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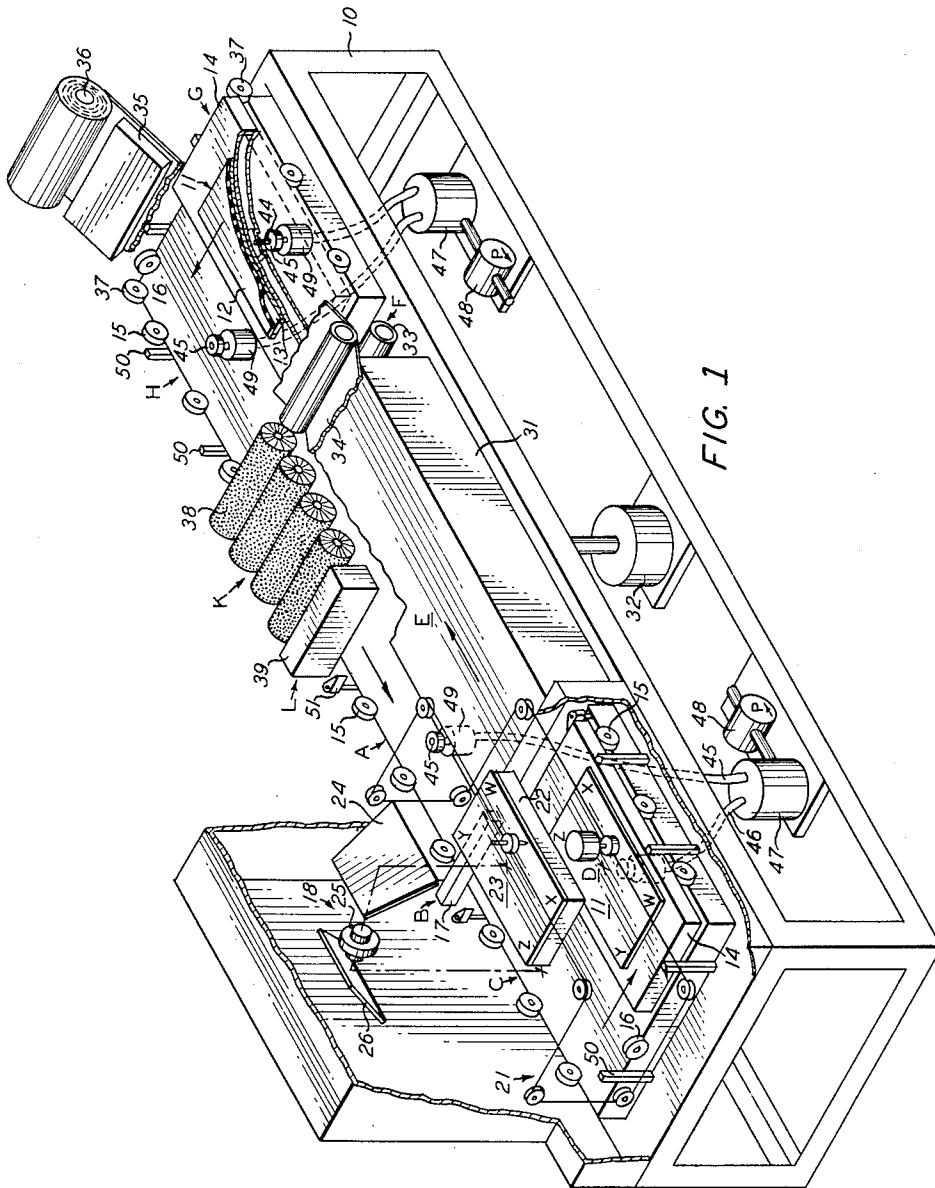
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3,013,203

