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(54) **Imaging method, apparatus, and product.**

(57) A method for generating a latent image on a substrate surface using a low current (e.g., less than about 2×10^{-3} amperes), non-pulsating electrical discharge. The method may be used, for example, to image lithographic plates, with a resolution of approximately 1,000 lines/inch, directly from a digital source of image data. The discharge is confined within a thin stream of a relatively inert gas (48) which is directed at the plate surface (20) with a velocity of at least about Mach 0.05.

EP 0 167 352 A2

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Croydon Printing Company Ltd.

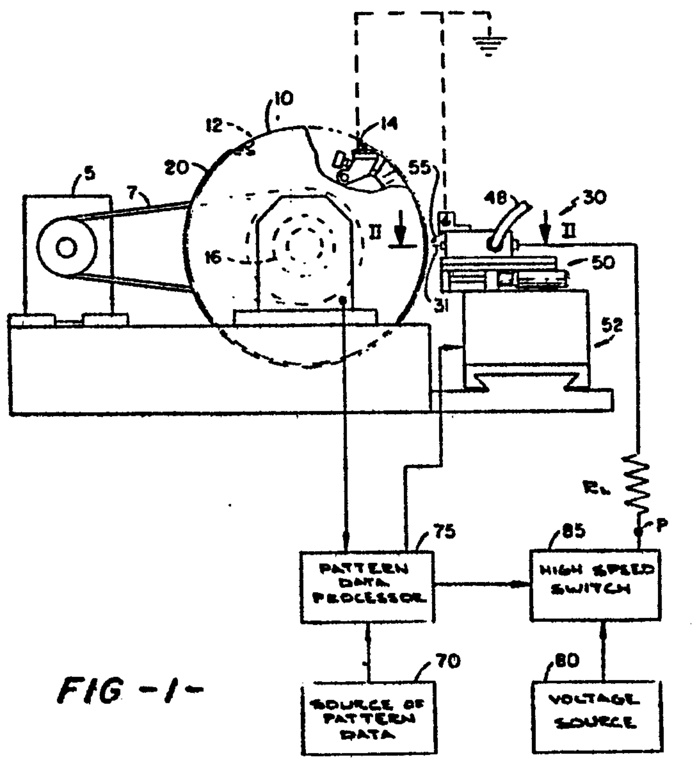

PATTERN DATA PROCESSOR
HIGH SPEED SWITCH
SOURCE OF PATTERN DATA
VOLTAGE SOURCE

FIG -1-

IMAGING METHOD, APPARATUS, AND PRODUCT

This invention relates to an improved method and apparatus for imaging a substrate having a coating thereon which is transformable by means of a relatively low current electrical discharge, and the product produced thereby. More particularly, this invention relates to a method and apparatus whereby commonly available diazo-type lithographic printing plates may be electronically imaged inexpensively and with relatively high resolution, and subsequently used in conventional lithographic printing processes without requiring a photocomposition or photo-typesetting step.

BACKGROUND OF THE INVENTION

In most lithographic printing systems in use today, the lithographic printing plate is imaged by means of a photographic process during which a photographically-generated film positive or negative transparency carrying the desired image is first prepared and then projected onto or exposed in contact with the light sensitive surface of the plate. In certain systems the plate may be exposed directly by the original copy without the need for an intermediate film transparency (i.e., by reflection), but such systems still require the initial preparation of "camera-ready" copy.

Attempts have been made to eliminate the need for art and copy preparation, as well as the need for various photoconversion process steps, by generating an image carrier, i.e., an imaged lithographic printing plate, directly from electronically stored or generated data. Such systems may, for example, rely upon a laser beam which impinges upon a light sensitive plate surface, or rely upon an electrical spark or arc, or other source of energy, which removes one or more layers of material from the surface of a lithographic-type plate, often a plate having a special construction, or may use electrostatic charges to define the desired image.

Lithographic plate imaging systems of these types frequently have significant shortcomings, among the most significant being one or more of the following: the relative complexity and therefore high cost and low reliability of the apparatus necessary to implement these systems, the high cost of the specially formulated and prepared unimaged lithographic plates which generally must be used in such systems, or the generally low quality of the resulting printed image generated by plates which have been imaged by such systems.

Other known processes invented by others include a process which provides an efficient, inexpensive system for generating, for example, an image of high quality on a variety of relatively inexpensive diazonium resin lithographic plates of conventional design, without the need for specialized plate coatings, or the need for photocomposition, "camera-ready" art or copy preparation, or photoconversion steps, and preferably using image data which is electronically generated or stored. In this previously known process, which is the subject of our copending European Patent Application No. 84 304105.4 (published as EP 0130028) by F. S. Love, a relatively low current electrical discharge is used to produce a latent image capable of conventional image development on the plate surface by inducing a chemical change in the material found on the face of the plate (which may be a photopolymer or other plate, although diazonium resin-type plates are generally preferred) which changes the relative solubility of the plate coating in the areas traced by the discharge, without displacing or removing significant quantities of the coating material as is usually done with spark-type systems, and without relying upon photo-induced processes commonly encountered in laser systems.

A limitation of this previously known process is an inability to generate line segments or dots of good print quality having a width or diameter smaller than about 4 to 5 mils. In other words, by using the process disclosed by Love, one is limited to generating images of good visual quality having an effective print resolution of approximately 200 lines per inch. The process is capable of generating images having higher resolution, up to about 300 to 400 lines per inch, but only with a dramatic decrease in image quality, i.e., irregular line widths and edges, unintended breaks in line segments, missing image dots or groups of dots, etc. The imaging speed (i.e., speed at which the stylus sweeps over plate areas to be imaged) is relatively slow in the process disclosed by Love and would be a substantial limitation in many commercial situations.

The method and apparatus of the invention disclosed herein overcomes the limitation on effective print resolution, and at the same time increases the imaging speed. In but one of several embodiments, this invention comprises contacting an unimaged printing plate with a low current, localized type electrical discharge which is aligned within a thin stream of a relatively inert gas, whch is directed at the plate surface with a velocity of at least about Mach 0.05.

Utilizing the teachings of this invention, the full scope of which will be better understood upon reading the description herein below, latent images on many diazonium resin or other plates may be generated which contain line segments or dots having a width or diameter of approximately 1 mil, which therefore makes possible lithographically printed images having an effective print gauge of approximately 1000 lines per inch. It has been found that the method and apparatus of this invention result in a low current electrical discharge which is much more localized than that of the process disclosed by Love. Because of this increased localization, it is believed the resulting electrical discharge is significantly more intense with respect to the area of discharge contact on the plate surface. It is therefore possible to increase the speed at which the discharge is made to sweep over the plate surface with no significant degradation in image quality. It is believed the relative linear speed of the discharge over the plate surface can be increased by a factor of ten or more when compared with the relative linear speeds possible using the teachings of Love.

A detailed description of the invention follows, in which yet other features and advantages of this invention will become apparent, and in which reference is made to the Figures summarized below.

Figure 1 schematically depicts an apparatus which may be used to image a printing plate, in accordance with the teachings of this invention.

Figure 2 is a section view of the apparatus shown in Figure 1, taken along the lines II-II, showing details of the stylus assembly;

Figure 3 is an enlarged section view of the tip of the stylus depicted in Figure 2;

Figure 4 is a section view of the stylus assembly of Figure 2, taken generally along the lines IV-IV;

Figure 5A is a diagrammatic enlarged section view of the tip of the stylus of Figure 3, showing the "diffuse" electrical discharge effect described herein;

Figure 5B is a diagrammatic section view of the tip of the stylus of Figure 3, showing the localized, non-pulsating electrical discharge effect described herein;

Figures 6A through 6D are generalized plots showing the parameter regions in which the various discharge effects are observed;

Figure 7 is a schematic diagram of a switching circuit which may be used in connection with this invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

An apparatus and process embodying this invention as applied to plates commonly used in conventional offset lithography are schematically depicted in Figure 1. Roll 10 serves as a support for conventional lithographic plate 20. Appropriate securing means 12, 14 may be employed to attach plate 20 securely to roll 10 during the imaging process described below. Means 12, 14 may be any means capable of attaching and holding a lithographic plate of conventional design on a roll surface, such as, for example, means employing an array of tapered pins as is used by many offset lithographic press manufacturers to attach and secure lithographic plates having a row of holes for accommodating the pins along each end. It is preferred that the plate itself be at least moderately electrically conductive, so that the plate may be electrically grounded during the imaging process. To facilitate the grounding arrangement, means 12, 14 may be designed to afford a grounding path from plate 20, as, for example, by electrically grounding roll 10 and ensuring that means 12, 14 are in electrical contact with both the roll 10 and the conductive plate 20. Other arrangements for electrically grounding plate 20 may be used as well.

