

Nov. 11, 1969

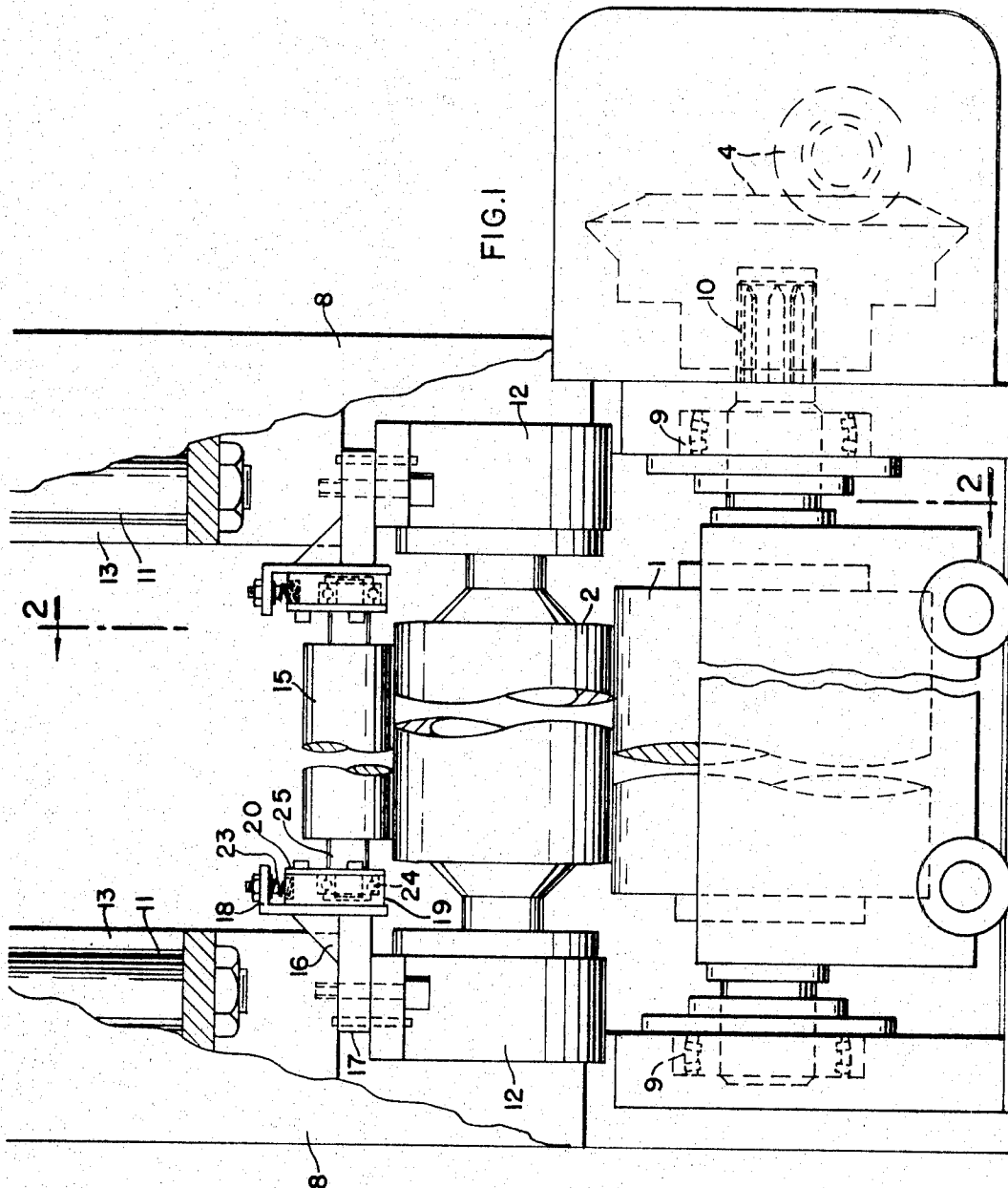
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3,477,369