XEROGRAPHIC ELECTROMETER APPARATUS

Filed July 1, 1958

3 Sheets-Sheet 1



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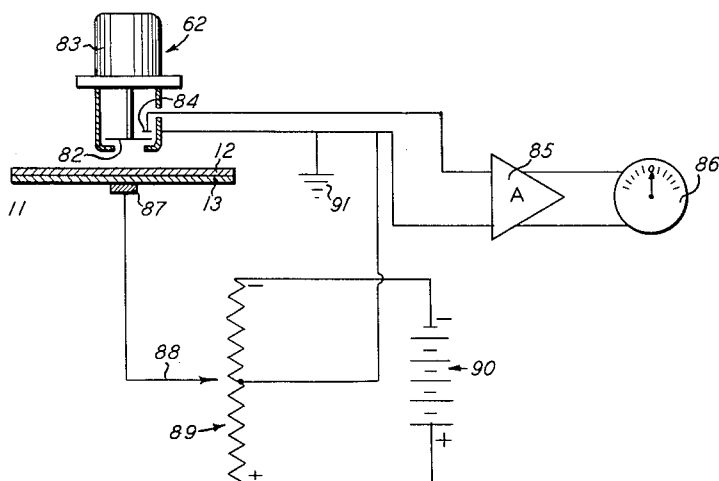


FIG. 3

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XEROGRAPHIC ELECTROMETER APPARATUS

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This invention relates to the field of xerography and in particular to an improved device for use in probing a charged and exposed xerographic plate to determine the highest or lowest electrical potential remaining on the xerographic plate.

More specifically, the invention relates to a xerographic electrometer apparatus that is particularly adapted for use in a xerographic machine, wherein, in order to bias a development electrode to a desired electrical potential, it is first required to determine the potential remaining on an exposed xerographic plate.

In the art of xerography an electrostatic latent image is formed on an insulating surface, such as, for example, a photoconductive insulating layer or electrophotographic surface by the combined action of an electric field applied through a photoconductive material and action of light or suitable activating radiation on the photoconductive material to cause selective conductivity in accordance with the pattern of radiation to which the material is exposed. The result of this combined exposure and field is to form a pattern of electric charge on the photoconductive layer that is known in the art as an electrostatic latent image which is capable of utilization, for example, by deposition thereon of finely divided material, such deposition being known in the art as development.

It has been found by others in the art of xerography, as disclosed in Landrigan Patent 2,725,304 and Hayford Patents 2,808,023 and 2,817,598, that an electrostatic latent image can be developed very satisfactorily by presenting, to the image surface, a cloud of charged powder particles with a conductive surface or development electrode positioned closely adjacent to the image surface, preferably at a distance therefrom in the order of about .010 to .025 of an inch or in some instances even closer than .010 of an inch, but in practice this spacing has actually ranged from .030 to .050 of an inch due to manufacturing limitations. It has also been found by others in the art of xerography that one effective way of preparing a cloud of substantially uniformly charged particles is to form a powder cloud in a suitable cloud generator and to pass the cloud under conditions of turbulence through a restricted opening, such as, for example, a capillary tube.

Basic to the use of the development electrode is the desire to reproduce copies of the original image of high quality and without distortion. Electrostatic lines of force exist between the electrostatic charges on the photoconductive insulating layer and areas of different charge potential. When large areas carrying electrostatic charges exist, the lines of force which are present due to charges in the central area of the large area tend to run inward through the photoconductive insulating layer to the conductive backing member which is the nearest surface carrying a different potential. Lines of force running from electrostatic charges near the external boundaries of this large area will tend to extend outward and around the outside border of the large area at which point their paths will extend inward through the photoconductive insulating layer to the conductive backing member. Development of such an electrostatic latent image creates deposition which relates to the paths taken by the electrostatic lines of force or development of the electrostatic fields. Therefore, development of a large area, as has just been

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described, tends to reproduce copies with hollow centers and emphasized edges. To prevent such development a surface is positioned at a slight distance from the photoconductive insulating layer during development. This surface, the development electrode, is composed of a conductive material and, in the case of positive-to-positive reproduction, is usually maintained at about the same potential as the lowest charge on the photoconductive layer; whereas, in negative-to-positive reproduction, is usually maintained at a potential equal to the highest charge on the photoconductive layer. In this manner, a surface is formed that causes an increase in the lines of force extending outwardly from the plate member, thereby creating electrostatic fields which when developed produces distortion-free and fringe-free high quality copy.

