electric cell 39 energizes the coil 45 of the relay 46 and closes the relay contact 47 with the second fixed contact 49. This completes a circuit that drives the motor 51 and the worm 52 in the opposite direction increasing the resistance 53 in the circuit to the motor 54 and reducing the speed of the motor 54 and the commutator 55. This results in a decrease in the frequency at which discharges take place between the electrodes 11 and 12 and a reduction in the total area of the perforations in the sheet material.

It will be understood that various changes and modifications may be made in the embodiments of the invention that are illustrated and described herein without departing from the scope of the invention as defined by the claims appended hereto.

I claim:

1. The method of maintaining the porosity of an electrically perforated sheet material consisting of at least one opaque ply at a fixed value which comprises electrically perforating the sheet material by passing a moving web of sheet material between a set of opposed electrodes and periodically causing electrical discharges to pass between the electrodes and through the moving sheet material, directing a stationary beam of light against one surface of the moving web of the electrically perforated sheet material, measuring the amount of light from said beam passing through the moving perforations in the sheet material and varying the frequency of the periods during which electrical discharges are caused to pass between the opposed electrodes in response to deviations in the measured amount of light from the amount of light transmitted through electrically perforated sheet material having a porosity corresponding to the fixed value.

2. The method of maintaining the porosity of an electrically perforated sheet material consisting of at least one opaque ply at a fixed value as set forth in claim 1 wherein the frequency at which the electric discharges take place is varied electrically in response to deviations in the measured amount of light.

3. The method of maintaining the porosity of an electrically perforated sheet material consisting of at least one opaque ply at a fixed value as defined in claim 1 wherein the frequency of the electrical discharges is increased in response to a decrease in the measured amount of light from the amount of light passing through electrically perforated sheet material having a porosity corresponding to the fixed value and the frequency of the electrical discharges is decreased in response to an increase in the measured amount of light from the amount of light passing through electrically perforated sheet material having a porosity corresponding to the fixed value.

4. The method of maintaining the porosity of an electrically perforated, multiple-ply sheet material having at least one opaque ply at a fixed value which comprises electrically perforating the sheet material by passing a moving web of the sheet material between a set of opposed electrodes and periodically causing electrical discharges to pass between the electrodes and through the moving sheet material, directing a beam of light from a stationary source of light against one surface of the moving sheet material following its perforation and measuring the amount of light from said beam passing through the moving perforations in the sheet material, maintaining the plies of said moving sheet material in register during the movement of the sheet material between the electrodes and past the beam of light, and then electrically varying the frequency of the periods during which electrical discharges are caused to pass between the electrodes and through the sheet material in response to deviations in the measured amount of light from the amount of light transmitted through the perforations of a sheet having a porosity corresponding to the fixed value.

5. The method of maintaining the porosity of an electrically perforated, multiple-ply sheet material having at least one opaque ply at a fixed value which comprises electrically perforating the sheet material by passing a moving web of the sheet material between a set of opposed electrodes and periodically causing electrical discharges to pass between the electrodes and through the moving sheet material, separating the opaque ply from the other plies of the sheet material as the sheet material continues to move, then directing a beam of light from a stationary source of light through the moving perforations

in the separated opaque ply and measuring the amount of light passing through said perforations, and then electrically varying the frequency at which the electrical discharges take place between the electrodes in response to deviations in the measured amount of light from the amount of light transmitted through the perforations in a sheet of material having a porosity corresponding to the fixed value.

6. In an apparatus for maintaining the porosity produced by electrical perforations in sheet material having at least one opaque ply at a fixed value, the combination of a set of opposed electrodes between which a moving web of the sheet material is adapted to pass, means for delivering a pulsating electrical current to said electrodes, said current being of a voltage capable of causing an electric discharge to pass between said electrodes and through the moving sheet material, a source of light having a beam thereof directed against one surface of the moving sheet material, said source of light being located at a position following the passage of the sheet material between the electrodes, electrically responsive light-measuring means positioned on the other side of the sheet material to receive the light from said source passing through the moving perforations, and electrical means controlled by said light-measuring means for controlling the frequency of the pulsations of current delivered to the electrodes in response to variations in the measured amount of light passing through the perforations in the moving sheet material.

7. In an apparatus for maintaining the porosity produced by electrical perforations in sheet material having at least one opaque ply at a fixed value, the combination as defined in claim 6 which includes means for maintaining the plies of said sheet material in register during the movement of the sheet material between the electrodes and the source of light and the light-measuring means.

8. In an apparatus for maintaining the porosity produced by electrical perforations in sheet material having at least one ply of opaque material at a fixed value, the combination as defined in claim 6, which includes means for separating an opaque ply of the sheet material from the remaining plies following the passage of the sheet material between the electrodes and moving said ply between the source of light and the light-measuring means.