ELECTROSTATICALLY ASSISTED INTAGLIO PRINTING

Filed May 4, 1967

5 Sheets-Sheet 1



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5 Sheets-Sheet 2

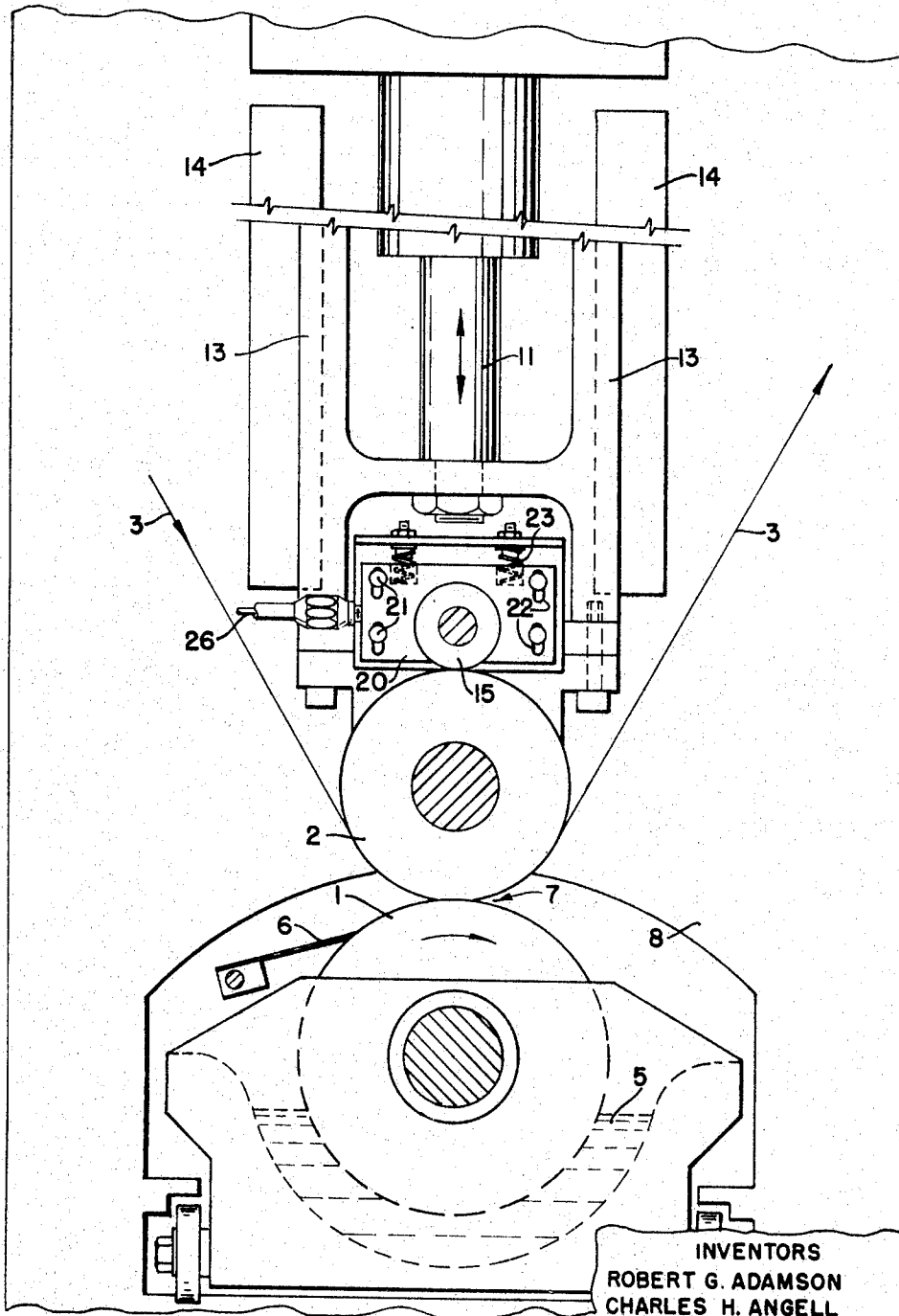


FIG. 2

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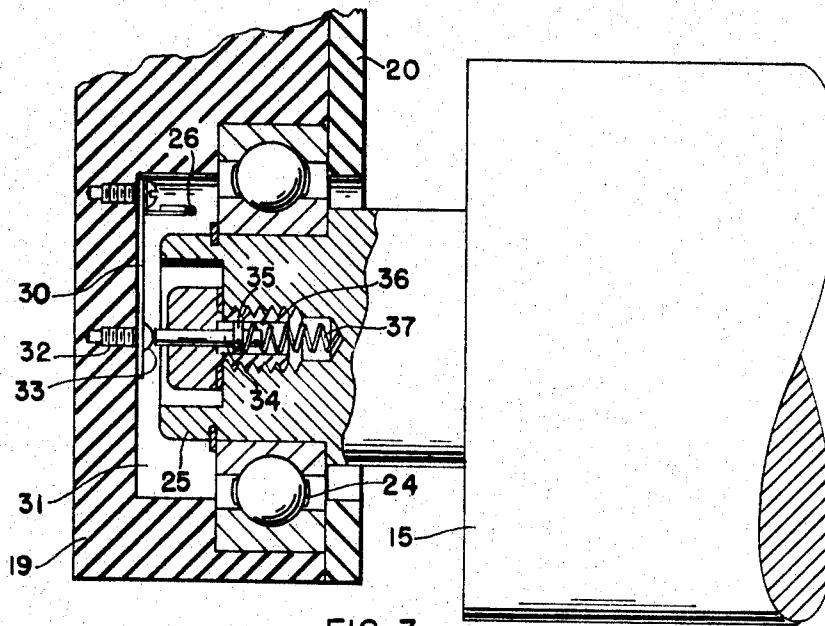
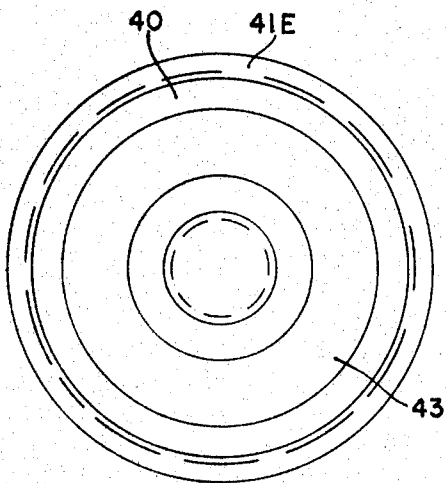
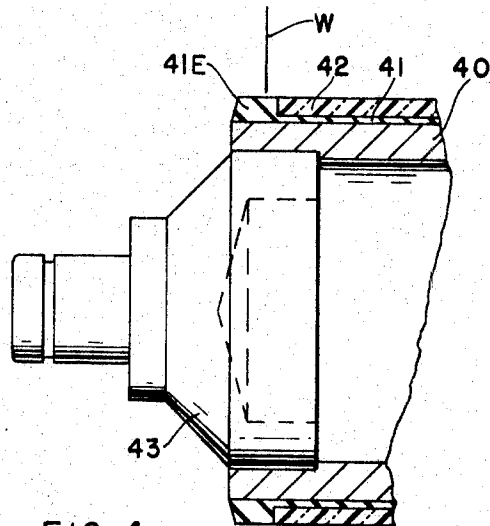
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5 Sheets-Sheet 4

