

[54] **HIGH SPEED COLOR PRINTER FOR SCINTILLATION SCANNER**

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[51] Int. Cl. **G01t 1/20**

[58] Field of Search **250/71.5 S, 363, 366, 369**

[56] **References Cited**

UNITED STATES PATENTS

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[57] **ABSTRACT**

A scintillation scanner including a high speed color printer with a relatively low mass carriage for moving only a small portion of the printing ribbon. The carriage includes ribbon guide rollers of novel configura-

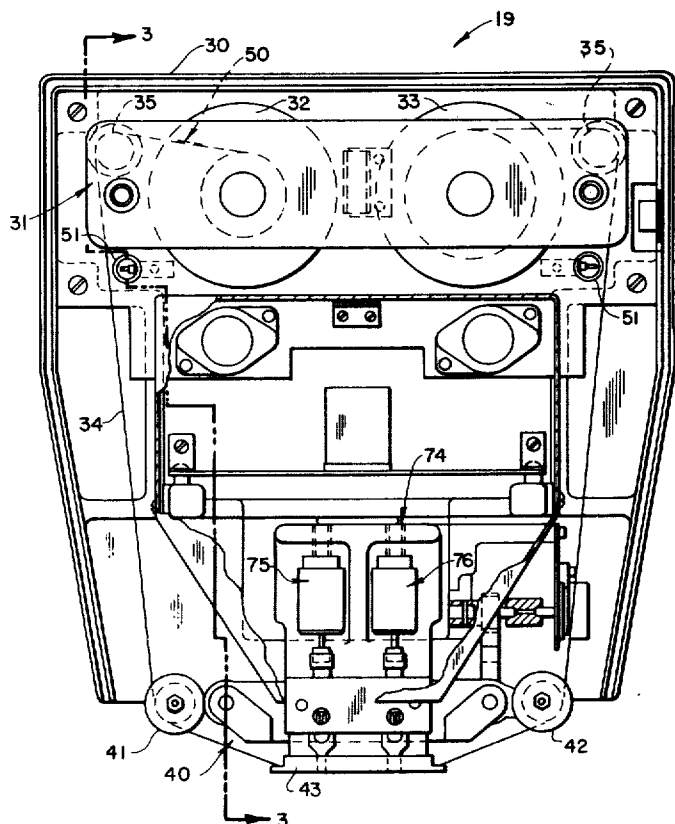
tion. A novel ribbon reversal system including magnetically actuated reed switches is provided. A novel printing surface is provided comprising a sandwich assembly including a block of relatively porous noise attenuating material.

A hammer-and-anvil type printing stylus assembly is provided. This assembly includes a solenoid with an armature having a sufficient stroke to positively drive a printing chisel to its printing position. The armature returns to and becomes settled in its retracted position faster than does the chisel, and hence may be recycled to drive the chisel back into a printing mode before the chisel has fully returned to and become settled in its retracted position. A memory circuit serves to store signals which cause the solenoid to be actuated so that those signals are not lost in the event they are received faster than the armature of the solenoid is capable of being retracted.

The ribbon positioning carriage serves to position the ribbon laterally in response to the intensity of the radiation sensed by a scintillation detector. As the carriage approaches either of the extremities of travel, a position sensing circuit attenuates the signal applied to the carriage drive motor in order to prevent the carriage from slamming into stop structures at the extremities of travel.

There is also provided a contrast enhancement circuit for modifying the value of the signal applied to the carriage drive motor so that the contrast of the output presentation may be enhanced for a given range of measured radiation intensities.