To facilitate placing the desired latent image on the roll, roll 10 may be rotated by means of motor 5 and belt drive 7. Angular displacement sensor 16 may also be associated with roll 10. Such sensor may be used to indicate the precise rotational position of roll 10, and is particularly desirable if the pattern is to be placed on the plate automatically by electronic means, as is discussed below.

Opposite the surface of roll 10 and plate 20 is positioned an electrical imaging assembly, shown generally at 30. In the embodiment depicted in Figures 1-4, assembly 30 comprises an electrode or stylus 31 for establishing an electrical discharge within a discharge region between electrode or stylus 31 and the opposing surface of plate 20, gas supply line 48 for supplying the discharge region with a gas in the manner disclosed herein, and ionization promotion means 55 directed into the discharge region between the tip of stylus 31 and the opposing surface of plate 20. A primary function of electrical imaging assembly 30 is to establish and interrupt, or modulate, in accordance with externally supplied pattern information, a particular kind of localized electrical discharge within the region between the surface of plate 20 and the tip of stylus 31 which is capable of forming a latent image on the surface of plate 20 in accordance with the teachings herein. Imaging assembly 30 is described in more detail below.

Stylus 31 is a hollow needle-like shaft having an internal bore diameter of between about 0.001 and about 0.008 inch, through which an inert gas may be directed at velocities greater than about Mach 0.05. Stylus tip radii within the range of about .002 inch to about .004 inch have been used with success, although tip radii outside this range may be advantageous in certain applications. Stylus 31 may be constructed of any suitable electrically conductive material.

As depicted in Figures 2 through 4, stylus 31 may be constructed from a disposable steel needle 32 of the kind normally associated with a hypodermic syringe, which has been modified by securely fitting a section of tubing of the appropriate dimensions within the distal end of needle 32. Such attachment may be made by adhesive bonding, soldering, brazing, welding, etc. If necessary, tubing of the appropriate inside diameter may be made by crimping tubing having a larger than desired inside diameter about a solid wire having the desired diameter, and retracting the solid wire. Stylus 31 may be partially encased in a block of protective, electrically insulating material, depicted at 35 in Figures 2 and 4, to electrically isolate and facilitate handling and positioning of the stylus tip. Block 35 in turn is secured within stylus assembly block 40.

As depicted in Figures 2 and 4, block 40 has a channel 44 of circular cross section which extends through the central portion of the block. This channel is sized so as to snugly accommodate collar 42 associated with needle 32. If desired, block 40 may be made in the form of two or more mating sections of acrylic plastic or other suitable material. Screw 38 may be used to provide electrical connection, via tab 39, between stylus 31 and an appropriate electrical source, discussed in more detail below. As is apparent from the Figures, one end of channel 44 houses stylus 31 and its associated fittings. The opposite end of channel 44 is securely connected, by means of fitting 46, to a source, not shown, of an ionizable gas which is at some pressure above atmospheric and which is relatively inert with respect to the plate surface in the absence of an electric discharge. Among others, commercially available relatively inert gases intended for spark chamber applications have been found generally suitable and satisfactory. Such gases can have helium and neon as principal constituents. The presence of oxygen in the discharge gap appears to inhibit the imaging process of this invention. Generally speaking, a relatively uniform gas pressure sufficient to generate a stream of ionizable gas through stylus 31 at a velocity within the range of about Mach 0.05 to about Mach 0.4 or higher is desired; it is contemplated that stream velocities of up to about Mach 0.9, or perhaps even higher, may be used.

The tip of stylus 31 is preferably positioned radially perpendicular to the surface of plate 20, at a distance ranging from about 0.001 inch to about 0.010 inch, via micrometer stage 50, although it should be emphasized that distances outside this range are known to be operable. Hereinafter, the immediate region between the tip of stylus 31 and the opposed surface of plate 20 shall be referred to as the discharge gap. To facilitate scanning of the stylus across the face of plate 20, the stylus may be attached to a translating stage 52 capable of precisely controllable motion along the rotational axis of roll 10; data specifying the relative position of stage 52 is preferably made available to a pattern data processor 75 to facilitate the relative positioning of stylus 31 over the surface of plate 20 and to assure proper synchronization of the flow of pattern data to the stylus to maintain accurate image re-creation on the plate surface.

Ionization or breakdown promotion means 55 may be any means which is found effective in promoting electrical breakdown of the gas in the discharge gap. It is believed that use of such means 55 can minimize certain time lags associated with electrical discharges in gases by acting as a source or generator of free electrons or negative ions which initiate the subsequent secondary ionization processes ultimately responsible for the avalanche behavior leading to breakdown. By use of such means 55, the time lag between the application of the requisite electrical potential between the stylus and the plate and the establishment of the particular kind of electrical discharge utilized in this invention may be reduced dramatically. It should be noted that the voltage necessary to initiate such breakdown is lowered by the action of means 55 as well. In one embodiment of the invention, means 55 may be a shielded corotron device, comprising a short section of tungsten wire positioned within a semi-cylindrical, electrically grounded shield, similar to that commonly employed in electrostatic copying machines as an ion source for charging the xerographic plate. Alternatively, a relatively low-powered ultraviolet light source directed into the discharge region may be used, as is depicted at 55 in Figures 2 and 4. Optionally, no ionization or breakdown promotion means need be employed.

It is believed that the electrical discharge phenomenon utilized in this invention is separate and distinct from the arc or spark discharge phenomenon described generally in the literature. Much of the literature addresses electrical discharge phenomena which occur at low or extremely low pressures, and wherein a relatively large anode is positioned at a substantial distance from a relatively large cathode. In the instant invention, however, the electrical discharge may occur at or near atmospheric pressure, and occurs between a needle-like stylus and a substantially flat plate, with a gap spacing of only perhaps 0.001 to 0.010 inch or so. Typical time-averaged electrical current values may range from about $2x10^{-6}$ amperes to about $2x10^{-3}$ amperes, although operation above this range, but below the spark discharge regime, may be preferred under some conditions. With commonly available diazonium resin plates, time averaged current values within the range of from about $2x10^{-5}$ amperes to about $2x10^{-3}$ amperes have been found to be preferable. It is therefore not possible to directly correlate some of the physical parameter values recited herein with all references found in the literature. It appears clear, however, that electrical arcing, as the term is generally understood in the electrical discharge art, is not involved. Arcs may be generally categorized as high current electrical discharges, involving currents greater than one ampere or so, rather than the relatively low time-averaged currents discussed herein. (See e.g., Gaseous Electronics, Volume I, Edited by Hirsh and Oskam, pages 294-295)

It is also believed that the electrical discharge phenomenon utilized in this invention is distinct from the electrical discharge phenomena described by Love. By using the voltages, gap sizes, and gas-introduction techniques taught by Love, the resulting electrical discharge creates a bright glow region within the discharge gap which, when viewed with the aid of a microscope, has a generally outwardly flaring cross section (measured perpendicular to the axis of the stylus), as depicted in Figure 5A. The glow region generally contacts the plate surface in an area which is substantially larger than the cross-sectional area of the stylus, and appears somewhat diffuse. Furthermore, the voltage measured between point P of Figure 1 and ground with the aid of an oscilloscope during such discharge may be seen to have a small oscillating component which causes the observed waveform to have a distinct sawtooth appearance, with the sawtooth component having a frequency within the range of about 20 kHz to about 200 kHz, and an amplitude on the order of 10 volts or less. This type discharge may therefore be described as visually diffuse and electrically pulsating.