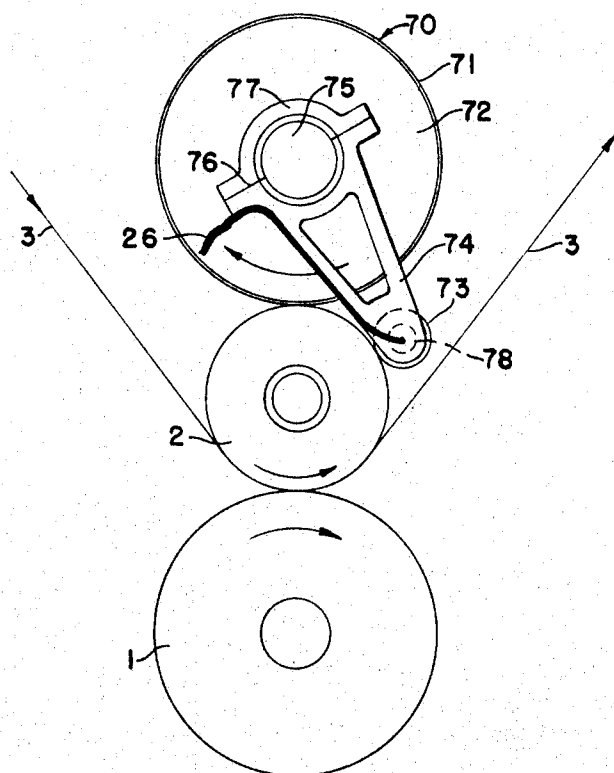


FIG. 7

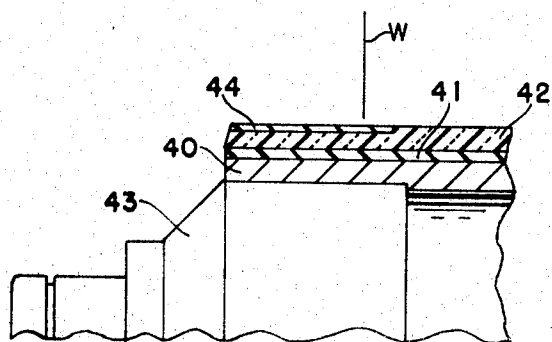


FIG. 6

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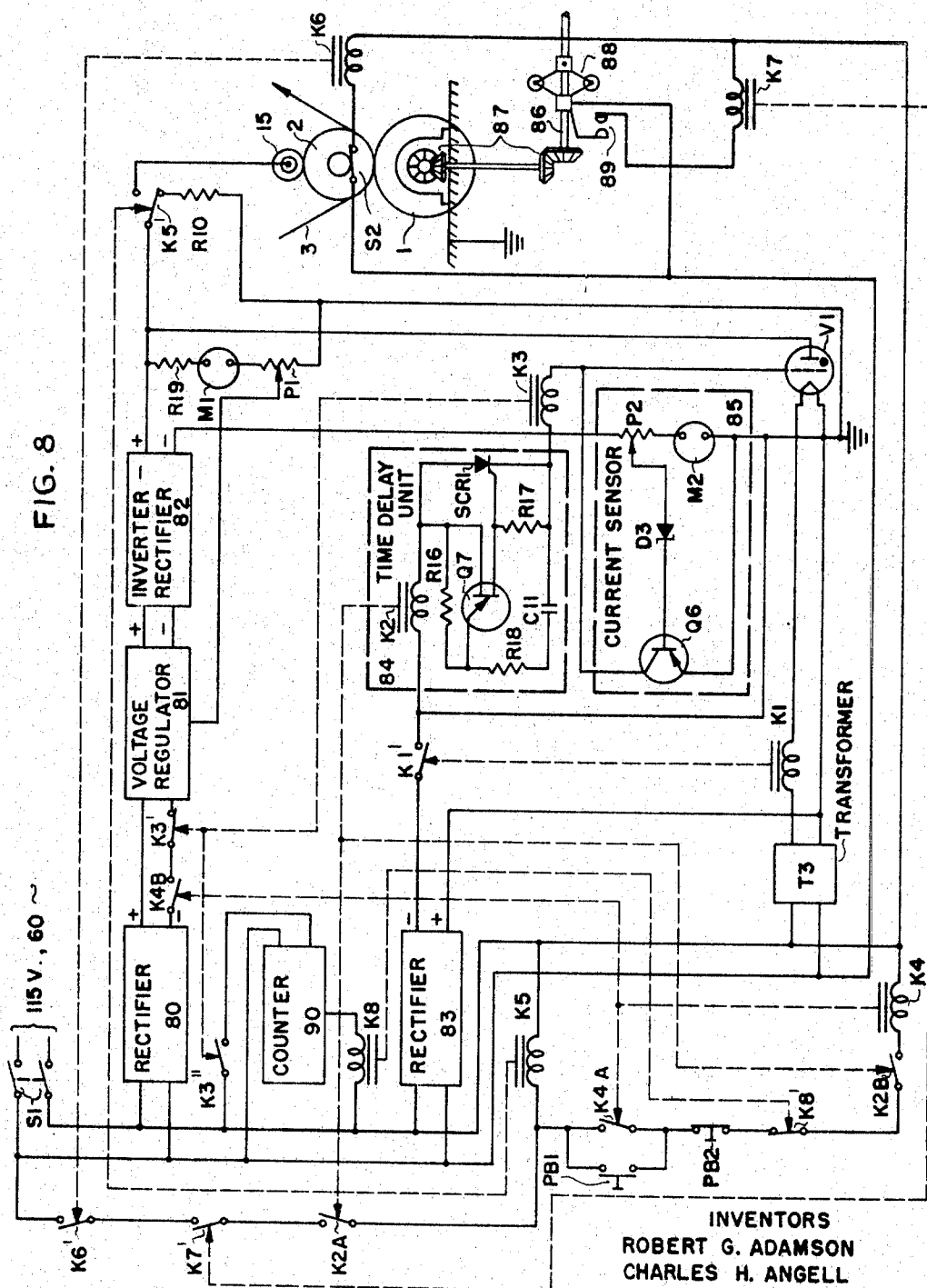
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5 Sheets-Sheet 5

FIG. 8



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3,477,369

ELECTROSTATICALLY ASSISTED INTAGLIO PRINTING

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6 Claims

ABSTRACT OF THE DISCLOSURE

The invention is directed to means for electrostatically assisting the transfer of ink from a pattern thereof on a printing cylinder to a web of substantially non-conductive material, such as paper, paper board, plastic film and the like, as the web passes between and in contact with the printing cylinder and an impression cylinder.

A covering of electrically conductive, resilient material is provided on the cylindrical surface of the impression cylinder, and a layer of electrical insulating material is disposed between said conductive covering and the cylindrical, metallic body of the impression cylinder. A source of relatively high voltage current is provided and connected with an electrically conductive member which is insulated from short circuiting the current to ground and which bears directly upon said conductive covering on the impression cylinder, thus establishing a difference in potential from said covering, through the web to the printing cylinder, which is grounded, to polarize the ink on the printing cylinder and attract it to the web.

The invention also provides safety devices for preventing the further flow of current from said source to said conductive member when it reaches a preselected value and for preventing current flow to the conductive member until the impression is made and the printing and impression cylinders have reached a predetermined rotational speed. Current flow to the conductive member is also discontinued automatically in case of a break in the web.

When the length of the printing and impression cylinders exceed the width of the web, a relatively thin covering of high dielectric material may be provided over the portion or portions of said conductive covering on the impression cylinder which extend beyond one or both edges of the web and, preferably, such portion of the conductive covering is thinner than the remaining portion covered by the web, by an amount equal to or slightly more than the thickness of said dielectric material.

When an additional, relatively rigid metal cylinder is required to back up the impression cylinder and prevent its flexing, the cylindrical surface of the back-up cylinder is also covered by a relatively thin coating or sheet of high dielectric material.

The printing industry has long sought an effective and economical method and means of printing by applying an electrostatic charge to pigmented fluid and attracting it to a running web of paper or the like to form a predetermined, repetitive, pigmented pattern on the web. Most of the efforts along these lines have undertaken to avoid the use of a printing impression (i.e., positive physical contact between the web and a printing cylinder or similar element carrying the pigment) and have undertaken to attract the pigment to the web through a small air gap ionized by an electrostatic charge. Such concepts do not lend themselves to the use of liquid inks or dyes but require relatively light and finely divided dry pigments having low cohesive and adhesive properties, so that they

will flow readily and can be attracted to the web across the air gap. While some experimental progress has been made along these lines, such methods have had little or no commercial impact in publication and package printing, primarily because of their experimental nature, questionable advantage over conventional printing and the highly special and rather costly and complex equipment required.