42 Claims, 13 Drawing Figures



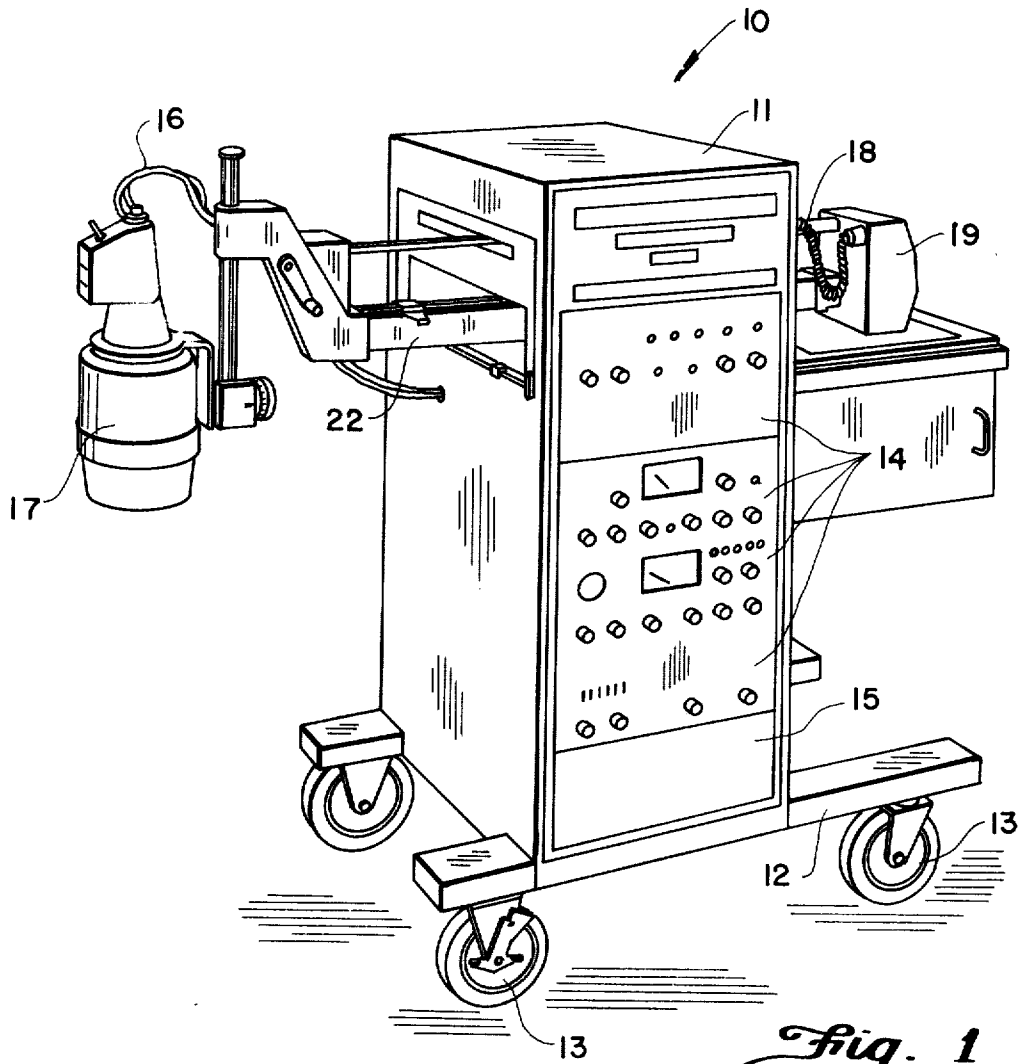


Fig. 1

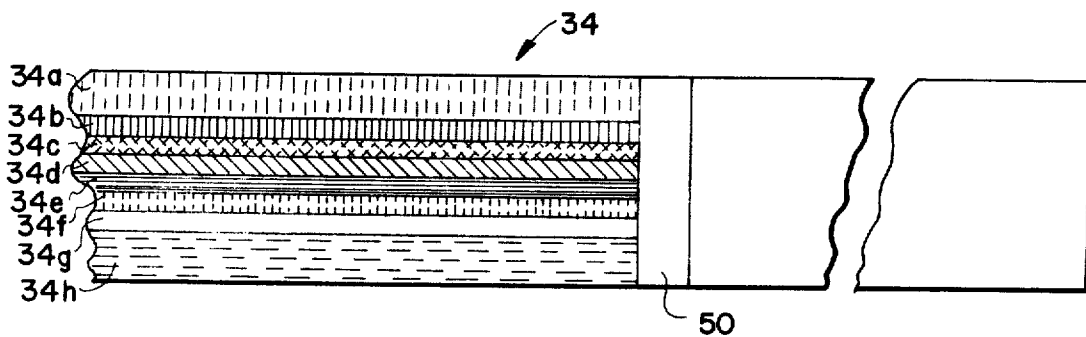


Fig. 10

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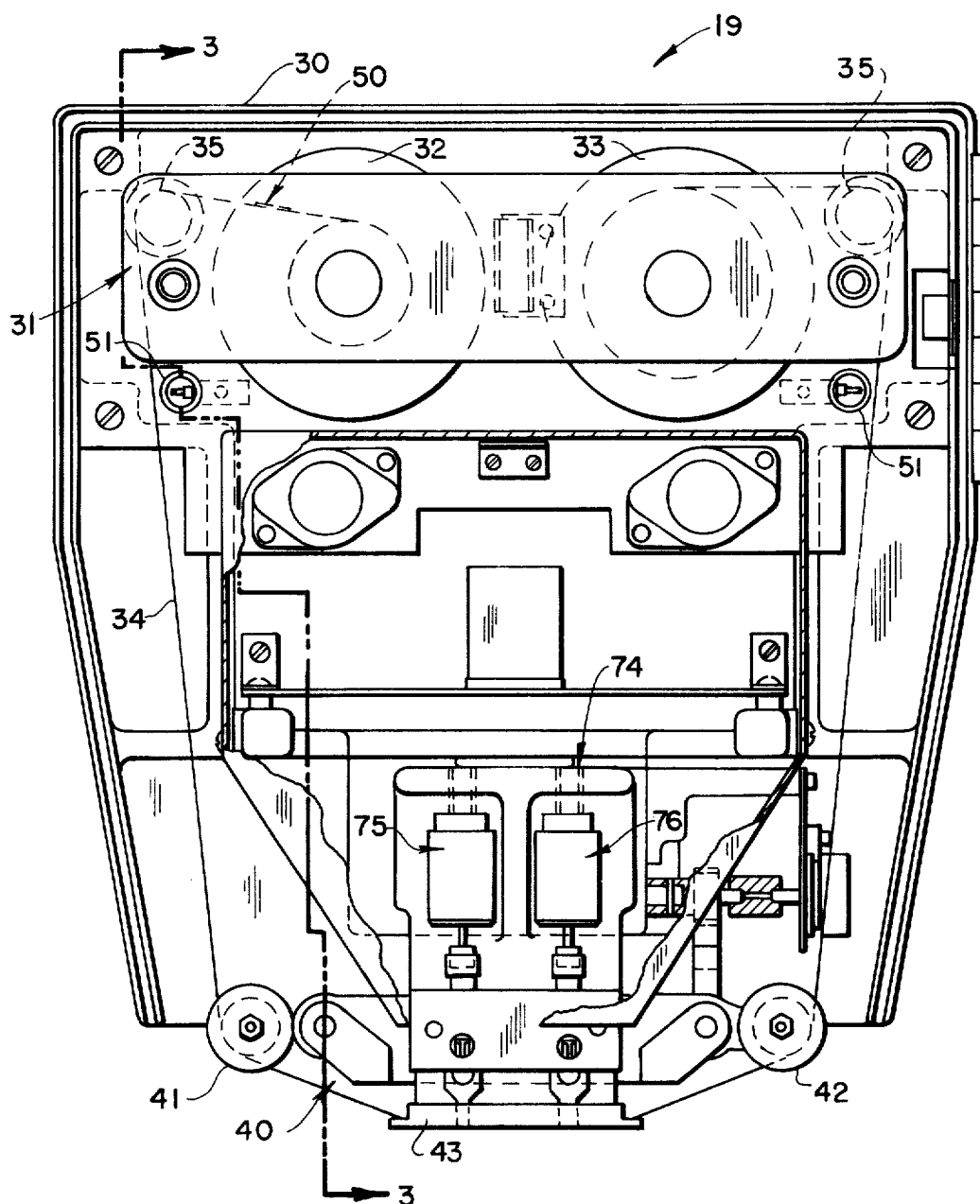