It has now been discovered that the introduction of a gas in accordance with the teachings herein, e.g., via the bore of perpendicularly-oriented hollow stylus 31, when employed with the other process parameters disclosed herein, can cause the electrical discharge utilized by Love to undergo a change in which the width or cross-sectional area of the observed glow region within the discharge gap, when viewed with the aid of a microscope, appears to shrink both abruptly and dramatically, resulting in a much more localized electrical discharge which appears to emanate principally from within the distal end or bore of stylus 31 and which has a distinct, bright non-flaring "core" as depicted in Figure 5B. The resulting glow region appears to maintain a generally uniform diameter as it progresses toward the plate surface; the area of the plate surface which appears to be contacted by the electrical discharge is therefore approximately equal to the area of the bore of stylus 31. Additionally, the voltage measured between point P (Figure 1) and ground with the aid of an oscilloscope during such discharge contains no observable pulsations or sawtooth-like components. This localized discharge is significantly different than the diffuse discharge observed using the teachings of Love even with coaxial feeding of the gas, as depicted in Figure 5A, wherein the discharge flares outwardly from the stylus tip to the plate surface, and wherein the central bright "core" flares outwardly as well, resulting in a discharge "footprint" on the plate which is substantially larger than the area of the bore of stylus 31. This difference is believed to result in an ability to image a plate using a localized-type discharge, as described above, with a resolution totally beyond that available using the teachings of Love, as well as an ability to image a plate using much higher relative tracing speeds between stylus and plate surface (i.e., significantly less "exposure" time to the influence of the discharge is required to bring about the changes in the plate surface necessary to generate a latent image) than is possible with the diffuse-type discharge techniques taught by Love.

Figures 6A through 6D diagrammatically illustrate the different discharge effects which have been observed with the apparatus depicted in Figure 1. These graphs represent generalizations of experimental plots of applied voltage, measured from point P (Figure 1) and ground, versus gap size, obtained with a hollow stylus having an inside diameter of 0.002 inch and using helium gas at the indicated flow rate. As may be seen, for voltage levels below a certain minimum threshold, no discharge of any kind is observed regardless of gap size (Region I). Increasing the voltage results in the establishment of a diffuse-type discharge, and increasing gap size generally dictates increasing the gap voltage to maintain the discharge (Region II). Increasing the voltage above a second threshold value while maintaining a small gap spacing results in the abrupt transition of the discharge from the diffuse type to the localized type (Region III).

The relative voltage values "A" and "B" indicated in Figure 6A represent operating points which may be used to take advantage of the speed at which this abrupt transition takes place in controlling the pattern or image imparted to the plate. First a roll speed is chosen which is slow enough to permit a localized type discharge to induce the necessary insolubilizing effect on the plate, yet fast enough to render the diffuse type discharge totally ineffective in imaging the plate. One may then set the relative voltage levels so that a non-imaging diffuse type discharge is present at all times (i.e., at voltage level "B") except when an image is to be formed, at which time a voltage pulse at voltage level "A" is used to form an image by initiating an abrupt transition from the diffuse type discharge to the localized type discharge.

It is believed that introduction of the thin gas stream into the discharge region and against the plate surface area to be imaged need not be coaxial with the stylus or electrode, although this is a preferred embodiment. Within broad limits, the electrical discharge appears to follow preferentially the flow of gas, even if the path of the gas stream is not along the line defining the shortest distance between the stylus tip and the plate. It is believed this is due to the fact that the ionization potential within the gas stream is significantly lower than the ionization potential in the ambient air surrounding the gas stream, thereby making ionization within the gas stream much more likely. It is therefore foreseen that, under certain conditions, the stylus and the means by which the thin gas stream is introduced and directed onto the plate may be separate structures mounted independently in proximity to the discharge gap, and need not be mounted perpendicularly to the surface of the plate. Of course, if high resolution is desired, it is important that the cross-sectional area of the gas stream, as it contacts the plate, be minimized. It is therefore generally preferred that the means for delivering the gas to the discharge region be capable of forming the gas into a fine stream having an appropriately small cross-sectional area, and having the requisite velocity, i.e., a velocity above about Mach 0.05, and preferably subsonic. In general, stylus bore inside diameters within the range of about 0.002 to about 0.004 inch are preferred, which in turn generate correspondingly thin gas streams; bore diameters outside this range may be used so long as gas velocities of at least about Mach 0.05 are generated.

It is believed the electrical discharge utilized in this invention is not sufficiently intense to remove significant or substantial quantities of the plate coating. No physical change in the underlying plate surface is observed. The nature of the transformation mechanisms involved are not known. To what extent the same chemical reactions which occur in conventional imaging (e.g., photographic) processes occur during the imaging process of this invention is not known; it merely appears that the post-treatment behavior of the resulting latent image is generally similar, although not always identical, to that of a conventionally imaged plate. It is believed the electrical discharge forms a stream of ions which are directed into the plate coating, and that the fast moving stream of gas serves to "contain" or "direct" the ions in a stream which is more concentrated or focused, or less diffuse, than the ion stream generated using the teachings of Love. The interaction of these ions with the chemical compunds in the coating is believed to cause a chemical transformation in the coating which modifies the relative solubility of the coating. The term "insolubilizing effect" is used herein to mean the chemical (or whatever other) effects which such discharge treatment has on these plates which permit such plates to be developed and used in a manner similar to conventional plates which have been exposed or imaged by conventional (e.g., photographic) methods.

Current limiting resistor 60 may be used to prevent the electrical current between the stylus 31 and the surface of plate 20 from becoming excessive. Excessive current can result in the transition of the discharge phenomenon between stylus 31 and plate 20 from the normal low current electrical discharge used in this invention to the arc discharge behavior described in the literature. Excessive current can also result in the undesirable rearrangement or removal of substantial portions of the coating on the surface of plate 20. The use of a current limiting resistor prevents the discharge current from approaching values which would characterize an arc-type discharge. Because increasing the time-averaged current within the discharge gap also tends to increase the width of the image lines (see Example IV), changing the value of such resistor allows for adjustment of the width of the lines appearing on the resulting imaged plate. Line width may also be adjusted by varying the cross-sectional area of the gas stream, the speed of the plate surface relative to the stylus, etc., if desired.

The blocks designated 70, 75, 80, and 85 collectively comprise electronic circuitry which expedite the generation of a latent image on the surface of plate 20 in a timely manner from electronically stored, generated, or transmitted pattern data. Block 80 schematically depicts a voltage source adapted to provide voltages within the range of about 200 to about 2000 volts, at current levels within a range of between about $2x10^{-6}$ and about $2x10^{-3}$ amperes. Block 85 depicts a high speed switch capable of switching the voltage generated by the voltage source 80 at the frequencies necessary for the desired image resolution or print gauge. The necessary switching frequency is, of course, a function of the speed at which the surface of plate 20 is traced over or scanned by stylus 31, the desired image resolution, as well as other factors, such as the delay between the application of the requisite voltage and the initiation of the desired electrical discharge. It has been found that, for imaging small (e.g., 10 x 15 inch) lithographic plates at a roll circumferential speed of about 72 inches per second and a print gauge of about 1,000 lines per inch, switching frequencies within the range of about 0 to about 72 kilohertz are necessary.

An example of one circuit which may be used in this application is shown schematically in Fig. 7. The circuit operates as follows: Data input at nodes A, B in the form of a train of +5 volt pulses are shifted from a ground reference to a bias voltage reference across nodes C, D by voltage level shifter 100. MOSFET Q2 then amplifies the output of level shifter 100, relative to the bias voltage. This results in a signal $\mathcal{V}_{GD}$ wherein the +5 volt data pulses are now on the order of +400 volts, referenced to the +250 volt bias voltage. MOSFET Q2 acts as a voltage follower, decoupling the output of MOSFET driver Q1 from the discharge gap and load resistor R_L. Voltage $\mathcal{V}_{JF}$ represents the buffered, amplified, shifted data output of high speed switch 85. The output voltage of approximately 650 volts is divided between current limiting resistor R_L and the gap formed between the stylus tip and the plate surface.