9. In an apparatus for maintaining the porosity produced in a sheet of opaque material by electrical perforations at a fixed value wherein a web of sheet material having at least one opaque ply is moved between at least one set of opposed electrodes and electrical discharges periodically pass between the opposed electrodes and through the moving web of sheet material, the combination which includes means for delivering a pulsating electrical current to the opposed electrodes, said current being capable of causing an electrical discharge to pass between the electrodes and through the sheet material, a source of light located at a point following said electrodes, said source of light being positioned to direct a beam of light against one surface of the moving web of perforated sheet material, light-measuring means located on the other side of the sheet material in opposed relation to the beam from the source of light, and means controlled by said light-measuring means for varying the frequency of the pulsations of electric current delivered to the electrodes in response to deviations of the measured amount of light from a fixed amount.

10. In an apparatus for maintaining the porosity produced in a sheet of opaque material by electrical perforations at a fixed value wherein a web of sheet material having at least one opaque ply is moved between at least one set of opposed electrodes and electrical discharges periodically pass between the opposed electrodes and through the moving web of sheet material, the combination as defined in claim 9 wherein the means for delivering a pulsating electrical current to the opposed electrodes includes a current conducting tube of the gas discharge type, and the means controlled by the light-measuring means for varying the frequency of the pulsations of the electric current includes an amplifier having its output connected to a control element of the current conducting tube.

11. In an apparatus for maintaining the porosity produced in a sheet of opaque material by electrical perforations at a fixed value wherein a web of sheet material having at least one opaque ply is moved between at least one set of opposed electrodes and electrical discharges periodically pass between the opposed electrodes and through the moving web of sheet material, the combination as defined in claim 9 wherein the means for delivering a pulsating electrical current includes an electric motor and a commutator driven by said motor and the means controlled by the light-measuring means for varying the frequency of the pulsations of the electric current delivered to the opposed electrodes includes a reversible electric motor connected to the light-measuring means and a variable resistance driven by said reversible motor, said resistance being connected in a circuit connecting the electric motor driving the commutator to a source of electrical energy.

12. In an apparatus for maintaining the porosity produced by electrical perforations in a multiple-ply sheet material having at least one opaque ply at a fixed value wherein a web of the sheet material is moved between at least one set of opposed electrodes and electrical discharges periodically pass between the opposed electrodes and through the moving web of sheet material, the combination which includes means for delivering a pulsating electrical current to the opposed electrodes, said current being capable of causing an electrical discharge to pass between the electrodes and through the sheet material, a source of light located at a point following said electrodes, said source of light being positioned to direct a beam of light against one surface of the moving web of perforated sheet material, light-measuring means located on the other side of the sheet material in opposed relation to the beam from the source of light, means controlled by said light-measuring means for varying the frequency of the pulsations of electric current delivered to the electrodes in response to deviations of the measured amount of light from a fixed amount and means engaging with the sheet material for maintaining the plies of the moving web of sheet material in register during the movement of the sheet material between the electrodes and between the light source and the light-measuring means.

13. In an apparatus for maintaining the porosity produced by electrical perforations in a multiple-ply sheet material having at least one opaque ply at a fixed value wherein a web of the

sheet material is moved between at least one set of opposed electrodes and electrical discharges periodically pass between the opposed electrodes and through the moving web of sheet material, the combination as defined in claim 12 wherein the means for maintaining the plies in register includes a pair of rolls about which the sheet material passes, said rolls engaging with the sheet material in advance of the opposed electrodes and a second set of rolls about which the sheet material passes, said second set of rolls engaging with the sheet material after its passage between the electrodes and between the light-measuring means and the source of light.

14. In an apparatus for maintaining the porosity produced by electrical perforations in a multiple-ply sheet material having at least one opaque ply at a fixed value wherein a web of the sheet material is moved between at least one set of opposed electrodes and electrical discharges periodically passs between the opposed electrodes and through the moving web of sheet material, the combination as defined in claim 12 wherein the means for maintaining the plies of the sheet material in register includes a set of rolls engaging with the sheet material, one of the rolls of said set having pin-like projections extending from its surface, said pin-like projections penetrating through the plies of the sheet material passing between the rolls.

15. In an apparatus for maintaining the porosity produced by electrical perforations in a multiple-ply sheet material having at least one opaque ply at a fixed value wherein a web of the sheet material is moved between at least one set of opposed electrodes and electrical discharges periodically pass between the opposed electrodes and through the moving web of sheet material,

the combination which includes means for delivering a pulsating electrical current to the opposed electrodes, said current being capable of causing an electrical discharge to pass between the electrodes and through the sheet material, means for separating the opaque ply from the remaining plies of the sheet material, said separating means engaging with the sheet material after its movement between the opposed electrodes, a source of light positioned to direct a beam of light against one surface of the moving perforations in the separated opaque ply, light-measuring means located on the other side of the opaque ply in position to receive the light transmitted by said beam through the moving perforations in the opaque ply, and means controlled by said light-measuring means for varying the frequency of the pulsations of electric current delivered to the electrodes in response to deviations of the measured amount of light from a fixed amount.

EDWARD W. MENKE.

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