Fig. 2

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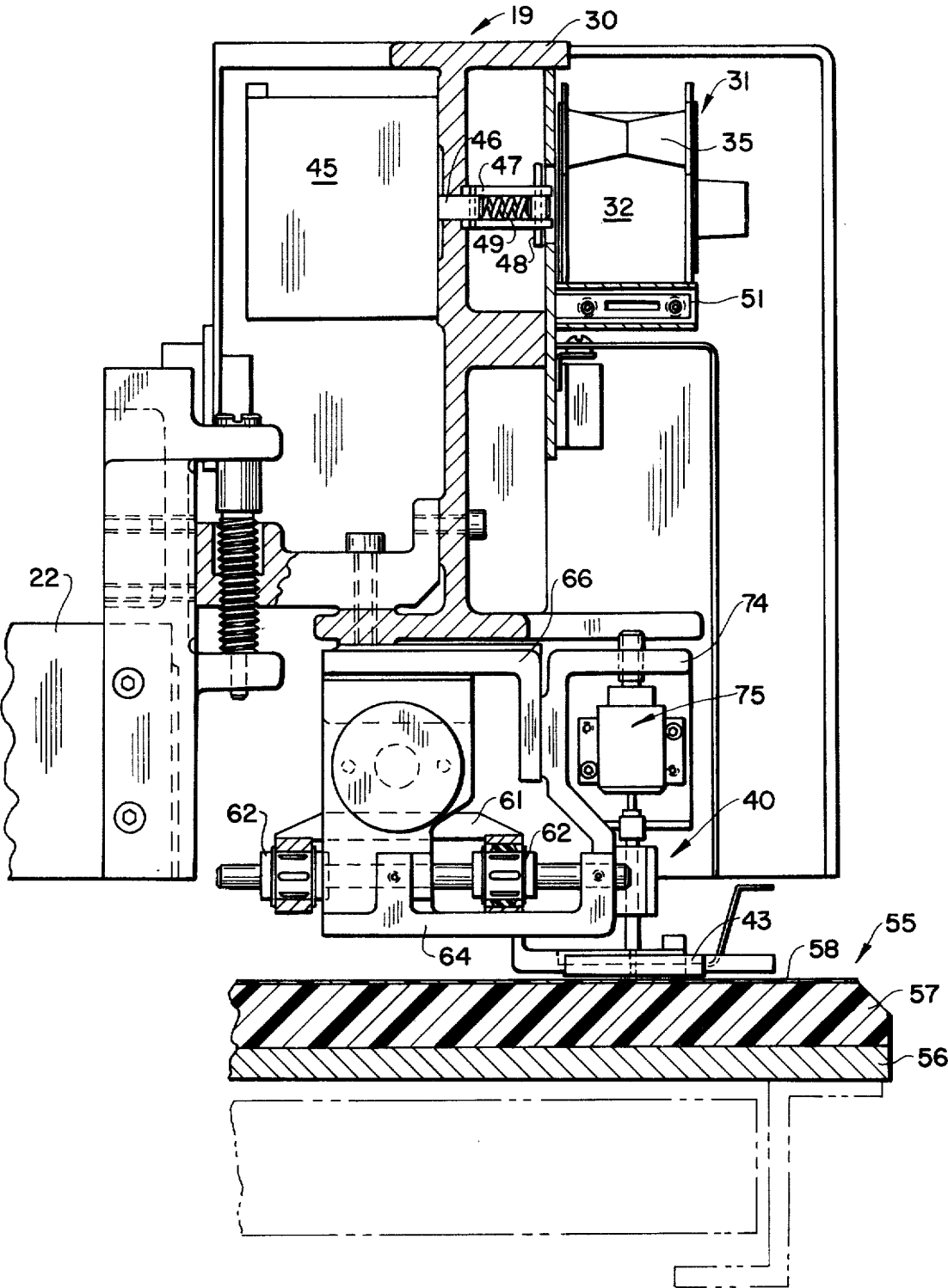


Fig. 3

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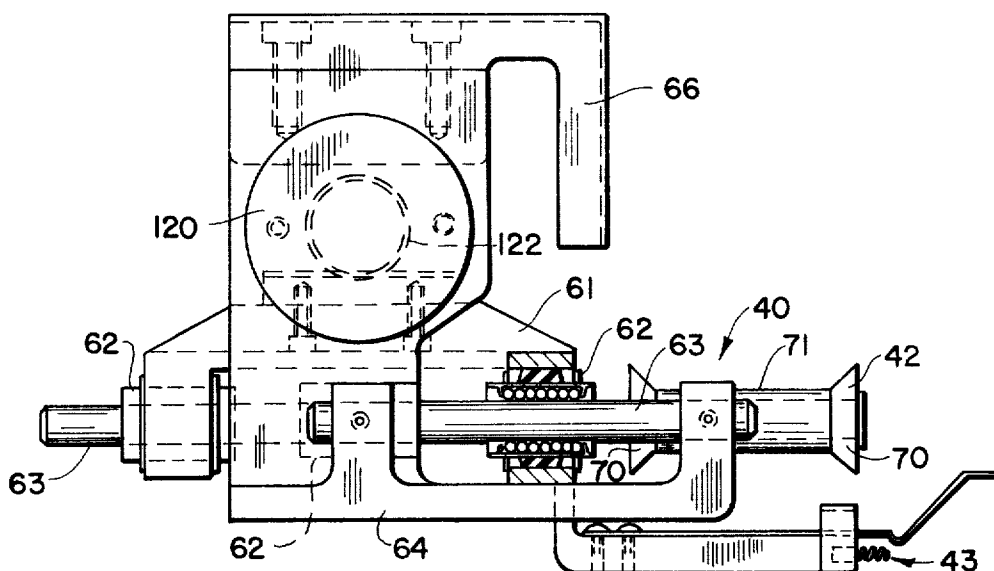


Fig. 4

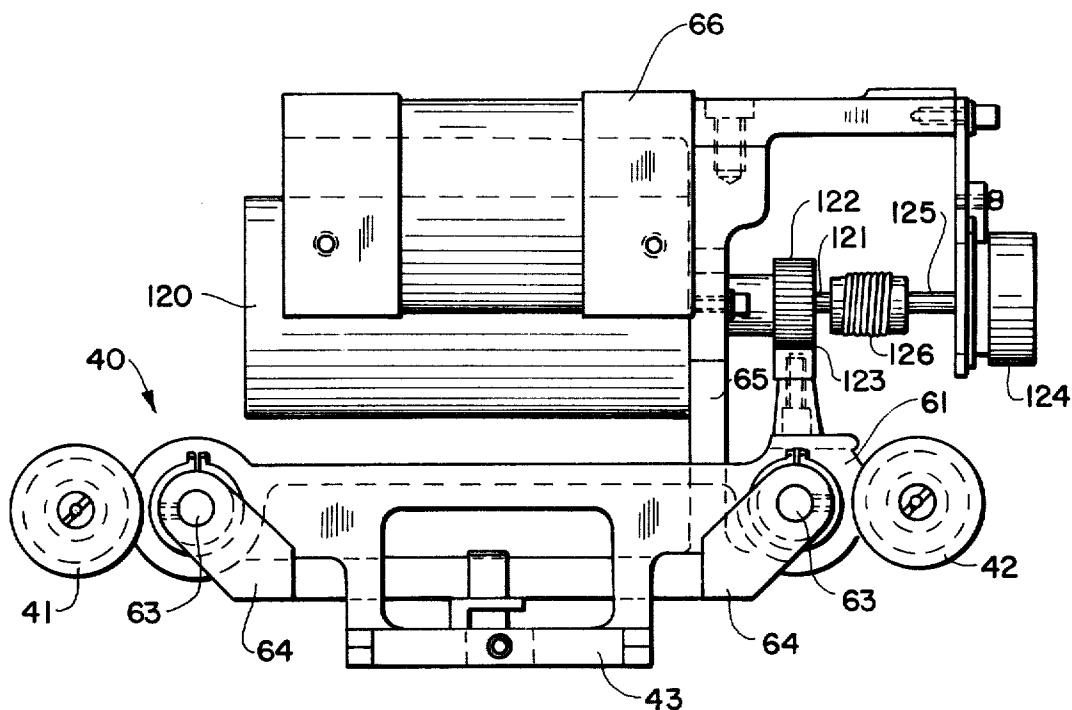


Fig. 5

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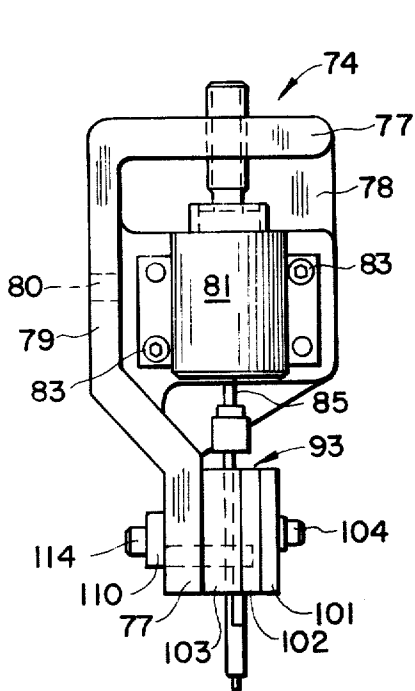