Although the above-described use of a development electrode is relatively simple in theory, this method of obtaining improved xerographic images has proved somewhat difficult to carry out in practice because of the need for knowing accurately the potential remaining on the xerographic plate after exposure.

For example, in the production of negative-to-positive images, the highest potential remaining on an exposed xerographic plate must be accurately determined. Unfortunately, even if the potential to which the plate was charged initially could be controlled and measured accurately, two major factors still would prevent knowledge of what the maximum potential was on the plate after exposure. The first factor is that most continuous-tone images do not have any totally opaque areas on them, and hence all areas of the plate are subject to some potential decay during the exposure. The second factor is that the potential on a plate is constantly decreasing, as the resistance of the plate is not infinite even when in the dark. In this respect, it is noted that the rate of dark decay may vary slightly between different plates of a group employed in a given application, and on some types of plates the rate is known to vary with the temperature.

It is apparent that similar problems, as outlined above, hinder the accurate determination of the lowest charge remaining on an exposed xerographic plate when making positive-to-positive reproductions.

It is therefore an object of this invention to provide improved probing apparatus which will permit accurate determination of the potential remaining on an exposed xerographic plate to thereby permit adjustment of the potential on a development electrode to prevent reversal development in negative-to-positive applications while obtaining good white areas in both negative-to-positive, and positive-to-positive applications.

Another object of this invention is to provide improved apparatus, which is both simple in construction and relatively inexpensive, to permit rapid determination of the charge remaining on an exposed xerographic plate.

These and other objects of the invention are attained by means of an electrometer parallel motion positioning apparatus having an index pointer and an electrometer mounted thereon for coordinated movement with respect to each other, and wherein the electrometer forms part of a null-type electrical circuit for measuring the potential remaining on a charged and exposed xerographic plate.

A preferred form of the invention is shown in the accompanying drawings, in which:

FIG. 1 illustrates schematically an embodiment of a xerographic apparatus adapted for flat xerographic plate operation, and incorporating a parallel motion electrometer positioning apparatus in accordance with the invention.

FIG. 2 illustrates an embodiment of a parallel motion electrometer positioning apparatus in accordance with the invention.

FIG. 3 illustrates diagrammatically a preferred electrical circuit for determining the potential remaining on a previously charged and exposed xerographic plate.

Referring now to the drawings, the xerographic apparatus shown in FIG. 1 comprises a frame 10 which structurally supports the various processing elements of the xerographic device in their respective stations. A flat xerographic plate 11, comprising a photoconductive layer of insulating material 12 on a conductive backing 13 is supported on a vacuum backed plate support 14, described in more detail in copending Crumrine application Serial No. 745,992, filed July 1, 1958, which in turn rests on either drive rolls 15 for longitudinal movement or on drive rolls 16 for lateral movement through the various processing elements of the xerographic machine. The drive rolls 15 and 16 are driven through suitable means, not shown, so that the plate carrier 14 with a xerographic plate 11 thereon, is moved in the direction of the arrows in FIG. 1 starting from stand-by position A. The drive rolls 15 and 16 are made of a suitable material, such as rubber on a metal core, to electrically insulate the plate support 14 and thereby insulate the xerographic plate 11, from the frame of the xerographic machine.

Positioned at a desired point adjacent to the path of movement of the xerographic plate is a charging station B containing a corona discharge electrode 17 or the like. Next subsequent thereto in the path of motion of the xerographic plate is an exposure station C and a scanning station D. Exposure may be effected by one of a number of types of mechanisms or members such as desirably an optical projection system 18 whereby an optical image is projected onto the surface of the xerographic plate while the xerographic plate is held stationary in exposure station C.

Although any one of a number of types of optical projection systems may be used, the system illustrated includes a copy board 22, having lamps therein (not shown) which project the image from copy material 23, such as film, onto mirror 24 from where it is reflected through lens 25 onto mirror 26 which reflects the image onto the xerographic plate 11, the resultant image being inverted longitudinally from right to left as seen by the symbols W, X, Y and Z. Scanning of the charge on the xerographic plate may be effected by a xerographic electrometer apparatus, generally referred to by reference 21, described in greater detail hereinafter in connection with FIGS. 2 and 3. A plate 11, previously charged and exposed is shown in the scanning station D.