The circuit depicted in Fig. 7 may be any by which a logic signal of modest voltage (e.g., 5 volts) from the pattern generation means may be impressed upon a relatively high voltage d.c. bias (e.g. 300 volts). For example, an optical coupler such as that available from Texas Instruments (of Dallas, Texas) as Model TIL 111 may be used. Use of such a bias scheme permits the stage shown in Figure 7 to achieve switching of approximately 900 volts (to ground) with only about 600 volts across the output transistors.

The pattern data processor represented by block 75 represents the means by which the required switching instructions dictated by the pattern data from block 70 are sent to the high speed switch 85 so that the desired pattern data is synchronized with the appropriate relative location of the stylus on the face of plate 20, and in registry with the latent image previously generated on the face of plate 20, thereby resulting in the proper switching of the electrical discharge from the diffuse mode of Love to the localized mode disclosed herein, and vice versa, as the stylus sweeps over the areas of the plate intended to carry the pattern. Any suitable means for generating or retrieving such instructions may be employed. Pattern data of course may be generated manually, but in most situations electronic generation or retrieval of pattern data or switching instructions is preferred, for example, through the use of analog or digital data storage means such as magnetic or paper tape, a ROM, RAM, or EPROM, a bubble memory, etc. Appropriate data from the angular displacement sensor 16 associated with roll 10 may be input to processor 75 to facilitate the necessary task of converting the pattern data to a series of switching instructions to switching means 85, and translating instructions to translating means 52 which will result in a train of correctly timed and sequenced electrical discharges of the desired type between stylus 31 and the relatively moving face of plate 20.

It is contemplated that, in addition to merely generating a series of "on-off" switching instructions which would sequentially establish and extinguish the electrical discharge in digital fashion in rigid accordance with pattern data, one may wish to modulate the electrical discharge by varying the discharge current over a range of values which lie substantially within the discharge current envelope recited herein. The range of values may be defined by a series of pre-determined discrete levels, or, alternatively, may employ a more-or-less continuum of values within pre-determined limits. In either case, the desired result is the ability to vary the effective area in which the latent image-forming chemical transformation takes place within the surface of plate 20 traced by the stylus, and thereby vary the effective resolution or effective print gauge of the imaging process. Generally speaking, lower time-averaged current values result in narrower lines formed on the plate surface. By employing this method for discretely or continuously modulating the current associated with establishing or maintaining a low current electrical discharge, latent images containing well-formed lines or dots having a wide range of widths or diameters are possible. For example, dots of excellent quality and uniformity having diameters of approximately one mil have been produced on ordinary diazonium resin plates by using a localized-mode discharge, as taught herein (see Example I). Furthermore, one or more dots of almost any desired diameter within the range of the system may be generated, without the need for having to limit dot size to one of a relatively few available choices, or having to build larger "dots" from the massing or aggregation of smaller dots of uniform size, as is done in many conventional laser systems. Such capability is advantageous in producing latent images wherein extremely fine detail or half-tone graphics are desired.

While the plates suitable for use with this invention are conventional, photosensitive lithographic plates which may be imaged by conventional methods using a high intensity light source, it is believed that the light produced by the low energy electical discharge employed in this invention does not contribute substantially to the imaging process. The intensity of the light given off by the electrical discharge employed herein is quite modest by conventional plate exposure standards. The apparent diameter of the visible electrical discharge is comparable to the resulting line width which is produced by the discharge. No masking of nonimaged areas from the light generated from the discharge appears to be necessary. Sharp, microscopically well-defined boundaries may be observed between those lines traced by the electrical discharge and areas immediately adjacent to such lines, which areas have been exposed to the light of the discharge, but not to the discharge itself. It is believed the experiment described in Example V indicates that the light of the discharge is not a principal or primary contributor to the insolubilizing effect which the discharge is observed to have on conventional diazonium resin plates.

Following the operation of one embodiment of this invention, pattern data information generated or stored in data source 70 is fed to pattern data processor 75, which receives the instructions along with data on the rotational position of roll 10 from angular displacement sensor 16. Processor 75 then generates two sets of instructions. One set of instructions is sent to translating stage 52 to assure correct placement of the imaging stylus along the axis of roll 10. A second set of instructions is sent to high speed switch 85 to generate the train of voltage pulses necessary to establish the sequence of electrical discharges which serve to image the plate with the desired pattern information.

The current sent from switch 85 passes through R_L, a load resistor which serves to limit the direct current delivered to stylus 31, which stylus may be precisely spaced from the surface of plate 20 by means of a micrometer assembly 50 or other means. For most plates imaged using the process disclosed herein, the voltage impressed upon stylus 31 is electrically positive with respect to the plate, although in some cases, a negative stylus polarity may be preferred.

Imaging assembly 30 is traversed across the face of plate 20 by translating stage 52. A controlled quantity of a relatively inert gas such as helium or a mixture of helium and neon is directed, via stylus bore 33, into the discharge gap, i.e., the region between stylus 31 and the surface of plate 20, in the direction of plate 20 at a velocity in excess of about Mach 0.05. Ionization promotion means 55 is directed toward the region between stylus 31 and the surface of plate 20 for reasons discussed above. Motor 5 is used to turn roll 10 at a constant rate via belt 7 thereby allowing stylus 31 to scan over the entire surface of plate 20, which is temporarily but securely attached to the perimeter of roll 10 and allowing the electrical discharge from stylus 31 to sweep over all pattern areas on the plate. By establishing and controlling the requisite electrical discharge in the pattern or image areas of, for example, diazonium resin plates under these conditions, the plate surface in those areas becomes resistant to (i.e., relatively insoluble in) the developing materials used in developing such plates. By carefully adjusting the desired voltage and gap size, and by properly establishing the flow of gas, in accordance with the teachings herein, the preferred localized electrical discharge of this invention may be utilized to image plates with an image resolution of approximately 1,000 lines per inch. These plates, imaged by the electrical discharge process of this invention, may thereafter be developed using conventional developing techniques.

The electrical discharge employed in this invention has been used to place a latent image exhibiting extremely fine detail, as well as excellent solid image areas, on a variety of commercially available, lithographic-type printing plates under a variety of operating conditions, as may be determined from the following illustrative examples, which are not intended to be limiting in any way. Additive-type plates have been found to be particularly suitable for use in connection with this invention.

EXAMPLE 1

An apparatus similar to that schematically depicted in Figure 1 was used, in accordance with the following specifications and operational parameter values:

Plate: 3M "R", a negative working, additive-type photosensitive plate distributed by 3M

Corporation, St. Paul, Minnesota, conventionally mounted with the metallic plate surface electrically grounded to the electrically conductive roll via conventional conductive fastening pins attaching the plate to the roll.

Stylus: Hollow steel tube having an inside diameter of 0.002 inch, and a tip radius of approximately 0.002 inch. The stylus tip is spaced approximately 0.0015 inch from the plate surface. The stylus shank is embedded in the bore of a hypodermic needle. A channel is provided for the delivery of gas to the discharge area via the bore of the tube, as depicted in Figures 2 and 4.

Gas: Helium, fed through the configuration indicated in Figures 2 and 4 at a flow rate of 31 standard cubic centimeters/minute.

Breakdown Promotion Means: A UV lamp Model 22SC-35 (Ultra Violet Products, Inc. San Gabriel, California 91778) is positioned in close proximity (approximately 0.75 inch) to the stylus tip and plate surface (see Figures 2 and 4).

Current Limiting Resistor (R_L): 5.00 Megohms, 0.5 watt.

High Speed Switch: Similar to that depicted in Figure 7.

Source of Pattern Data: PDP 11/40 Computer (distributed by Digital Equipment Corporation, Maynard, Massachusetts) with appropriate associated electronics of conventional design.

With the above-specified apparatus, the plate was continuously rotated on the roll with a roll circumferential speed of approximately 72 inches/second. Ambient light in the vicinity of the apparatus was subdued to prevent fogging of the photosensitive plate. Applied voltage of the electrical discharge during the imaging period was 900 volts, resulting in a localized type discharge, and was maintained at 300 volts during the non-imaging period, resulting in a diffuse type discharge, with the polarity of the voltage on the stylus being positive at all times with respect to the grounded plate roll. The stylus was slowly and automatically traversed along the axis of roll rotation at a rate of approximately 0.2 inch/minute, thereby causing the stylus to trace a closely spaced helical path on the plate surface. The desired pattern was a typographical test form pattern, requiring minimum dot diameters of approximately 0.001 inch. The maximum switching frequency was about 72 kilohertz.