Fig. 6

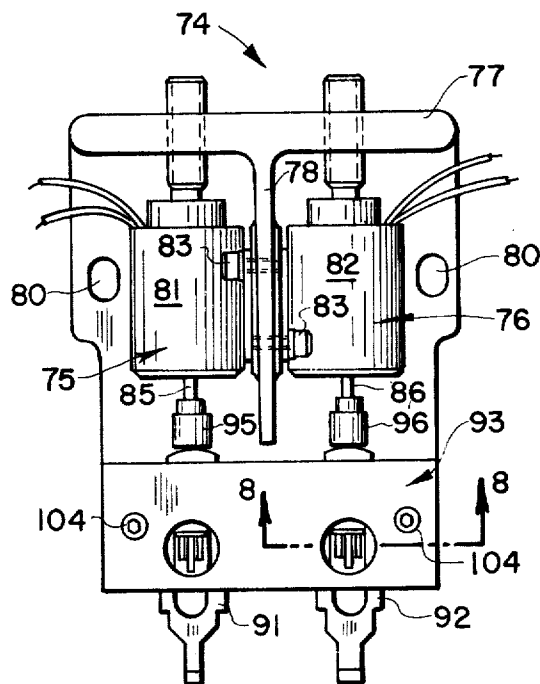


Fig. 7

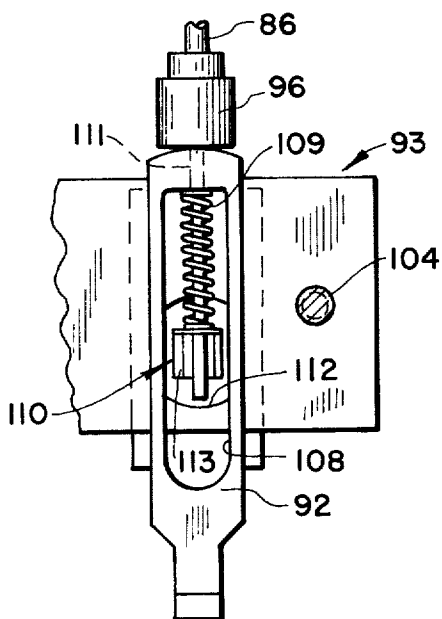


Fig. 9

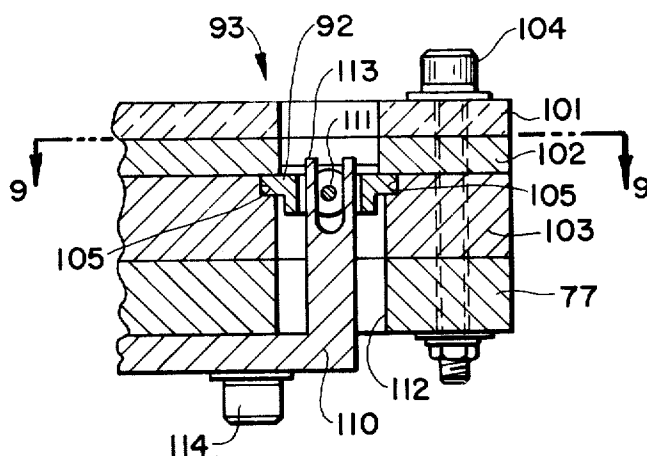


Fig. 8

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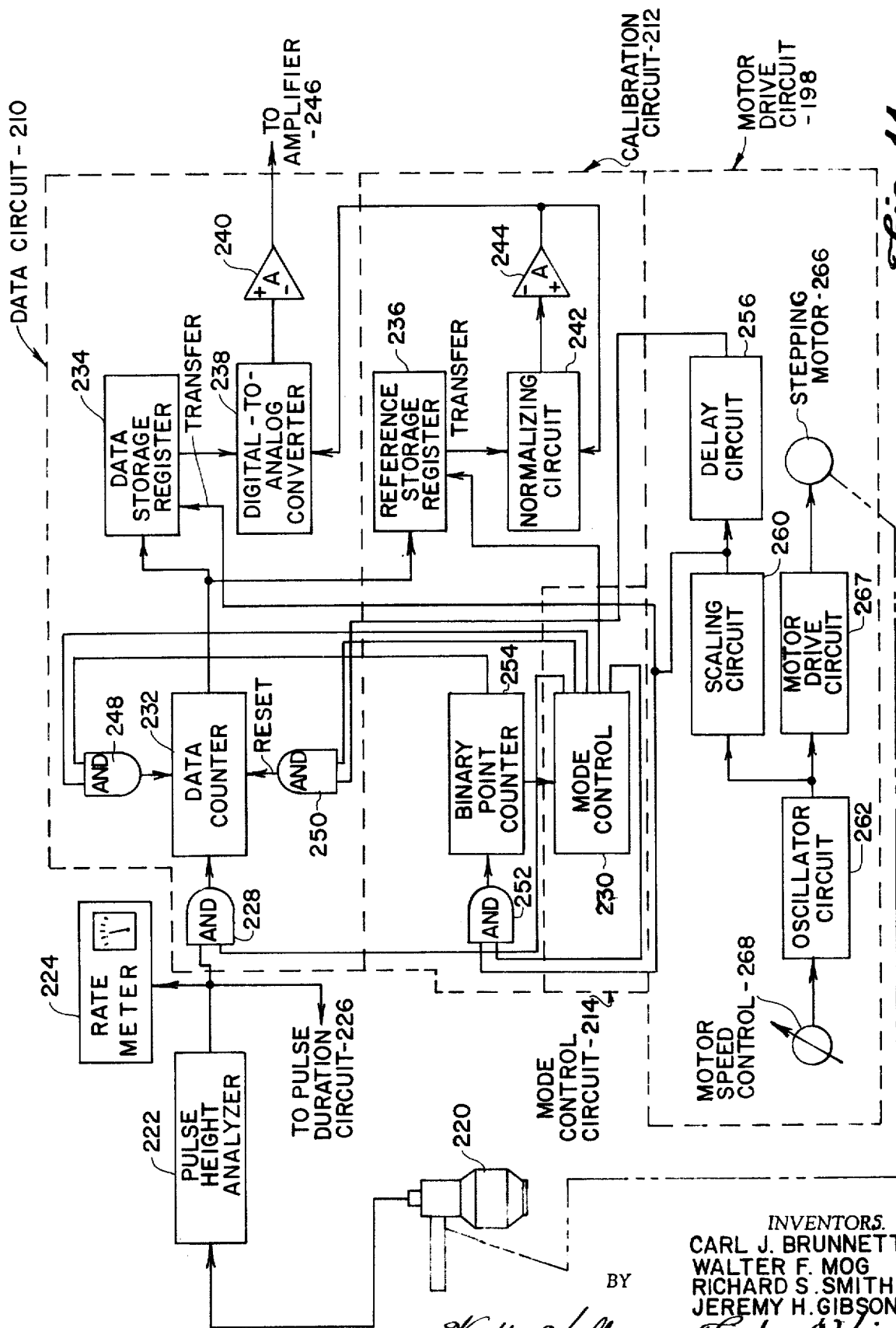