Recent experimental work and tests, initiated by the Gravure Research Institute and continued by the firm to which this application for Letters Patent is assigned, have been directed along lines quite different from those above mentioned. This work has contemplated utilization of the many hundred existing high-speed, web-fed presses in use, without extensive or costly modification, and the use of conventional liquid inks and commonly used grades of paper, paperboard, plastic film, and laminates of such materials. It deliberately makes use of a printing impression or "nip" which induces some transfer of ink to the web as it is propelled between an impression cylinder and a conventional printing cylinder which carries the inked pattern to be applied to the web. However, it permits the use of lighter impression pressures than normally required in conventional printing, since the ink transfer is materially augmented and improved by the application of an electrostatic charge.

In accordance with the features of the present invention, a source of relatively high voltage, low amperage direct current is provided. A terminal of one polarity (preferably but not necessarily the positive pole) is connected and supplies regulated electrical energy to an outer covering of conductive, resilient material provided on the impression cylinder. This conductive outer covering is prevented from short-circuiting the current to the frame of the press or to other conductive structure by a layer of dielectric material provided between the cylindrical metal shell or core of the impression cylinder and the aforesaid outer covering. The metal printing cylinder is grounded (or connected to that terminal of the power supply of opposite polarity to that connected to said conductive outer covering), so that a difference in potential is established between the impression and printing cylinders through the web which is in contact with both cylinders. The resulting electrostatic charge applied to the ink, in the pattern thereof on the printing cylinder, attracts it to the web and materially improves its transfer.

In a conventional web-fed printing press, the printing and impression cylinders normally rotate at relatively high speed. The printing cylinder is journaled in bearings mounted on or in the frame of the press, which, in the practice of the invention, adequately grounds this cylinder, so that it is convenient to employ this arrangement, leaving the printing cylinder at ground potential. This necessitates applying a positive charge on the impression cylinder and, to establish a difference in potential through the web to the printing cylinder, the charge on the impression cylinder must not be dissipated to ground via its metal core or shell, shafts and bearings, and the frame of the press or other supporting structure.

Conventionally, the impression cylinder shafts are journaled in a vertically movable, metal framework which slides on ways which are a part of the press frame. This presents a serious problem in establishing the necessary difference in potential between the impression and printing cylinders, and preventing short-circuiting of the charge applied to the impression cylinder. It is overcome in the present invention by making the resilient outer covering of the impression cylinder electrically conductive, insulating this covering from the metal shell or core of the cylinder, and applying the charge directly to the surface of the conductive covering. In the preferred em-

bodiment of the invention, this is accomplished by providing an idler roller, bearing directly on the conductive outer covering of the impression cylinder at a location circumferentially displaced from the nip between the impression and printing cylinders. This relatively light-weight idler roller is journaled in suitable bearings carried in spring-loaded mounting blocks secured to but electrically insulated from the aforesaid sliding framework in which the impression cylinder is journaled. Thus the idler roller moves up and down with the impression cylinder as the latter is lifted and lowered to part or make the impression.

The above described and other details of the invention, including the means by which the idler roller is connected with the power supply, are illustrated in the accompanying drawing, which will be later described.

While some or all of the features of the invention will be found advantageously applicable to other than rotogravure printing, such as stereotype or letterpress, planographic or offset, flexographic (formerly known as aniline printing) and the various hybrid forms such as letter-set or dry offset, gravure offset, etc., they are particularly desirable in intaglio or gravure printing and the subsequent illustrations and description will be addressed primarily to this type of operation.

Intaglio or gravure printing is particularly needful of the subject system because of the difficulty often encountered, in conventional practice, of adequately and uniformly emptying the small etched or engraved cells which make up the dot structure of the pattern in which the ink is carried. This difficulty causes what are known as skipped dots in the printed pattern on the web, particularly in lightly pigmented and delicately shaded areas of the copy. This may also be quite noticeable in darker and denser areas. The augmented ink transfer accomplished with the subject system largely overcomes this difficulty and results in greatly improved appearance of the printed copy.

On relatively rough stocks, such as uncoated and lightly calendered or uncalendered papers produced from ground wood pulp, for example, and also on the typically rough surfaced and relatively unyielding paper boards widely used in package printing, the improvements resulting from use of the subject system are surprisingly noticeable, even to the unpracticed eye. Both monotone and multi-color work are materially improved. Greatly improved results are obtained on practically any type and grade of printing stock, and the system has the advantage of providing good reproductions on cheaper stocks than would otherwise be required for acceptable work. It also permits the use of lighter impression pressures than otherwise normally required for acceptable printing. The use of lighter impression pressures saves wear, maintenance and replacement of bearings and other load-carrying members, and prolongs the useful life of both the printing cylinders and the resilient covering of the impression cylinders.

Initial attempts to assist gravure printing by the use of an electrostatic charge were rendered hazardous by fact that gravure inks are light (e.g., of relatively low viscosity) compared with those used in other types of printing, and normally contain a high percentage of flammable hydrocarbon solvents of low volatility. Numerous fires were encountered and, in the absence of precautionary measures, it is possible to cause an explosion. Purging systems, intended to keep the hydrocarbon-air mixture in the vicinity of the impression below flammable proportions, sometimes aggravate rather than help the situation, presumably on account of the turbulence created in this area. However, we have found that the ignition hazard can be avoided by limiting the current drawn at the nip or impression to a low value of the order of 1.5 to 3 milliamperes. To insure that it does not exceed a safe value, provision is made in the power supply circuit provided by the invention, for quickly shorting the output of the power supply to ground

when the current drain reaches a predetermined, adjustable maximum value.

The invention also incorporates other safety features which will be described in conjunction with the accompanying drawing.

In the accompanying diagrammatic drawings, FIG. 1 is an elevational view shown, partially in cross section, of one printing unit of a rotogravure press incorporating the invention.

FIG. 2 is a sectional elevation of the same press unit, taken along line 2—2 in FIG. 1.

FIG. 3 is an enlarged detail, shown partially in cross section, of one end of the conductive idler roller, and its bearing and bearing housing.

FIG. 4 is an enlarged longitudinal view, shown partially in cross section, of an end portion of the impression cylinder in FIGS. 1 and 2.

FIG. 5 is an end view of the impression cylinder shown in FIG. 4.

FIG. 6 is an enlarged detail, shown principally in cross section, of an end portion of an impression cylinder provided with a modified form of the dielectric and resilient conductive coverings shown in FIG. 5.