Adjacent to the scanning station D is a development station E. Positioned at the development station E is a development electrode 31, which may be of the type disclosed in copending Crumrine application Serial No. 725,702, filed April 1, 1958, now Patent No. 2,942,573, the development electrode being supplied with a powder cloud of developing material from a powder cloud generator 32 to develop the electrostatic latent image formed on the xerographic plate.

At the area generally designated F, transfer of the developed image from the xerographic plate occurs. This transfer of the image to a suitable support material is preferably effected by the use of a pressure transfer apparatus 33 described in greater detail in copending Crumrine et al. application Serial No. 742,373, filed June 16, 1958. A supply roller (not shown) supplies a web of support material 34 around the upper roller of the transfer mechanism 33 which forces the support material into contact with the xerographic plate 11 as it moves thereunder, whereby transfer of the powder image is effected. The web of support material, carrying the transferred image, passes an image fixing apparatus 35, for example, a heated platen, whereby the copy is made permanent, and finally the support material is wound onto take-up roller 36.

Positioned next adjacent to the transfer area F is a holding station G and next adjacent to this latter station

is a plate changing station H where xerographic plates and plate support elements may be removed or added. Rollers 37, which are not power driven, are positioned at the end of the machine to permit plate support elements to be manually rolled on or off of the machine at stations G and H.

A cleaning station K having a power driven cleaning brush 38 is positioned adjacent to the second holding station H.

The next and final station is a floodlight station L where the xerographic plate is flooded with light from lamp 39 to cause dissipation of any residual electrical charge on the xerographic plate.

The xerographic plate 11 is detachably secured to the plate support apparatus 14, as it is transported through the above-described processing stations of the xerographic machine, by means of normal atmospheric pressure acting on one side of the plate while the other side or the back of the plate is subjected to a negative pressure. To obtain a negative pressure on the back of the plate a plate support apparatus 14 may be connected by means of valved quick disconnect coupling 44 on the plate support apparatus to any of the valved quick disconnect couplings 45 on vacuum lines 46 to an evacuating means, such as ballast tanks 47 maintained at a vacuum of 16 to 24 inches of mercury by vacuum pumps 48.

To effect automatic coupling of the quick disconnect couplings to a plate support apparatus, the quick disconnect couplings 45 may be actuated by an air cylinder 49 or other similar power means for movement into engagement with the mating coupling 44 on the plate support apparatus.

A quick disconnect coupling 45 and an air cylinder 49 are located at stand-by station A for automatically re-evacuating a plate support apparatus each time it reaches the stand-by station.

Whenever the xerographic machine has been stopped long enough to dissipate the vacuum in a plate support apparatus, for example, when the machine is idle overnight, it may be necessary to re-evacuate each plate support apparatus before it moves through a critical station. For this purpose quick disconnect couplings and air cylinders are also provided at stations D, G and H. In this respect it is noted that more than one xerographic plate and plate support apparatus may be in operation on the xerographic machine at one time, one such combination being shown in the scanning station D in FIG. 1, while a second plate and plate support apparatus, partially broken away to show the details of construction, is shown in holding station G.

For momentarily holding the plate support apparatus stationary in stations A, C and D, stops 50 and anti-rebound latches 51 are positioned at these stations.

The operation of the various elements of the xerographic apparatus is controlled through a suitable circuit (not shown), which synchronizes the sequence of operation of the various elements.

Since xerographic plates are light-sensitive, the entire xerographic machine must be enclosed in a light-tight housing similar to the light-tight housing 52 enclosing the optical elements and the xerographic plate during charging, exposing and scanning.