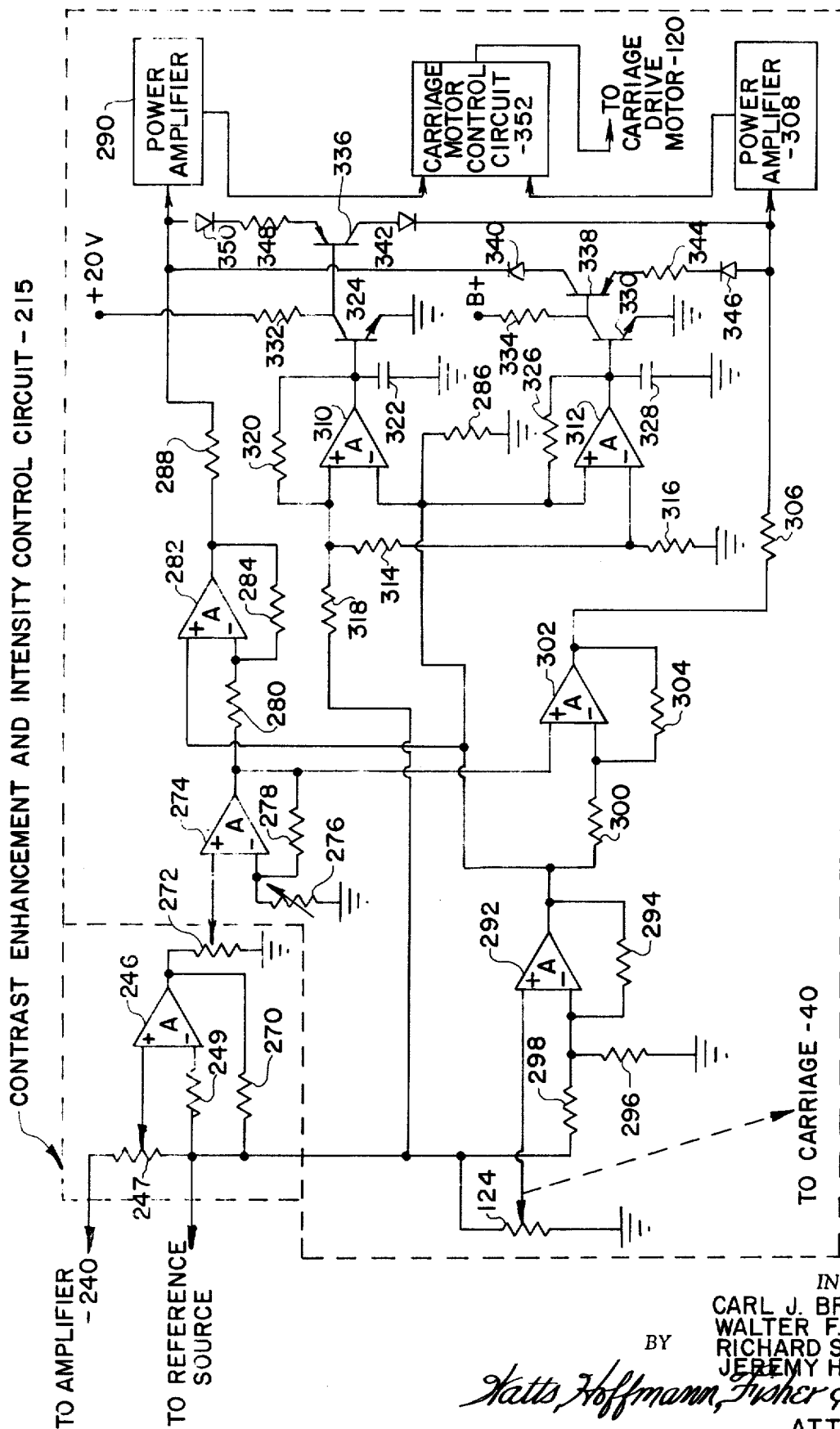


Fig. 11

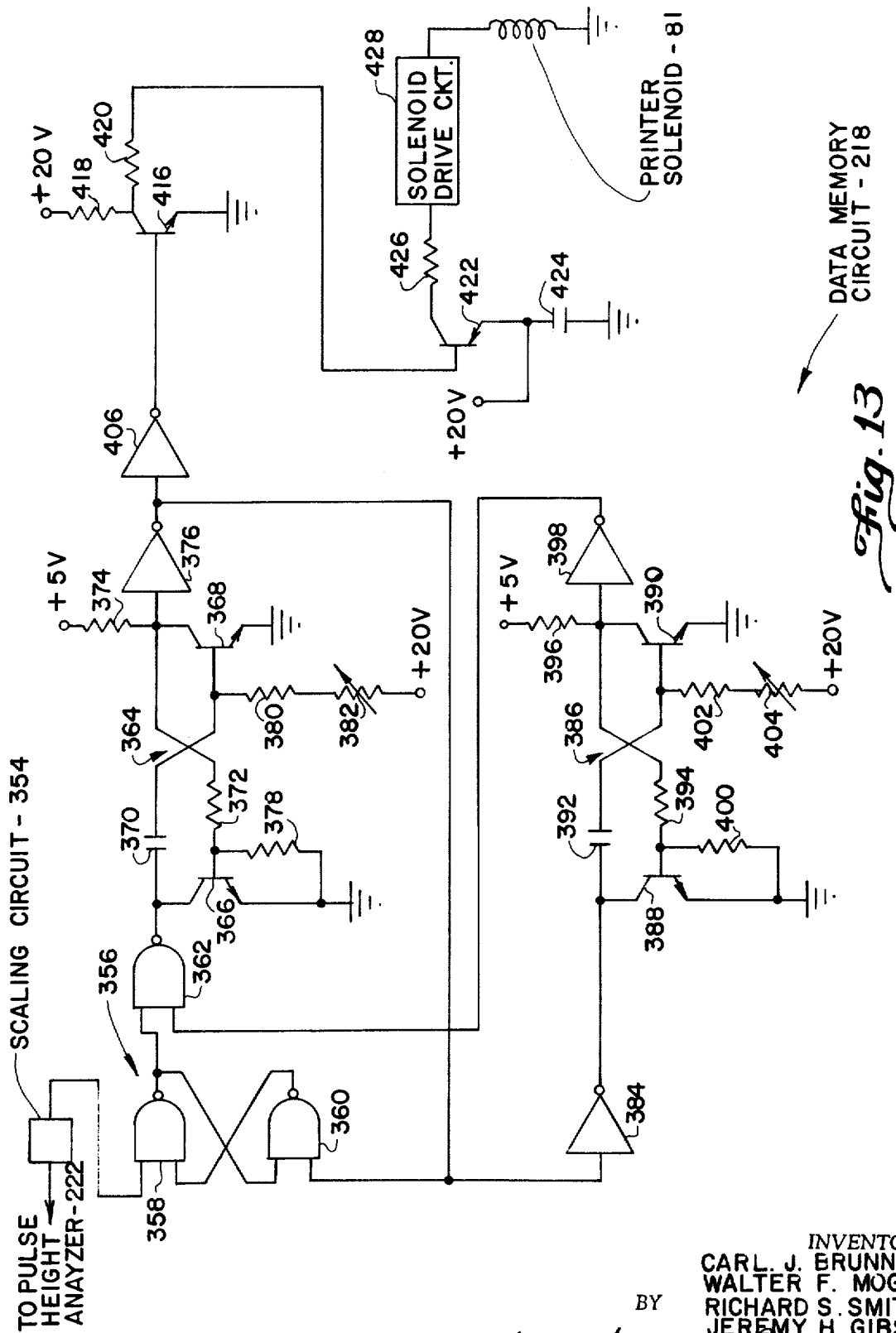
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HIGH SPEED COLOR PRINTER FOR SCINTILLATION SCANNER