FIG. 7 illustrates the general arrangement of a printing cylinder, impression cylinder, back-up cylinder, and the idler roller on a printing unit utilizing the invention.

FIG. 8 is a circuit diagram of the power supply and associated elements provided by the invention.

In FIGS. 1 and 2, the substantially conventional portions of the rotogravure printing unit here illustrated comprise a printing cylinder 1 and an impression cylinder 2, between and in contact with which the web 3 to be printed upon is propelled in the direction indicated by the arrows. The printing cylinder is driven through suitable gearing indicated at 4 in FIG. 1, and its lower portion is immersed in a pool 5 of ink. An intaglio pattern of the printing to be applied to the web is normally etched into the gravure printing cylinder and consists of closely-spaced minute depressions or cells which are substantially filled with ink as the printing cylinder passes through the pool. Since the entire cylindrical surface of the gravure cylinder is wetted with ink by immersion therein, the excess (i.e., that not contained in the intaglio pattern) is wiped or "doctored" from the cylinder by a doctor blade 6 before it reaches the impression or nip, indicated at 7, formed between the printing and impression cylinders.

A portion of each of the side frames of the press is indicated at 8. The gravure cylinder 1 is journaled at its opposite ends in bearings 9 in such manner that the assembly, including the cylinder 1, bearings 9, bearing housings, and splined shaft 10, which connects the cylinder with the drive gearing, may be readily removed for replacement or reworking of the cylinder to apply a different pattern of printing.

To assist removal and replacement of the gravure cylinder and, when desired, the impression cylinder as well, the latter is lifted by suitable double-acting hydraulic cylinders attached to shafts 11, but not shown in the drawing. The hydraulic cylinders also lower the impression cylinder and exert pressure between the printing and impression cylinders in the nip area 7 when the impression is "made" (i.e., when the impression cylinder is down). At times during operation of the press and for a variety of reasons, the impression may be parted by lifting the cylinder 2, as, for example, while the web is being threaded through the press or in case of a web break. This permits rotation of the gravure cylinder to keep it wetted and prevent drying of the ink thereon while there is no web passing through the impression and, otherwise, until it is desired to start printing.

To accommodate lifting and lowering of the impression cylinder, it is journaled at its opposite ends in suitable bearings, not shown, contained within the bearing housings 12 which are detachably secured to a framework 13 to which the shafts 11 are attached. This frame 13 slides

vertically on ways 14 which are a part of or are secured to the press side frames 8.

The arrangement illustrated and above described, or its functional equivalent, is employed on all web-fed, roto-gravure presses and a similar arrangement is used on most other types of web-fed presses.

Since, in conventional practice, the entire printing press is mounted on a heavy foundation of reinforced concrete and the framework, cylinder shells, shafts, bearings, gearing, etc., are constructed of steel or other metals or alloys, the entire structure is electrically conductive and is at ground potential. The features of the present invention which will now be described are designed to obviate the difficulties, arising from this conventional printing press construction, in undertaking to apply a controlled electrostatic charge in the nip area and in reducing or eliminating the hazard of fire and explosion when vapors from the ink may create this hazard.

In the embodiment of the invention shown in FIGS. 1 and 2, an electrically conductive idler roller 15, is attached to the sliding frame 13 to which the impression cylinder 2 is also secured, so that the roller 15 bears directly upon the surface of the impression cylinder and moves with the impression cylinder as the latter is lifted and lowered. The means of such attachment here illustrated (see FIG. 1) include a mounting bracket 16, one portion 17 of which is interposed between the bearing housing 12 for the impression cylinder 2 and the sliding frame 13, these members being firmly bolted and pinned together, as shown. Another portion of the mounting bracket 16 is an angle-shaped member 18 in which a bearing housing 19 is slidably mounted by means of the shoulder bolts 21 and slots 22 (see FIG. 2). The bearing housing 19 is spring-loaded, as indicated at 23, to urge it into firm contact with the impression roller 2. This housing 19 and its cover 20 cage the bearing 24, into which the shaft 25 of the idler roller extends and, to electrically insulate the idler roller from the press frame, these members 19 and 20 are made of material having good dielectric properties. Suitable materials for this purpose, which combine sufficient tensile and compressive strength with dielectric properties, include laminated fabrics impregnated and bonded with phenolic resins, tempered hardboard, and other materials having similar properties.

It will be understood that a mounting such as above described is provided at each end of the idler roller. From at least one of these assemblies, a wire or similar electrical conductor, covered with high tension insulation and indicated at 26, is connected to the positive terminal of a power supply such as shown in FIG. 8. Within the assembly this conductor is connected, as indicated in FIG. 3, with another conductor 30 secured to the bearing housing within a cavity 31 provided in the housing on the outboard side of bearing 24. A drive screw 32, in the case illustrated, secures one end of conductor 30 to housing 19, in line with the axis of rotation of the idler roller 15, and has a wear-resistant head 33 of hardened steel or hard chrome-plated steel, for example. The head 33 bears upon a spring-loaded electrically conductive plunger 34 which is retained by shoulder 35 in a bolt 36 drilled to receive the plunger 34 and spring 37. Preferably, plunger 34 is made of or plated with copper, silver, or other highly conductive, relatively soft metal which will form good contact with the button or head 33. The head of bolt 36 is recessed in the counterbored end of shaft 25 and a tapped hole in the shaft retains the threaded portion of the bolt. This or other functionally equivalent arrangement is employed to conduct current from the power supply to the idler roller as the latter is rotated by its contact with the rotating impression cylinder.

Friction and wear between the conductive element and the surface of impression cylinder 2 are minimized by the use of a roller as the conductive element. We do not wish to limit the invention to this arrangement nor to the specific construction shown and described, since other means

of applying current from the power supply to the impression roller will be readily apparent. However, a construction and arrangement of this general nature, which provides rolling contact with the surface of the impression cylinder, is preferred.

Referring to FIGS. 4 and 5, the cylindrical metal shell of the impression cylinder 2 is indicated at 40 and is closed at each end by members which include the bearing journals, one of these members being shown at 43.

Extending over the length of the metal shell and bonded thereto is a layer 41 of material of good dielectric strength which insulates the shell from the outer conductive covering 42. The insulating layer may be a compound of natural rubber, one of the synthetic elastomers or suitable thermoplastic insulation, preferably of the type and grade used for high tension insulation on wires and cables. It is selected for good bonding to the shell 40, which is ordinarily steel, as well as to the resilient conductive covering 42 and for good dielectric strength, preferably in a thickness of the order of $\frac{1}{8}$ " to $\frac{3}{8}$ ".