As illustrated in FIG. 2, the xerographic electrometer apparatus 21 consists essentially of a parallel motion electrometer positioning apparatus 60 having an index needle or pointer 61 and an electrometer 62 arranged so that a xerographic machine operator, by a quick visual inspection of the copy material 23 to determine the general dense areas or light areas on the copy material, may position the index needle or pointer 61 over the selected dense or light area of the copy thereby automatically positioning the electrometer 62 over the corresponding exposed area of the xerographic plate 11 to determine the charge remaining thereon. In the case where the index pointer 61 is positioned over a dense or black area of the

copy material 23, the electrometer 62 would be positioned over the corresponding area of the xerographic plate 11, which area would contain the highest charge remaining on the xerographic plate 11. If, however, the index pointer 61 is positioned over the lightest area of the copy material 23, the electrometer 62 would be positioned over the corresponding exposed area of the xerographic plate 11, which area would contain the lowest charge remaining on the xerographic plate 11.

In the particular embodiment disclosed, two pairs of hanger guide rods 63, which support a pair of hangers 64 movably mounted thereon by means of linear bearing 65, are attached in fixed spaced parallel relation to each other on upright post 66, which may be an integral part of the frame 10 of the xerographic machine, or optionally as shown, they may be separate elements mounted thereon, as by screws 56, the hanger guide rods being secured by nuts 57.

Index pointer 61 mounted on bearing bracket 67 is movably positioned in suitably closely spaced relation to the copy material 23 on copy board 22 by means of index slide arm 68 to which the bearing bracket 67 is slidably mounted. The index slide arm 68 is secured to the hangers 64 for movement therewith by arm brackets 70 and guide rods 71. The arm brackets 70 to which the index slide arm 68 is rigidly secured by screws 72 are attached by means of a force fit onto the guide rods 71, which are formed of tube stock to permit the use of felt seals 73 to seal the openings in the light-tight housing 52 through which the guide rods protrude. The guide rods 71 are fixed to the hangers 64 by means of clamp plates 74 secured by screws 72, both the upper portions of the hangers 64 and the upper portions of the clamp plates 74 being formed with semi-circular depressions thereon to facilitate the clamping of the guide rods 71 therebetween.

The electrometer 62 mounted on bearing bracket 75 is similarly positioned in closely spaced relation to the xerographic plate 11 by means of slide arm 76 to which the bearing bracket 75 is slidably attached. To permit movement of the slide arm 76 in fixed spaced parallel relation to the index slide arm 68, it is attached to hangers 64 by means of guide arms 77, screws 72 being used to secure these elements to each other.

Since both the index slide arm 68 and slide arm 76 are rigidly secured to the hangers 64, movement of the index slide arm 68 in a plane parallel to the copy material 23, visible to a xerographic operator, will cause movement of the slide arm 76 in a plane parallel to a xerographic plate 11 positioned in scanning station D and enclosed by housing 52.

As the bearing bracket 67, to which the index pointer 61 is mounted, is moved by an operator from left to right or right to left on the index slide arm 68 as shown in FIG. 2, the bearing bracket 75 supporting the electrometer 62 will move from right to left or left to right, respectively, on the slide arm 76. This movement of the electrometer 62 with respect to the index pointer 61 is controlled by cable 78 secured as by screws 72 to bearing brackets 67 and 75.

To eliminate additional light seals, the cable 78 secured to bearing bracket 67 passes over pulleys 79 rotatably mounted on arm brackets 70, through guide rods 71, over pulleys 79 secured by pulley brackets 80 to hangers 64, and over pulleys 79 mounted directly to guide arms 77, the cable terminating at bearing bracket 75.

Although any one of a number of well known types of electrometers may be used, it has been found preferable to use a well known rotating vane type electrometer 62, also referred to as a rotary self generating electrostatic voltmeter, in which a grounded vane 82, rotated by motor 83 connected to a motor circuit (not shown), alternately exposes and shields a small area probe 84 to the potential on a charged xerographic plate 11, the direct current po-

tential from the charged plate being modulated by the rotation of vane 82 to produce alternating current for more accurate measurement of the voltage potential.