CROSS REFERENCE TO RELATED PATENTS AND APPLICATION

SCINTILLATION SCANNER, U.S. Reissue Pat. No. 26,014, reissued May 3, 1966 to J. B. Stickney et al on original U.S. Pat. No. 3,070,695 issued Dec. 25, 1962. This patent will be referred to as the Apparatus Patent.

SCINTILLATION SCANNER PHOTO-CIRCUIT, U.S. Pat. No. 3,159,744 issued Dec. 1, 1964 to J. B. Stickney et al. This patent will be referred to as the Circuit Patent.

AUTOMATIC CALIBRATION SYSTEM FOR A SCINTILLATION DEVICE AND METHOD OF OPERATION U.S. Pat. No. 3,732,420 issued May 8, 1973 to Carl J. Burnnett and Basil N. Ioannou. This patent will be referred to as the Calibration System Patent.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to scintillation scanners and more particularly to an improved scintillation scanner including a color printer recording system.

2. Prior Art

In a number of modern medical diagnostic procedures a quantity of radioactive substance is administered to a patient. The distribution of the radioactive substance in the patient's body is then studied. Such studies are useful for many purposes such as locating cancerous tissue and determining the condition of body organs such as the thyroid gland.

Mechanisms known as "scintillation scanners" have commonly been used to conduct such tracer studies. They include a means to move a scintillation probe over an area being studied and a means to provide a graphic reproduction of the activity measured by the probe.

The scintillation scanner of the referenced Apparatus Patent comprises a portable unit which can readily be moved to a patient's bed or other location where a study is to be conducted. The scintillation probe is supported in cantilevered fashion over the patient or other object to be studied. The probe is movable manually to a desired location whereupon its supporting boom is operably connected to an automatic drive to move the probe through a predetermined geographic pattern for a tracer study. The scan is then conducted by moving the probe at a selected speed across a series of parallel paths which are at selected spaced intervals.

A light source and a printing mechanism are carried by the boom and move simultaneously with it. This simultaneous movement permits production of both a printed composite dot graph and a photographic reproduction of the distribution of the isotopes over an area under investigation.

A number of color printer devices have been proposed for use in producing the printed composite dot graph recording. Such color printers serve to print dots of increasingly brighter colors as the intensity of the radiation sensed by the detector increases. By this arrangement, radiation "hot spots" and "holes" are more vividly indicated to the doctor to facilitate a semi-quantitative interpretation of the dot graph.

One problem commonly encountered with such color printers is that they have a relatively low printed speed

capability. Since an ink ribbon wide enough to accommodate a plurality of colors is used, a certain amount of time is involved in moving the ribbon from side to side for color change during printing. In one prior art design, the entire ribbon along with the ribbon support spools and spool drive motors are shifted laterally as a unit to achieve color shifting. Such an arrangement has the disadvantage of providing a large mass, the inertia of which impedes extremely high speed color shifting.

In order to reduce the inertia of the ribbon shifting mechanism, another prior art design pivots the entire ribbon drive system with the larger mass components disposed along the pivot axis to reduce the moment of inertia. While such an arrangement does serve to provide a color shifting system which is faster in operation, it introduces a new problem.

The multi-colored inked ribbon commonly used in color printers is relatively wide, on the order of 1½ to 2 inches in width. In order to prevent ribbon wrinkling, the ribbon must be disposed in a flat planar fashion in the region adjacent the printing stylus. Pivotal mounting of this planar printing region results in a height change of the planar region during pivoting, i.e., the spacing between the ribbon and the printing surface changes depending on which ribbon color is aligned with the printing stylus. In order to accommodate this ribbon height change, the space between the stylus and the printing surface must therefore be increased. Consequently, the stylus must move a greater distance during the forward and reverse portions of each printing stroke. Hence, printing speed is substantially diminished.

Another problem commonly encountered with known color printers is that the printing stylus design itself imposes a restrictive upper limit on printing speed. A number of such stylus designs include a power driver device having a movable armature rigidly secured to a printing stylus or chisel. While the armature and chisel may be designed with minimal mass to facilitate rapid cycling, the combined inertia of the chisel and the armature imposes restrictive upper limits on printing speed which are not easily overcome.

Another drawback of known color printers is that they fail to provide a capability to spread their available color spectrum over any selected variation in measured radiation intensity. Hence, it is not possible to enhance the color presentation of the composite image over a limited measured radiation range. To describe this drawback in another way, where it may be desirable to distinguish by a variation in color presentation a relatively small variation in measured radiation intensities, the color printer may lump them all into the same color range and print them all in the same color.

Still another problem with known color printers is their exceptionally loud and noisy operation. It should be appreciated that a scintillation scanner complete with color printer unit is operated immediately adjacent a patient. The detector of the scanner is disposed over the patient and the control console including the color printer is positioned alongside the patient. When the scanner is set into operation, the calm of the hospital environment is suddenly broken by the rapid-fire action of a typewriter-like printer banging dots onto a piece of paper at rates upwardly of 150 print-outs per second. This can be disquieting to an already ill patient.