The resilient outer covering 42 is preferably a compound of rubber or other elastomer containing sufficient carbon black, or the like, to give it an electrical conductivity of the order of 10^4 to 10^8 ohm-centimeters and having a durometer reading of from about 60 to about 90 by the Shore A scale.

In general, aside from having reasonable conductivity, the resilient covering 42 may have other properties substantially corresponding to the resilient impression roll covering conventionally employed on the particular press with which it is used. As in conventional practice, this material may be built up (laminated) to a thickness of from $\frac{3}{8}$ " to $\frac{7}{8}$ " from sheet material of lesser thickness, with the laminations vulcanized or otherwise bonded to form a homogenous covering. The outer surface is carefully ground, usually with a slight crown at the center, tapering evenly to the ends of the cylinder. A substantial thickness of the order of $\frac{3}{8}$ " to $\frac{7}{8}$ " permits several regrindings when the surface begins to deteriorate due to prolonged use or damage.

It will be noted that, as shown in FIG. 4, the end portions 41E of the dielectric layer 41 are thicker than its intermediate portion, these ends being ground to the same outside diameter as the outer covering 42. The reason for this is that the impression cylinder and the printing cylinder are usually somewhat longer than the widest web which the press is intended to handle. By making the length of the conductive covering 42 slightly less than the web width (say about $\frac{1}{2}$ " less), it will be completely covered by the web under normal conditions and the insulated end sections 41E, which extend beyond the edges of the web, will prevent short circuiting of the charge in the conductive covering to ground by contact with the bare end portions of the printing cylinder. In FIG. 4, the approximate position of the edge of the web is indicated by the line W.

As an alternative to the use of insulated end sections 41E, or in case a web of less than maximum width is sometimes employed, a construction such as illustrated in FIG. 6 may be used. In FIG. 6, the metal shell of the impression cylinder is again designated as 40, the dielectric layer 41 and the conductive outer covering 42. The approximate position of the adjacent edge of the web is again indicated by the line W. In this embodiment, the conductive covering 42 preferably is undercut on its outer surface for a distance extending slightly say $\frac{1}{4}$ " to $\frac{1}{2}$ ", inside the length which will be covered by the web and over this undercut portion a relatively thin covering 44 of material of high dielectric strength is applied. This material may conveniently be a seamless sleeve of one of the substances, such as fluorocarbon resins, for example, which can be slipped over the end of the cylinder and shrunk securely in place by the application of heat.

Of course, an insulating covering, such as shown in FIG. 6, may also be used in combination with a section

41E such as shown in FIG. 4. In either case, the depth of the undercut in the outer layer 42 preferably is the same or slightly more than the thickness of the dielectric covering 44, after the latter is in place on the cylinder, so that it is unnecessary to grind the covering 44 to the same outside diameter as the covering 42. In some instances a good grade of electrical tape may be wrapped about the end of the cylinder without undercutting the covering 42, providing the compressibility of the materials at the thus covered ends of the cylinder permit sufficient impression or nip between the impression and printing cylinders in the area covered by the web.

Many printing presses designed to accommodate web widths greater than about 48", for example, avoid the necessity of employing the massive and rigid impression cylinder construction, which would otherwise be required, by providing a relatively heavy, rigid back-up roller to prevent flexing of the impression cylinder. The primary reason for this is that the impression cylinder must occasionally be removed for replacement and/or regrinding of the resilient covering and it is desirable to keep the cylinder light enough to permit ready removal and handling. A back-up cylinder, on the other hand, ordinarily does not have to be removed and can be of solid construction, similar to calendar rolls used in paper-making. FIG. 7 diagrammatically illustrates the normal cylinder arrangement in a press employing a back-up roller.

In applying the subject system to a press having the cylinder arrangement shown in FIG. 7, the back-up roller 70, which is of heavy metal and, therefor conductive, is given a coating 71, on its cylindrical surface, of dielectric material which insulates the metal core or shell 72 to prevent current leakage or short circuiting from the impression cylinder.

In FIG. 7, the printing cylinder, impression cylinder, and the web are designated by the same reference numerals as used in the other figures of the drawing, namely 1, 2, 3, respectively. The impression cylinder may be covered in the same manner as above described in connection with FIGS. 4 and 5, or as described in connection with FIG. 6. However, since the back-up roller occupies a position on the impression cylinder diametrically opposite the position of the printing cylinder, the conductive idler roller, which in this case is designated as 73, occupies a different position and is conveniently mounted in a different manner, as will be later described.

Since the back-up cylinder 70 is difficult to remove from the press, the dielectric coating 71 is preferably painted or sprayed on this cylinder while it is in place, when the subject system is applied to an existing press of this construction. Suitable liquid coatings, which may be sprayed or brushed onto the surface of the back-up cylinder and cured to a well-adhering film by heating or by catalytic action, are available from several sources under different trade names. Usually, these are epoxy resins to which a suitable catalyst is added before application. Such materials are particularly suitable for the purpose here intended, because they readily bond to the metal cylinder, have good dielectric properties, and are resistant to the solvents used in gravure inks.

A suitable alternative coating for the back-up cylinder, which also may be applied with the cylinder in place in the press, consists of two or more wrappings of plastic film having good dielectric strength. At least two such wrappings are recommended in order that the ends of each wrap may be butted and the abutted joints in alternate wraps displaced from each other about the circumference of the cylinder. Tetrafluoroethylene and similar fluorocarbon resins in sheet form are examples of such material.

In the case illustrated in FIG. 7, the idler roller 73 is supported on arms 74, disposed at opposite ends of the roller, and pivoted about the end shafts 75 of the back-up roller 70. The hub of each of the arms 74,

which bears upon the shaft 75, is preferably divided, as indicated at 76, to accommodate a removable cap 77, which is secured to the other portion of the hub by bolts, not shown. This construction, or its equivalent, permits mounting the idler roller on the press without removing the backup roller. The weight of the arms 74 and the idler roller will normally be sufficient to hold the idler roller in firm contact with the resilient, conductive surface of the impression cylinder 2, and when mounted as shown, with reference to the direction of rotation of the back-up roller, this will also assist in maintaining good contact between idler roller 73 and impression cylinder 2.

A suitable end closure, indicated at 78, at one or both ends of the idler roller shaft, accommodates a contact arrangement of the same general type shown in FIG. 3, to which the conductor 26 from the power supply is attached.

Referring now to FIG. 8, which is essentially a circuit diagram, it also shows in diagrammatic form the printing cylinder 1, impression roller 2, web 3, and idler roller 15, to indicate how the circuit between these elements and the source of power for the subject system is connected and completed. Certain elements and sub-assemblies in the circuit of the power supply and its associated parts are of well-known construction and they function, individually, in a well-known manner. To avoid unnecessary complexity in the diagram, these well-known subassemblies are shown in block form.