After the latent image of the desired pattern was created on the coated surface of the plate by contact with the localized type electrical discharge, the plate was removed from the roll and developed conventionally, i.e., the plate was treated with process gum (R Process Gum, a product of 3M Corporation of St. Paul, Minnesota), then with a lacquer developer (Reliable Red Lacquer Developer, distributed by Anchor/Lithkemco of Hicksville, New York) for image reinforcement, and then treated with a 50-50 (by weight) mixture of gum arabic and distilled water. During the development process, the areas contacted by the localized type electrical discharge appeared to behave similarly to areas on similar plates imaged conventionally, i.e., imaged photographically via actinic light, while areas contacted by the diffuse type discharge behaved as though unexposed. The resulting developed plate exhibited visually outstanding detail. The plate was then placed on a sheet fed offset lithographic duplicator of conventional design. The ink chosen was O/S Washfast Black NC 23424 distributed by Sinclair and Valentine of Charlotte, North Carolina. The dampening solution was 3M Duplicator Fountain Concentrate, distributed by 3M Corporation of St. Paul, Minnesota, diluted as directed (1-15 parts by volume). The paper chosen was a conventional white business paper having a basis weight of 20 pounds, distributed by International Paper Company. The resulting printed sheets carried an exceptionally clear and detailed image corresponding to the areas of the plate contacted by the localized type electrical discharge, with no undesired background.

EXAMPLE II

The procedures of Example I were followed, except that the plate used was an LKK brush grain "wipe-on" type plate, of 6 mil thickness, and LKK 6110 Sensitizer Base and LKK 6110 Sensitizer Powder was used, all distributed by Anchor/Lithkemco of Lynbrook, New York, and the load resistor used was 2.5 Megohms. As in Example I, the image obtained on the plate was well defined, with excellent contrast and resolution.

EXAMPLE III

The procedure of Example I was followed except that the plate used was a 3M type "E" plate, distributed by 3M Corporation, St. Paul, Minnesota. The plate was imaged using the invention disclosed herein, and was developed as in Example I. The image obtained on the plate was well defined, with excellent contrast and resolution.

EXAMPLE IV

The plate of Example I was imaged and developed in accordance with the teachings of Example I, except that the gas flow rate was 25 standard cubic centimeters/minute, roll circumferential speed was 20 yards/minute, and the resistance values for the current limiting resistor R_L were varied over a range which permitted monitoring of current in the discharge region. The approximate associated line width achieved (based upon reproduction of a series of spaced parallel lines) is given below.

R_L (Megohms)	Current (Microamps)	Line Width (mils)
9	64.5	2.2
7	83.9	2.4
5	116.1	2.7
3	200	3.0
2	296.7	3.4
1	580.5	4.1

Image quality in all cases was excellent.

EXAMPLE V

A small section of Mylar-brand polyester plastic film having a thickness of 5 mils and having a conductive coating on one side was interposed between the stylus and the surface of the plate of Example I, with the conductive coating facing the stylus. The plastic film is distributed by Sierracin Corporation of Sylmar, California under the tradename "Intrex". The plastic film as used was partially transparent to visible light, the transmission having been measured over the visible region of the spectrum and averaging approximately 50%. The conditions of Example I were used to cause an electrical discharge to be established between the stylus and the conductive surface of the film, except that the gas flow rate was 25 standard cubic centimeters/minute, the relative speed between the stylus and the film surface was 0.1 inches/second, and the stylus was positioned approximately 0.002 inch from the film surface. To take into account the partial transmissivity of the film to light and the increase distance between the stylus and the plate, the rate of traverse of the stylus across the surface was made smaller than in Example I. The conductive surface of the film was suitably grounded to the roll carrying the plate.

It was observed that the characteristics of the various discharges between the stylus and the conductive film surface, in particular, the shape and luminosity of the discharges, were substantially identical to those which were observed in Example I. After exposure as above, the film was removed from the surface of the plate and the plate was developed as in Example I. No developed images of any kind were observed.

It is believed that visible light alone, as produced by the discharge of the instant invention, is insufficient in intensity to form a latent image on this plate. Because the light intensity to which the plate is exposed in this Example is calculated to be approximately ten times the intensity to which the plate is exposed in Example I (having taken into account the transmissivity of the film and the increased spacing of the discharge from the plate surface because of the finite thickness of the film), it is therefore concluded that, in the practice of this invention as exemplified in Examples I through IV above, the impingment of ions on the surface is the principal mechanism, and that the incidential production of light associated with the electrical discharges of this invention does not play a significant role.

To insure that light from a conventional source, if sufficiently intense, would be capable of producing a latent image after passing through the partially transmissive film used above, a plate identical to the one used above was partially covered with a small section of film as used above and then exposed to a source of conventional light. After exposure, the film section was removed and the plate developed as above. It was observed that both the regions directly exposed to the light and those which were beneath the film developed to the same degree, thus establishing the fact that the film is capable of transmitting at least some of those wave lengths of light to which the plate surface is sensitive.

CLAIMS

1. A process for creating a desired latent image on an unimaged, electrically conductive substrate surface, said surface carrying an unimaged material thereon, said material being capable of being insolubilized when acted upon by a low current non-pulsating electrical discharge to form a latent image thereon whch thereafter may be developed for use in a printing process by conventional lithographic-type developing processes, comprising contacting areas of said material on said surface corresponding to said image with a low current localized-type electrical discharge, said discharge being of sufficient energy density to insolubilize, with respect to conventional lithographic-type developing materials, said material only in said areas contacted by said discharge.

2. The process of claim 1 wherein said electrical discharge is substantially coaxial with a stream of a relatively inert gas directed at said substrate surface at a subsonic velocity of at least about Mach 0.05.

3. A process for creating a latent image on an unimaged printing plate, said plate having an unimaged coating thereon in which an insolubilizing effect may be induced by a low current localized type electrical discharge, comprising the steps of:

(a) positioning an electrode in close proximity to the coated surface of said plate thereby forming a discharge gap;

(b) directing a relatively inert gas into said gap in the direction of said plate surface in the form of a thin, well-defined stream having a velocity of at least about Mach 0.05;

(c) initiating a low current localized-type electrical discharge between said electrode and said plate surface, within said gas stream, and

(d) maintaining the time-averaged current flow within said discharge to a value sufficient to induce an insolubilizing effect in said coating contacted by said discharge.

4. The process of claim 3 wherein said value of the time-averaged current flow within said discharge gap is between about 2×10^{-6} and about 2×10^{-3} amperes.

5. The process of claim 3 wherein the voltage across said gap is non-pulsating.

6. The process of claim 3 wherein said gas stream has a minimum transverse cross-sectional area of less than about 2×10^{-5} square inches.

7. The product of the process of claim 6, wherein the resulting latent image has a minimum uniform dot diameter of less than about 0.004 inch.

8. The process of claim 3, wherein said gas stream is directed from an aperture associated with said electrode.

9. The process of claim 3, wherein said electrode is a tube, and said gas stream is directed from the tube bore.

10. The method of claim 3 wherein said current flow is limited to a maximum value which is insufficient to displace said coating so as to substantially expose said plate under said coating.

11. The method of claim 3 wherein said electrode is scanned over said plate surface by means of relative movement between said electrode and said plate surface, and said localized-type discharge is maintained only while said electrode is opposite areas of said plate surface wherein said insolubilizing effect is desired.

12. The method of claim 11 wherein said diffuse-type discharge is maintained at times other than those when said localized-type discharge is being maintained.

13. The method of claim 3 wherein the current flow in said discharge is modulated in accordance with pattern information.