The noise problem attendant high speed printing is aggravated by the need for a relatively hard printing surface to bounce the printing chisel or stylus back to

its home position. If a soft or mushy printing surface is provided, printing speed is significantly reduced. Known color printers have attempted to reduce noise levels by providing a hard rubber pad for the printing surface. This has done little to reduce the noise of the printing operation.

Still another problem with known color printers is the difficulty encountered in changing a printing stylus. It is desirable to perform some scans with a stylus of narrow width, and to perform other scans with a stylus of wide width. The narrow width stylus is used where an organ being scanned is relatively small and a high resolution image is needed. The wider width stylus is desirable where the scan is to include a significant portion of the patients body and high resolution is not needed.

Prior art color printers have provided a single stylus driver with interchangeable stylus chisels. It should be realized that these chisels are quite small in size and that they are positioned for operation in a closely confined area. These factors render the chisel changing operation difficult, calling for nimble fingers of a skilled and patient operator. The operation is somewhat akin to cleaning a typewriter, in that it is messy. The chisel which is not in use frequently becomes misplaced. And improperly installed chisels have a propensity for short life. All these factors tend to discourage frequent switching from one chisel size to another.

Another problem with known color printers relates to the ribbon drive reversal systems they commonly employ. Most such ribbon reversal systems employ feeler-type sensors which engage the ribbon being unwound from a spool so as to sense depletion of the ribbon supply. Such sensors frequently become bent or otherwise require adjustment. Ribbon reels also vary somewhat in tolerance such that their position relative to the sensor may vary. Such variance either results in ribbon end portions which remain used, or in the ribbon becoming completely unwound and disengaged from one of the reels.

Still another problem with known color printers is that the wide printing ribbon tends to wrinkle and to "walk" laterally of its feed path. The rapid lateral movement of the ribbon combined with the high speed vibration of the ribbon by the printing stylus aggravates these tendencies. Hence, the stability of the ribbon feed system on known color printers leaves something to be desired.

The above problems may largely be summarized by the observation that while scanners have consistently been improved to provide accurate scanning at increasingly higher scan speeds, color printers have not been available which will operate satisfactorily at these increased scan speeds.

SUMMARY OF THE INVENTION

The present invention overcomes the foregoing drawbacks of the prior art and provides a scintillation scanner with a novel and improved high speed color printer.

In accordance with one aspect of the present invention, an extremely low mass ribbon shifting mechanism is provided. Instead of shifting the entire ribbon and ribbon drive components, as has been done in the prior art, the present invention serves to shift only a small portion of the ribbon. Hence the inertia of the ribbon shifting system is minimized to maximize printing speed.

The ribbon shifting operation is performed in a translatory manner to minimize stylus to printing surface distance. The ribbon is not pivotally mounted for lateral movement as has been done in the prior art, but rather is held taut in a planar fashion and translated between the closely spaced stylus and printing surface.

The printing surface which supports a sheet of paper to receive ink from the ribbon is of novel design. An aluminum baseplate provides a rigid, flat foundation. A polyethylene block is secured atop the baseplate. This block is of the order of $\frac{3}{4}$ inch of 1 inch in thickness, and serves to deaden the sound of the printing operation. Atop the polyethylene block is a sheet of relatively hard polyurethane. The polyurethane provides a surface of sufficient hardness to bounce or rebound the stylus during printing. By this arrangement, a printing surface is provided which has outstanding sound deadening capacity.

In accordance with another feature of the printing surface construction, the top layer of polyurethane is removably and replaceably secured to the underlying polyethylene block by adhesive. This permits the top printing surface to be easily replaced should it become damaged.

The color printer of the present invention is provided with a pair of selectively operable printing stylus assemblies. One is of narrow width, and the other of wide width. These stylus assemblies are disposed side-by-side along the ribbon feed path. By this arrangement, the need to physically change stylus elements is obviated.

The stylus assemblies are also of novel and vastly improved design. Instead of a rigidly connected driving armature and chisel arrangement, such as has been used in known color printers, the present invention provides a hammer-and-anvil armature and chisel arrangement. A solenoid is provided with an armature having a stroke of sufficient length to positively drive the chisel or stylus downwardly from its retracted position to its printing position. [The armature may then part company with the chisel so as to return to and become settled in its retracted position prior to the chisel. The chisel is spring biased for return to its retracted position.]

During the return stroke of the chisel, the armature can be re-cycled so as to impact the chisel before the chisel has entirely returned to its retracted position. By this arrangement, the chisel or stylus may never return entirely to its retracted position during printing, but rather is hammered back into operation during its return stroke. This arrangement minimizes stylus travel and permits faster printing.

The ribbon drive reversal system of the present invention is also unique. Instead of employing complicated and unreliable feeler-type ribbon sensors, a vastly improved ribbon depletion sensing system is used. Ribbon portions near each end of the printing ribbon carry small permanent magnets. Electrical reed switches are provided which are actuated by the magnets. By this arrangement, as the end of a ribbon approaches, one of the magnets passes over one of the reed switches, and a reversing signal is sent to the ribbon drive system. Such an arrangement provides a highly accurate and positive acting ribbon reversal system.

The carriage which laterally moves a portion of the printing ribbon to effect color changing includes ribbon positioning rollers of a novel design. "Walking" and

wrinkling of the ribbon is prevented by providing rollers of a length which is wider than the printing ribbon, and by tapering the ends of the rollers so as to increase the diameter of the ends of the rollers. This approach has succeeded in maintaining the ribbon in alignment along the desired feed path, where myriad of prior art proposals have been unsuccessful.

Electrical circuitry is provided which develops a train of electrical pulses representative of the value of radiation activity measured by the detector. This train of pulses is then converted to an output signal having a value representative of the number of electrical pulses developed in a predetermined time interval. A motor control signal is then developed which is representative of the output signal. This motor control signal is then fed to the carriage positioning control motor. By this arrangement the carriage is positioned in response to the intensity of the radiation detected.

A feedback circuit senses the carriage position and develops a signal representative thereof. This signal is fed to a speed control circuit which serves to attenuate the motor control signal when the carriage approaches the extremities of its travel. This prevents the carriage from impacting at the extremities of its travel.

A memory circuit is also provided for storing a signal indicative of the receipt of an electrical pulse from the detector. A gating circuit actuates the printing stylus at a predetermined period of time after a signal has been stored in the memory circuit. By this arrangement, a signal received while the stylus is in operation will be stored and utilized as soon as the stylus assembly can accommodate another printing stroke. However, only one such signal is stored, and a reset circuit is provided to reset the memory circuit upon actuation of the printing stylus.

Accordingly, it is the principal object of the present invention to provide a scintillation scanner with a novel and improved high speed color printer.