Readily available A.C. line current (such as 115 v., 60 cycle, for example, although other voltages and frequencies may be used) is supplied to low-voltage, full-wave rectifier 80 having, for example, an output of +50 volts D.C. This low-voltage D.C. is supplied to the voltage regulator 81, which is essentially a three-stage transistor amplifier with an internal source of reference voltage, such as a battery, and a regulating feedback which will be later described. The regulated low-voltage D.C. output is fed to the D.C.-to-D.C. transistor inverter-rectifier 83, where, in accordance with well-known practice, the low voltage DC. input is first converted into high-frequency, high-voltage square waves, in the inverter section. The inverter-rectifier assembly also contains a bridge-type rectifier section wherein the high-voltage square waves from the inverter section are converted to high-voltage direct current.

The positive output side of the inverter-rectifier is connected, as diagrammatically shown in FIG. 8 and described in more detail with reference to FIG. 3, to the idler roller 15. The negative side of the inverter-rectifier output is connected to ground through potentiometer P2 and meter M2. The printing cylinder 1 is also grounded to complete the circuit and provide energy for electrostatically assisting the transfer of ink as previously described.

The circuitry provided and illustrated in FIG. 8 makes provision for the following automatically-controlled safety features:

(1) Temporarily interrupting operation of the system whenever the load which it imposes on the power supply exceeds a preselected safe limit.

(2) Discontinuing operation of the system until it is intentionally started after clearing the difficulty, when it imposes a persistent or frequently recurring load on the power supply.

(3) Preventing operation of the system until the press reaches a predetermined operating speed (i.e., cylinder r.p.m. or linear web speed).

(4) Preventing operation of the system until the impression is made (i.e., the impression cylinder has been brought into firm contact with the printing cylinder).

The aforementioned safety provisions and their mode of operation are explained in conjunction with the following description of the sequence and mode of operation of the circuit components.

The aforementioned A.C. supply line has a main disconnect switch S1 and, with this switch closed, the line is connected with the low-voltage A.C.-to-D.C. rectifier 80. The supply line is also connected with another rectifier 83 of the same type to provide -20 volts D.C., for example, which is used as will be later described. Also, the A.C. power line is connected with a transformer T3 which provides a suitable filament voltage to the Thyatron tube V1.

As current flows through the Thyatron filament circuit from transformer T3, the current sensitive relay coil K1 is energized. This closes the corresponding contacts K1¹ of the relay to connect the negative side of the output from rectifier 83 with the time delay unit 84, which functions in the following manner to prevent energization of the rest of the system until the filament of the Thyatron tube warms up and renders this tube operative.

With contacts K1¹ closed, the capacitor C11 in the time delay unit starts charging from voltage drawn through relay coil K2 and the resistors R16 and R18. As soon as the voltage of capacitor C11 has risen to a sufficient value to cause the unijunction transistor Q7 to conduct, the resulting positive pulse of voltage generated at its unijunction base is applied to the gate of SCR1, turning it on. Conduction through SCR1 permits sufficient voltage to be applied to relay coil K2 to cause operation of this relay, closing its contacts K2A and K2B in a branch of the A.C. supply line. Until this happens, the pushbutton PB1, the relay contacts K6¹ and the relay contacts K7¹ in the aforesaid branch line are rendered ineffective to close the circuit of this branch line by virtue of the open contacts at K2A and K2B.

The function of the momentary contact pushbutton PB1 is to initiate the system operation, but until relay contacts K2A, K2B, K6¹ and K7¹ are all closed, no energy can be transmitted through the branch line in which these contacts are located, and the pushbutton PB1 remains ineffective. The manner in which contacts K2A and K2B are closed has been described above. The manner in which contacts K6¹ and K7¹ may also be closed, so that the system operation can be initiated by pushbutton PB1, will now be described.

When the impression cylinder 2 is lowered into contact with the printing cylinder, as shown at the right hand side of the diagram, the contacts of limits switch S2 will close. This causes power from the A.C. supply line to energize relay coil K6, closing the corresponding contacts K6¹.

After the press is started in the usual manner, not illustrated, the printing cylinder is accelerated to the desired running speed through the drive shaft 86 and the conventional gearing indicated diagrammatically at 87. A suitable speed sensitive switch which, for the sake of simple illustration, is here shown as a device 88 similar to a flyball governor attached to drive shaft 86 and having contacts 89, closes these contacts when cylinder 1 reaches a predetermined speed. Closing contacts 89 completes the circuit through relay coil K7, energizing the same to close the corresponding relay contacts K7¹.

With relay contacts K2A, K2B, K6¹ and K7¹ all closed, the impression between cylinders 1 and 2 will have been made, the cylinders will be rotating at the desired speed and the time delay unit 84 will have functioned to insure that the Thyatron V1 is ready to operate. The system is thus ready to start supplying power to the idler roller 15. By then manually operating pushbutton PB1, to close its contacts, this will complete the closing of the entire series of contacts in the branch A.C. supply line and relay coil K4 will energize to close the contacts K4A and K4B. Contacts K4A remain closed after pushbutton PB1 is released, thus keeping the aforesaid branch line conductive until the stop button PB2 is pushed or one of the series of other contacts in the branch line drop out.

When contacts K4B close, the D.C. output from rectifier 80 enters the voltage regulator 81 and the latter supplies

its regulated output to the inverter-rectifier 82. Meanwhile, since contacts K2A, K6¹ and K7¹ have closed, the relay coil K5 has become energized to close its contacts at K5¹, which connects the positive output terminal of the inverter-rectifier with the idler roller 15. Its corresponding negative terminal is connected to ground, as will be later described, to complete the circuit from the inverter-rectifier through the idler roller 15, web 3, and printing cylinder 1 to ground, and return to the inverter-rectifier.

A portion of the positive output from the inverter-rectifier is lead to ground through resistor R19, microammeter M1, which measures voltage, and potentiometer P1. A sample voltage, the value of which depends upon the setting of wiper arm of potentiometer P1 and which is positive with respect to ground, is picked from the potentiometer and fed back to the voltage regulator 81. Here the sample voltage is compared in a bridge circuit with the aforementioned reference voltage in the regulator and this comparison initiates an impedance change in the input to the inverter-amplifier from the regulator to bring the sample and reference voltages to equilibrium. Thus, changing the setting of the wiper arm of the potentiometer P1 changes the proportion of the voltage fed back to the regulator and causes the latter to alter its high voltage output to the idler roller 15. Meter M1 indicates the voltage level selected.