14. An apparatus for creating a latent image on an unimaged printing plate, said plate having an unimaged coating thereon in which an insolubilizing effect may be induced by a low current localized-type electrical discharge, comprising:

(a) means for positioning an electrode in close proximity to the coated surface of said plate thereby forming a discharge gap;

(b) means for directing a relatively inert gas into said gap in the direction of said plate surface in the form of a thin, well-defined stream having a subsonic velocity of at least about Mach 0.05;

(c) means for initiating a low current localized-type electrical discharge between said electrode and said plate surface, within said gas stream, and

(d) means for maintaining the time-averaged current flow within said discharge to a value sufficient to induce an insolubilizing effect in said coating contacted by said discharge.

15. The apparatus of claim 14 which further includes means for varying the time-averaged current flow within said discharge in accordance with pattern information.

16. The apparatus of claim 14 wherein said means for positioning said electrode may be controlled in accordance with pattern information.

17. The apparatus of claim 14 wherein said electrode comprises a hollow stylus having a longitudinal bore and wherein said means for directing said gas into said gap comprises said stylus bore.

18. The apparatus of claim 17 wherein said stylus bore has a maximum diameter of about 0.004 inch.

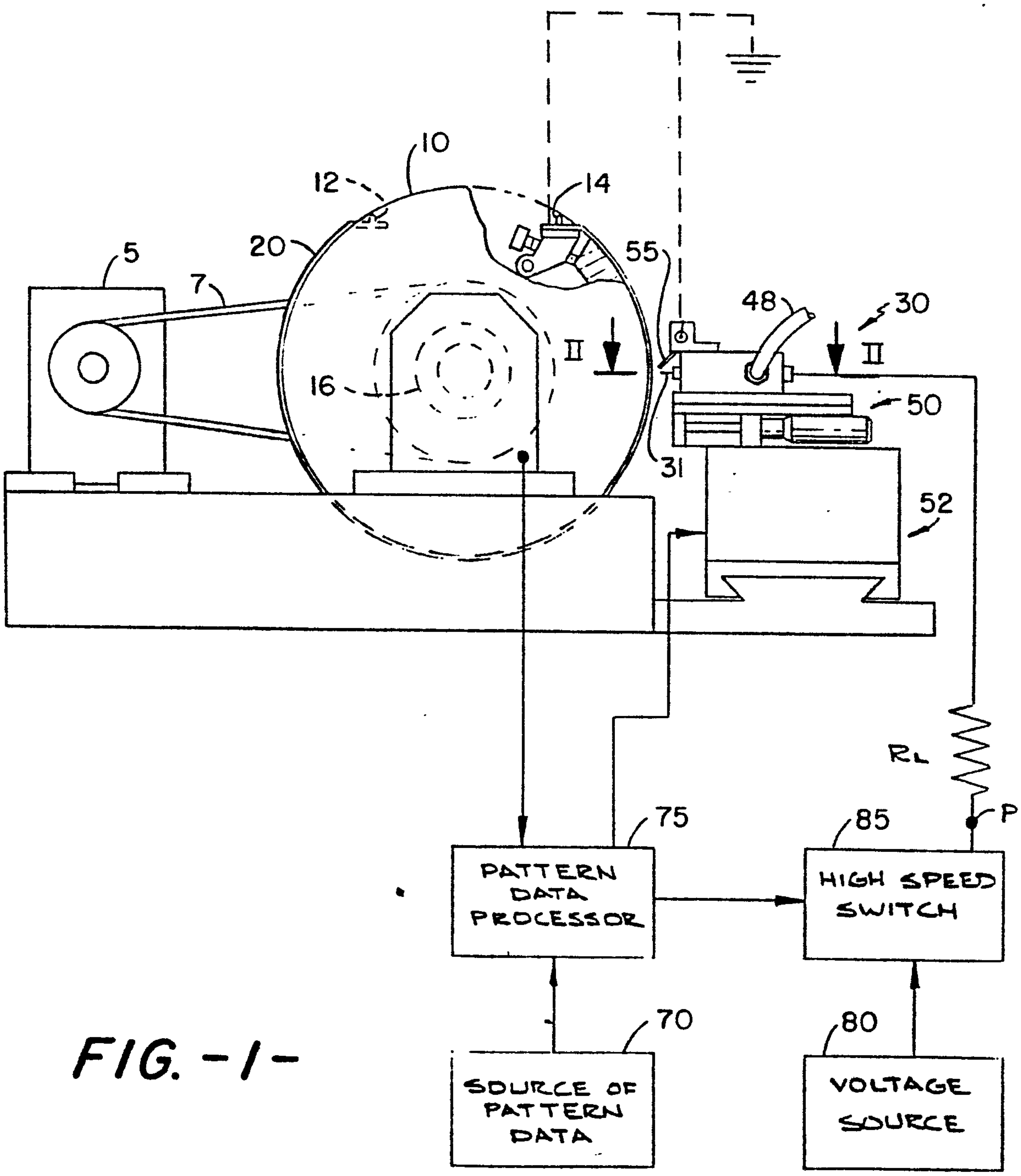

10
12
14
5
20
7
55
48
30
II
II
16
50
31
52
RL
P
75
85
PATTERN DATA PROCESSOR
HIGH SPEED SWITCH
70
80
SOURCE OF PATTERN DATA
VOLTAGE SOURCE