In regard to the accuracy required to measure the potential on a xerographic plate 11, it is noted that, since the dark or light areas of the image on the copy material may be relatively small, the probe 84, in order to accurately record the potential remaining on the exposed areas of the xerographic plate corresponding to these relatively small dark or light areas on the copy material, must be constructed so that it is only capable of seeing a small area. Since the size of an area in which the probe 84 will detect a potential is a function of both the size of the probe and its distance from the charged area, the probe 84 is formed as a button having a small surface area, and the probe is positioned in closely spaced relation to the surface of the xerographic plate 11, preferably within $\frac{1}{8}$ inch of the xerographic plate 11.

To obtain maximum accuracy in the determination of the potential remaining on a charged and exposed xerographic plate 11, the vane 82 and probe 84 of the electrometer 62 are connected through a suitable amplifier 85 to null indicator 86. Conductive backing 13 of the xerographic plate 11 is connected by nulling-potential contact 87 to the sliding contact 88 of a calibrated potentiometer 89.

A voltage source 90 is connected to the fixed terminals of potentiometer 89, and a fixed terminal of the potentiometer 89 is also connected to ground 91.

In the operation of the electrometer scanning apparatus, as, for example, when negative-to-positive reproductions are to be made, it is necessary to determine the highest potential charge remaining on the photoconductive layer 12 of the xerographic plate so that the development electrode may be maintained at a potential equal to this charge. To determine this charge, a xerographic plate 11, previously charged by a corona discharge electrode 17 and exposed in exposure station C to receive an image from the copy material 23 is positioned in the scanning station D, the xerographic plate during all these operations being enclosed in the light-tight housing 52.

With the xerographic plate 11 in scanning station D, the xerographic operator, by visual inspection, determines the darkest area on the copy material which corresponds to the area on the photoconductive layer 12 on the xerographic plate 11 retaining the highest charge. The operator by moving the index pointer 61 over the selected area on the copy material 23 will automatically position the electrometer 62 over the corresponding area on the photoconductive layer 12 by means of the linkage system of the parallel motion electrometer positioning apparatus. The operator then moves the sliding contact 88 of the calibrated potentiometer 89 until the null indicator reading is zero. Thus, for example, if the highest charge remaining on the selected area on the photoconductive layer 12 is 300 volts, the null indicator 86 would read zero when a -300 volt potential is applied to the conductive backing 13 of the xerographic plate 11.

In the above-described system, potentials on the charged and exposed plate are measured by applying to the conductive backing 13 a known potential, equal and opposite to that on the photoconductive layer 12. Thus, the electrometer acts only as a null indicator and need not be calibrated. When used in this way, zero-point stability is important, but changes in amplification do not introduce error into the readings.

With the apparatus disclosed, a xerographic plate which may be enclosed in a light-tight enclosure, can be rapidly probed in designated small areas as controlled by a xerographic machine operator after examination of the particular copy material being reproduced.

It is apparent that the subject apparatus, which permits pin-point probing of small areas of a xerographic plate

to determine the potential thereon, has many advantages over an alternative system in which the entire surface of a xerographic plate must be scanned by an electrometer to determine the potential remaining on a xerographic plate. Such a system would require mechanical and electrical apparatus which would be both complicated and expensive, but which would not permit as accurate and as quick a measurement of the potential remaining on a xerographic plate as obtainable with the disclosed apparatus.

Although a preferred form of the invention has been disclosed, it is apparent that any motion device, such as, for example, any one of a number of well known types of pantographs, may be used to coordinate the movement of the electrometer with respect to an index pointer, it being understood that the relative movement of the electrometer with respect to the index pointer will depend on the relative position of the image on a copy material with respect to the electrostatic image on a xerographic plate as a result of the projection of the original image through a particular projection system.

It is also apparent that, in lieu of the null reading electrical circuit shown, a direct reading circuit may be used to measure the potential remaining on a charged and exposed xerographic plate. Therefore, while there has been shown and described the fundamental novel features of the invention as applied to a preferred embodiment, it will be understood that various changes in form and details of the device may be made by those skilled in the art, without departing from the spirit of the invention. It is the intention, therefore, to be limited only as indicated by the scope of the following claims.