Preferably, the voltage to the idler roller 15 may be adjusted over a wide range, to accommodate printing stocks of different resistivity, depending upon the caliper (thickness), structure, etc. For example, uncalendered newsprint of about 32 to 34 pounds basis weight may require only about 800 volts into the idler roller to obtain good ink transfer. On the other hand, paperboard of from 20 to 40 mils thickness may require from 2,000 to 5,000 volts.

The negative output terminal of the inverter-rectifier is connected to ground through potentiometer P2 and meter M2. Since all load current flows through this circuit, meter M2 monitors the actual current drawn by the system and applied to the printing operation. To prevent this current from reaching a dangerously high level, which can happen, for example when web 3 breaks or when holes in the web pass through the impression, provision is made for limiting the current drawn by the idler roller 15 and shorting the inverter-rectifier output to ground if and when the current level becomes excessive. To accomplish this, part of the voltage drop across potentiometer P2 is picked off by the wiper arm and applied to the current sensor 85. The current sensor functions as follows.

If and when the current flowing through potentiometer P2 reaches a level at which the voltage at the wiper arm setting exceeds the threshold voltage of the Zener diode D3, to which this pick-off voltage is applied, the transistor Q6, to which the diode is connected as shown, conducts and grounds the grid of Thyatron V1. This causes the Thyatron to conduct heavily (crowbar) and effectively short circuit the high voltage output of the inverter-amplifier to ground through the Thyatron.

In addition, when transistor Q6 conducts to trigger the Thyatron, the coil of relay K3 will be energized to open the relay contacts K3¹ and interrupt the rectified low voltage supply to the voltage regulator. This, of course, turns off the inverter-rectifier and, when its high voltage output decays to zero, Thyatron V1 ceases to conduct, no current passes through the current sensor 85 and, with relay coil K3 thus de-energized, relay contacts K3¹ drop back to closed position. If the cause of the amperage surge has meanwhile been corrected or cleared, the system is then back in operation. If the fault persists or is repeated, the above described cycle is repeated.

When relay coil K3 is energized, relay contacts K3¹¹ are closed to connect a counter 90 with the A.C. supply line. Counter 90 is of the type which closes an internal contact when a selected count is reached and counts one

digit each time relay contacts K3¹¹ close. When the count reaches the preselected number, say three or five, for example, the internal contact completes the circuit from the A.C. supply line through relay coil K8, energizing the same to open the normally closed contacts K8¹ in the branch A.C. supply line. This de-energizes relay coil K4, causing contacts K4A and K4B to open and thereby discontinuing the operation of the system until pushbutton PB1 is manually operated. Thus, if there is a persistent heavy drain of current or this condition is repeated for a number of times corresponding to the preselected number on the counter, the current supply to the idler roller is discontinued until operation is intentionally renewed, giving the operator an opportunity to find and correct the difficulty. When desired, a warning, such as a light or audible signal, may be turned on automatically when the counter reaches the preset count, and/or operation of the press may be stopped automatically.

Since the Thyatron tube V1 is depended upon to ground the output of the inverter-rectifier in the event of an excessive current drain, provision is made for de-energizing the system in case the Thyatron filament fails. In this event, the current through relay coil K1 collapses, causing contacts K1¹ to open and disconnect the time delay unit 84 from the rectifier 83. This de-energizes relay coil K2, causing its contacts K2A and K2B to open, thus de-energizing relay coil K4 and opening its contacts K4A and K4B, which shuts down the system and returns all circuits to their initial inoperative condition.

It should be noted that, in FIG. 8, all relay contacts are shown with the corresponding coils in de-energized condition.

While the foregoing description and the drawings deal with only a single printing unit, it will be apparent that, on multiple unit presses, the subject system may be applied to all printing units or to as many as desired. It will also be apparent that numerous modifications of the specific embodiments illustrated and described may be made without departing from the spirit, scope and teachings of the invention.

We claim:

1. Means for assisting the transfer of ink, carried in an intaglio pattern on a metal printing cylinder, to a web of substantially non-conductive material as the latter passes through a nip between the printing cylinder and a resiliently covered metal impression cylinder, comprising the combination of:

an outer covering of resilient material on said impression cylinder having a resistivity of the order of 10⁴ ohm-centimeters to 10⁸ ohm-centimeters, the external peripheral surface of said outer covering contacting the substantially non-conductive material of the web at the nip between the printing cylinder and the impression cylinder,

a layer of dielectric material having a resistivity substantially greater than that of said outer covering disposed between said outer covering and the metal of said impression cylinder,

an electrically conductive contact element in physical contact with the external peripheral surface of said outer covering of said impression cylinder at a region about the periphery of said impression cylinder remote from said nip, and

an electric circuit connected with said electrically conductive contact element for applying a direct current electrical potential between said electrically conductive contact element and said printing cylinder with

the potential applied by said contact element being transmitted by electric current flow in a circumferential direction through the material of said outer covering of said impression cylinder from the portion of said outer covering instantaneously in contact with said contact element to the portion of said outer covering instantaneously in contact with the substantially non-conducting material of said web at the nip, said layer of dielectric material insulating said outer covering from the metal of said impression cylinder and the applied potential maintaining said outer covering and said printing cylinder at opposite polarities to charge the ink in said pattern to a polarity opposite to that of said outer covering for attraction of the ink to the web at the nip between the printing cylinder and the impression cylinder.

2. The combination of claim 1 with a transistor circuit having an input connected to said electric circuit for receiving an input signal in accordance with the current drawn at the nip between the printing cylinder and the impression cylinder and having an output for supplying an output signal when the current drawn at the nip exceeds a preselected value, and means connected with the output of said transistor circuit and controlled by said output signal therefrom to discontinue the flow of current to said outer covering when the current drawn at the nip exceeds said preselected value.

3. The combination of claim 1 with thyatron means connected to said electric circuit and shiftable to a conductive state to discontinue the flow of current to said outer covering, and a current sensor responsive to current flow in said electric circuit and controlling conduction of said thyatron means, said current sensor including Zener diode means receiving an input voltage proportional to current flow in said electric circuit and having a threshold voltage which must be exceeded before the thyatron means is shifted to its conductive state.

4. The combination of claim 1 with said electric circuit having means for limiting the current drawn at the nip between the printing cylinder and the impression cylinder to a value of the order of 1.5 to 3 milliamperes.

5. The combination of claim 4 with said electric circuit applying an electrical potential of about 800 volts between said electrically conductive contact element and said printing cylinder.

6. The combination of claim 4 with said electric circuit applying an electrical potential of about 2,000 volts between said electrically conductive contact element and said printing cylinder.

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