FIG. -1-

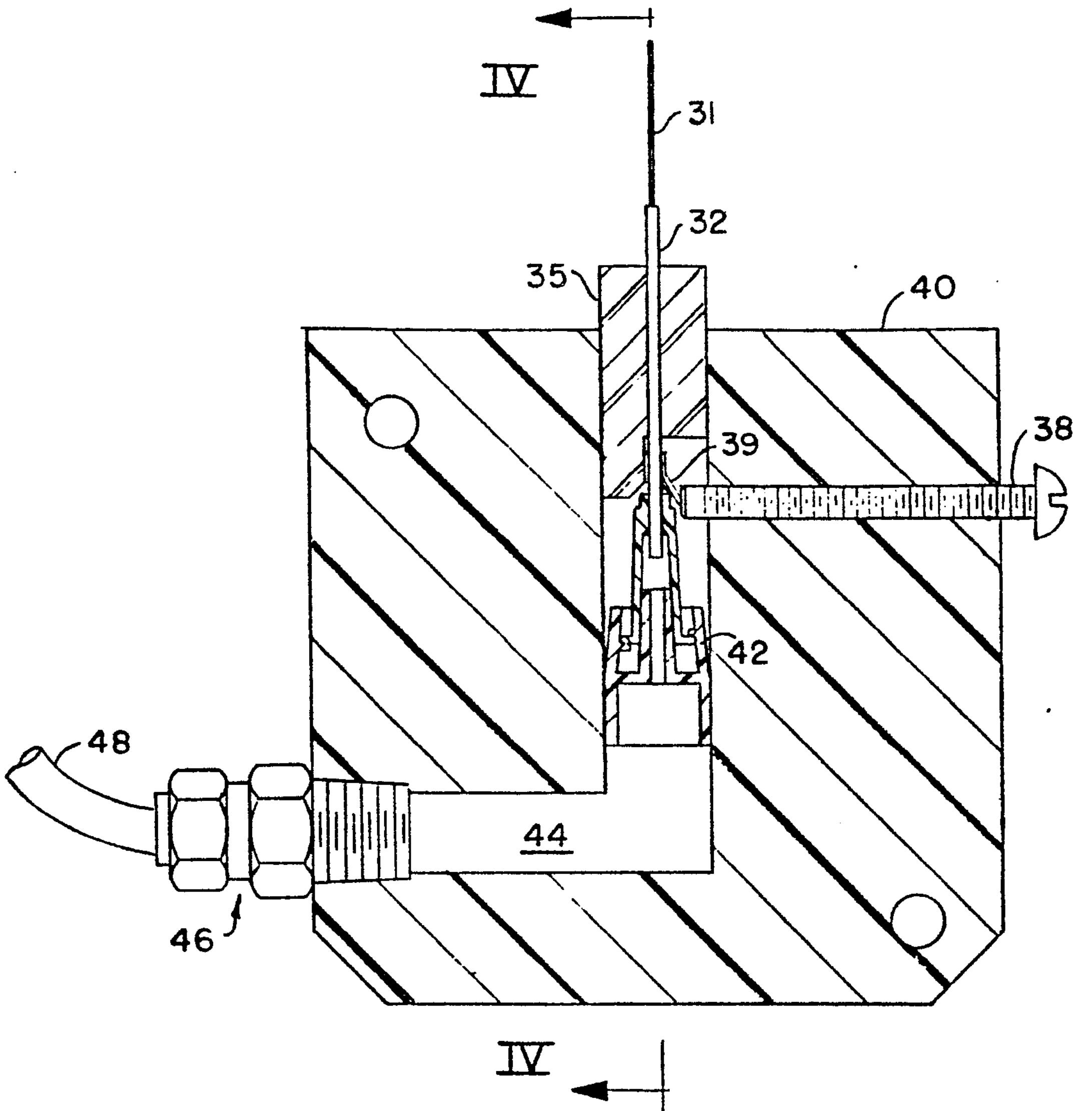


FIG. -2-

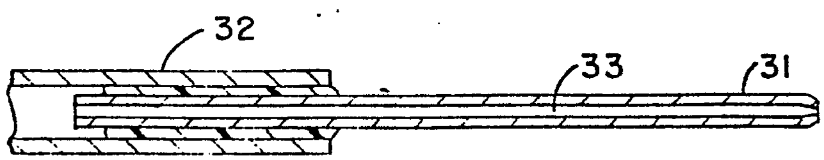


FIG. -3-

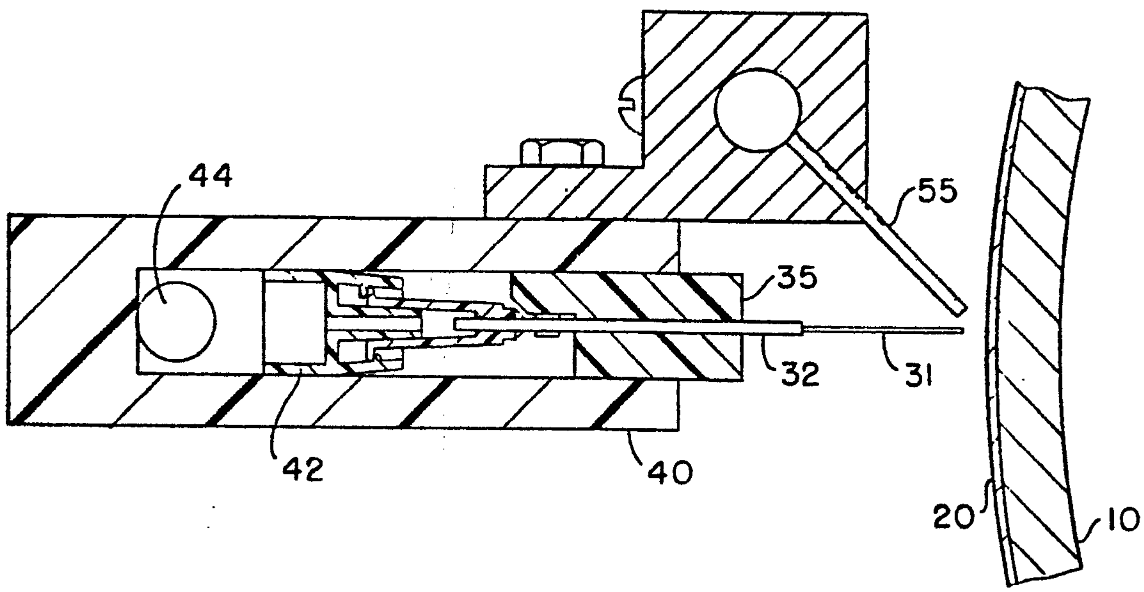


FIG.-4-

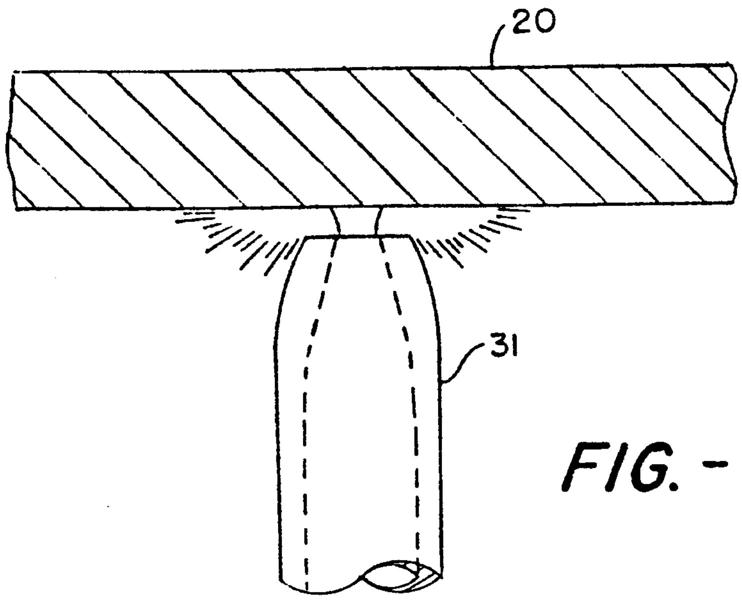


FIG. - 5A -

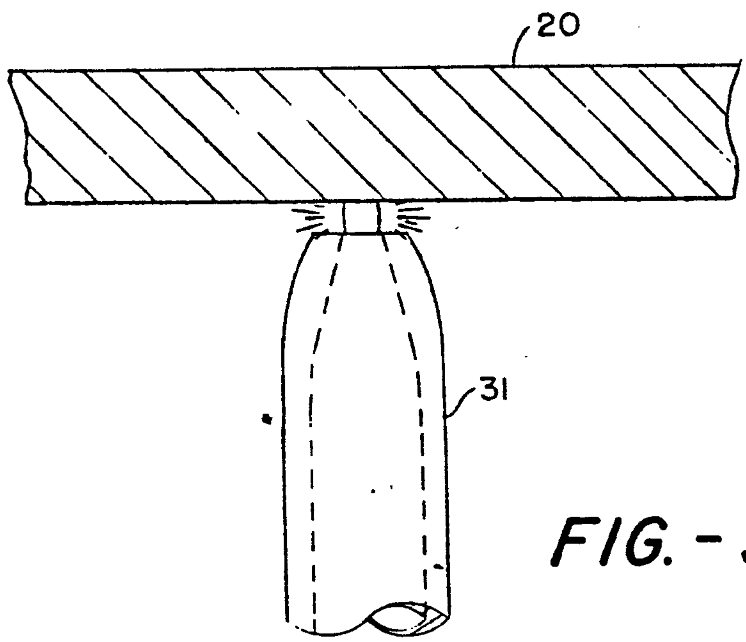


FIG. - 5B -

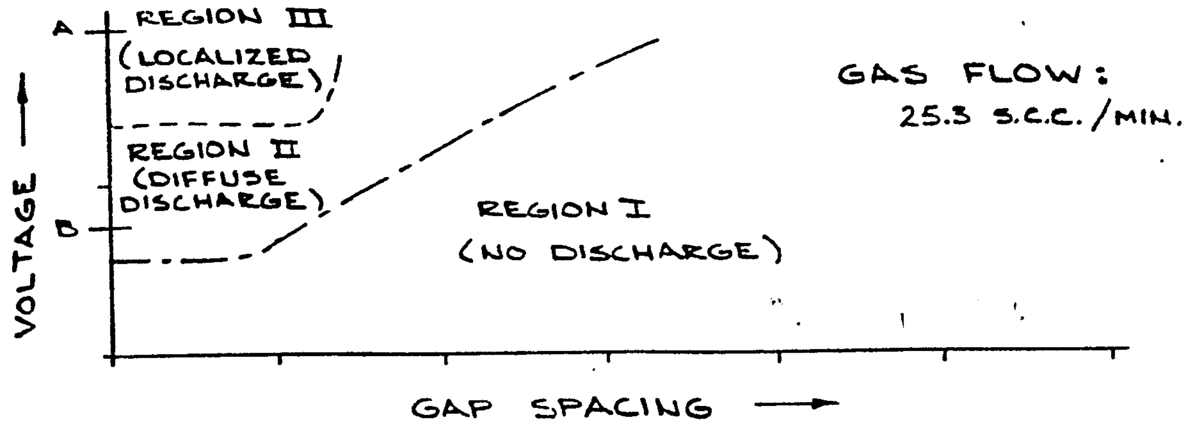


FIG.-6A-

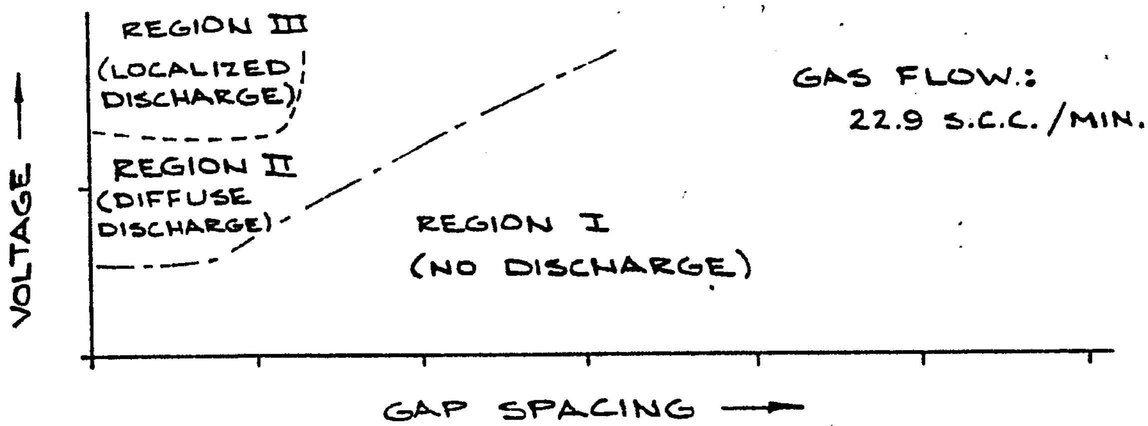