What is claimed is:

1. A xerographic electrometer apparatus for use in a xerographic machine wherein a previously charged and exposed xerographic plate is positioned in spaced relation to a copy material to which the xerographic plate has been exposed, said xerographic electrometer apparatus including a support means adapted to be connected to a frame element for a xerographic machine, a pantograph means connected to said support means, an index pointer mounted on said pantograph means for movement in spaced parallel relation to a copy material, an electrometer mounted on said pantograph means for coordinated movement with respect to said index pointer in a plane parallel to and closely spaced from the surface of a xerographic plate, and electrical measuring means connected to said electrometer for measuring the potential on a xerographic plate whereby the potential remaining on any portion of an exposed xerographic plate directly related to portions of a copy can be determined by placing said index pointer on desired portions of the copy.

2. An electrical scanning apparatus for use in a xerographic machine wherein a previously charged xerographic plate is positioned within a light-tight housing in spaced projection relationship to a copy material visible to a xerographic machine operator, an electrical scanning apparatus including a support means adapted to be connected to a frame element of a xerographic machine, a positioning means operatively connected to said support means having a first linkage means and second linkage means concurrently and cooperatively movable in closely spaced parallel relation to a copy material and to a xerographic plate, respectively, an index pointer connected to said first linkage means, an electrometer connected to said second linkage means, said electrometer thereby being adapted to be moved over a xerographic plate in relation to the movement of said index pointer over a copy material, and electrical measuring means connected to said electrometer for measuring the potential on a xerographic plate.

3. A parallel motion electrometer probe positioning apparatus for use in a xerographic machine wherein a

charged xerographic plate is positioned in spaced relation to a copy material for exposure to an image thereon, to form an electrostatic latent image thereon, the parallel motion electrometer probe positioning apparatus including a support means adapted to be connected to a frame element of a xerographic machine, a parallel motion positioning means having a first linkage means adapted for movement in a plane above and parallel to a copy material, a second linkage means adapted for movement in a plane above and parallel to a xerographic plate operatively connected to said support means, an electrometer means having an electrometer probe connected to said second linkage means, and an index pointer connected to said first linkage means adapted to be moved by an operator over the copy to thereby move said electrometer probe to a corresponding electrostatic latent image area on a xerographic plate.

4. A xerographic electrometer apparatus for use in a xerographic machine to determine the potential remaining on a previously charged xerographic plate which has been exposed to the image of a copy material, the copy material being positioned in a suitable projection relationship to the xerographic plate, said xerographic electrometer apparatus including a support means adapted to be connected to a frame element of a xerographic machine, pantograph means connected to said support means, said pantograph means including a first linkage means adapted for movement in a plane above and parallel to a copy material and a second linkage means adapted for movement in a plane above and parallel to a xerographic plate, an electrometer connected to said second linkage means for movement over a xerographic plate, an index pointer connected to said first linkage means for random movement by an operator over a copy material whereby movement of said index pointer causes a corresponding movement of said electrometer, and electrical measuring means connected to said electrometer for measuring the potential on a xerographic plate.

5. An electrometer apparatus for use in a xerographic machine wherein a charged xerographic plate is positioned in a light-tight housing in spaced relation to a copy positioned externally of the light-tight housing whereby the xerographic plate is exposed to form an electrostatic latent image thereon in image configuration to the copy, said electrometer apparatus including a parallel motion apparatus having a first linkage means adapted to be connected to the light-tight housing of the xerographic apparatus for movement in a plane above and parallel to a copy, a second linkage means connected to said first linkage means, for operation thereby, said second linkage means being adapted for movement in a plane above and parallel to a xerographic plate within the light-tight housing, an electrometer connected to said second linkage means, an index pointer connected to said first linkage means, an electrical measuring means connected to said electrometer for measuring the potential on a xerographic plate, said first linkage means permitting the positioning of said index pointer over random portions of the copy to thereby move said electrometer, through the inter-connection of said first linkage means and said second linkage means, over a xerographic plate in relation to the movement of said index pointer over the copy.

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