FIG.-6B-

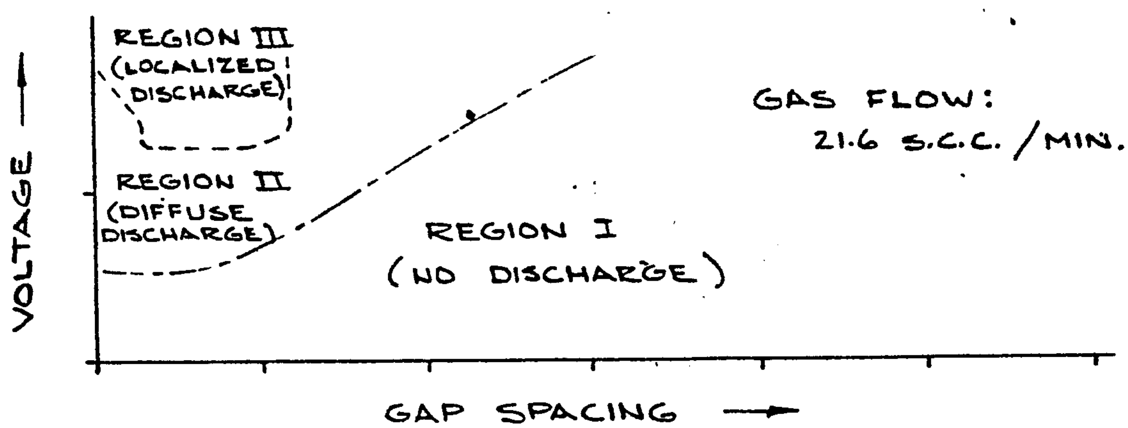


FIG.-6C-

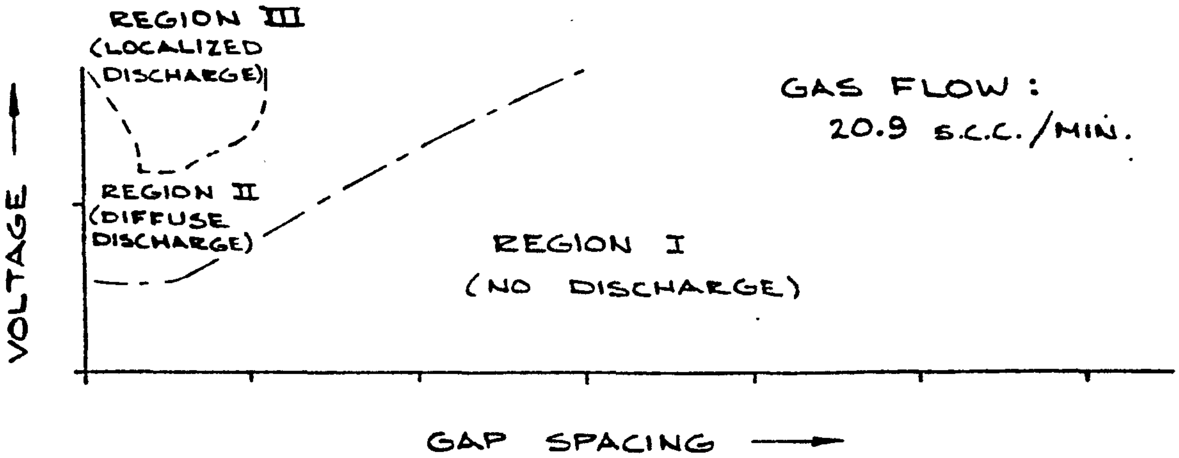
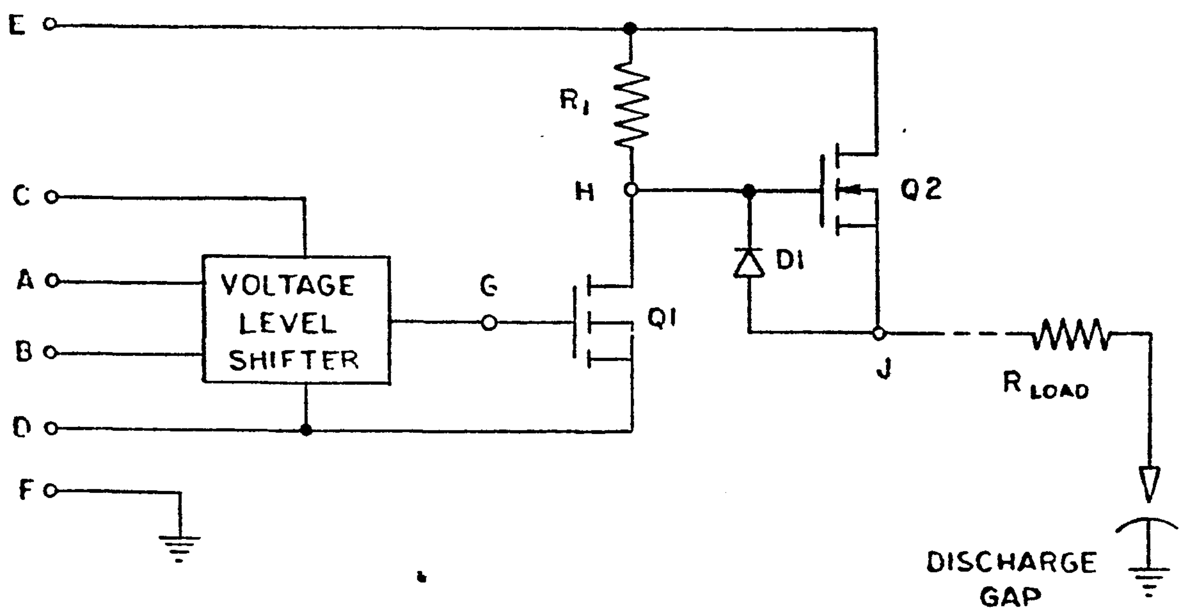


FIG. - 6D -



V_{ED} = HIGH VOLTAGE
V_{DF} = BIAS VOLTAGE
V_{AB} = DATA (PULSE TRAIN)
V_{CD} = BIAS + PULSE VOLTAGE LEVEL
V_{GD} = SHIFTED DATA
V_{HD} = AMPLIFIED SHIFTED DATA
V_{JF} = BUFFERED AMPLIFIED SHIFTED DATA

FIG. - 7 -