Other objects and a fuller understanding of the invention may be had by referring to the following description and claims taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a scintillation scanner including the high speed color printer of the present invention;

FIG. 2 is an end elevational view of the color printer with portions thereof broken away to illustrate detail;

FIG. 3 is a sectional view as seen from the plane indicated by the line 3—3 in FIG. 2;

FIG. 4 is an enlarged side elevational view of the carriage and carriage drive structure of the color printer, the view having some portions broken away and shown in cross section to illustrate detail;

FIG. 5 is a front elevational view of the carriage assembly of FIG. 4, the view being on the same enlarged scale as FIG. 4;

FIG. 6 is an enlarged side elevational view of the printing stylus assembly;

FIG. 7 is an end elevational view of the stylus assembly on the same enlarged scale as FIG. 6;

FIG. 8 is a sectional view as seen from the plane indicated by the line 8—8 in FIG. 7, the view being enlarged to an even greater extent than is FIG. 7;

FIG. 9 is a sectional view as seen from the plane indicated by the line 9—9 in FIG. 8, the view being on the same scale as FIG. 8;

FIG. 10 is a top plan view of a segment of the multi-colored printing ribbon employed by the color printer; and,

FIGS. 11, 12 and 13 are electrical schematic, block diagrams illustrating the electrical control system of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A. Description of Mechanical Aspects of the Color Printer

Referring to FIG. 1, a scintillation scanner is shown generally at 10. The scanner 10 includes a housing 11 supported on a base 12. A plurality of wheels 13 support the base for movement of the scanner.

A plurality of control modules 14 are mounted in the housing and have front panels which are essentially aligned with the front wall 15 of the housing 11. The control modules 14 include various operator actuated and adjusted circuits of the scintillation scanner. These circuits include a conductor 16 which transmits impulses from a scintillation probe 17. The impulses are transmitted, monitored, and amplified. The impulses are then transmitted through a conductor 18 to a color printer apparatus 19.

Suitable circuitry for these purposes is shown in the referenced Calibration System Patent, and will not be described in complete detail here. Such circuitry as forms a part of the present invention is described later in Section B of this description.

A boom 22 is supported in the upper portion of the housing 11. The boom 22 supports the scintillation probe 17 and the color printer 19. The boom 22 is supported for transverse and longitudinal reciprocation on carriage structure described in detail in the referenced Apparatus Patent. The referenced Apparatus Patent describes an automatic mechanism for driving the boom 22 in reciprocal paths both longitudinally and transversely. Suitable indexing control circuitry for causing the boom to reciprocate longitudinally at any of a wide range of selected speeds, as well as circuitry for transversely indexing the carriage any selected distance within a wide range of distances is also described in the referenced Apparatus Patent. These boom support and drive systems do not form a part of the present invention and accordingly will not be described here.

Referring to FIGS. 2 and 3, the color printer 19 is shown as comprising a housing 30 secured to the boom 22. Disposed within the housing is a removable ribbon cassette 31. The cassette 31 mounts a pair of ribbon support reels 32, 33 upon which the ends of a ribbon 34 are wound.

The ribbon 34 passes over a pair of idler rollers 35 journaled at opposite ends of the cassette. From the region of the guide rollers, an intermediate portion of the ribbon passes downwardly to the region of a movable ribbon positioning carriage 40.

A pair of ribbon guide rollers 41, 42 are journaled at opposite ends of the carriage 40. The ribbon 34 is reeved around the guide rollers 41, 42. Intermediate the guide rollers 41, 42, the ribbon 34 passes through a support 43 which serves to hold a portion of the ribbon taut in a planar fashion. As will be explained in greater detail, the portion of the ribbon positioned

the support 43 is used to print an image on a sheet of paper disposed beneath the support.

A separate drive motor is provided for rotating each of the ribbon support reels 32, 33. These motors are selectively energizable to wind the ribbon 34 selectively onto either reel 32 or reel 33. The directions of ribbon movement through the support 43 depends upon which of the drive motors is in operation.

One of these drive motors and its driving connection to one of the ribbon support reels is illustrated in FIG. 3. A motor 45 is mounted within the housing 30. The motor 45 has a drive shaft 46 which extends through an aperture in the housing 30. A drive coupling 47 is rigidly mounted on the drive shaft 46. The coupling 47 carries a transversely extending drive pin 48. The drive pin 48 is carried in a slot, not shown, so as to be movable axially relative to the coupling 47 a limited distance. A spring 49 carried interiorally of the coupling biases the drive pin 48 toward the ribbon support reel 31. The ribbon support reel 32 is provided with a slot, not shown, which is engaged by the pin 48 to provide a driving connection between the motor 45 and the reel 31.

In order to effect reversal of the ribbon drive system upon depletion of the ribbon supply from one of the reels 32, 33, permanent magnets are carried on opposite ends of the ribbon 34. One of these magnets is illustrated at 50 in FIGS. 2 and 10. A pair of magnetically responsive reed switches 51 are carried by the housing 30 and positioned adjacent the path of travel of the ribbon 34. These switches 51 are connected through appropriate relay circuitry, not shown, to the ribbon drive motors. When one of the magnets 50 passes one of the reed switches 51, a signal is sent which de-energizes whichever of the ribbon drive motors is then in operation, and energizes the other ribbon drive motor. This causes the ribbon to reverse directions.

Referring to FIG. 10, the ribbon 34 is shown in greater detail. Eight side-by-side longitudinally extending color bands 34a, 34b, 34c, 34d, 34e, 34f, 34g, and 34h are provided. The inner color bands 34b, 34c, 34d, 34e, 34f, and 34g are of a lateral width slightly greater than the narrow dimension of the printing chisels, which will be described below. The outer color bands 34a, and 34h are of a somewhat greater width to engage enlarged end portions formed on the guide rollers 41, 42, as will also be explained in detail below.

The ribbon positioning carriage 40 is illustrated in greater detail in FIGS. 4 and 5. The carriage 40 comprises a movably mounted frame 61 which mounts the ribbon guide rollers 41, 42 and the ribbon support 43. The frame 61 carries three roller bearings 62 which serve to support the frame at three points. The bearings 62 slidably receive a pair of rods 63.

The rods 63 are carried by a bracket 64 and positioned in parallel alignment with their axes extending in a direction transverse to the ribbon feed path. The bracket 64 has an upwardly extending projection 65, as best seen in FIG. 5. The projection 65 is secured to a mounting plate 66. The mounting plate 66 is, in turn, secured to the housing 30. By this arrangement, the carriage frame 61 is provided with bearing connections which permit its translation forwardly and rearwardly in directions transverse to the path of ribbon travel.

A carriage drive motor 120 is mounted on the mounting plate 66. The motor 120 has a drive shaft 121 which

carries a drive pinion 122. A toothed rack 123 is carried by the frame 61 for engagement with the pinion 122. By this arrangement, rotation of the motor drive shaft 121 will cause the carriage 40 to move along the guide rods 63.

The circuitry which serves to control the operation of the motor 120, and hence the position of the carriage 40, will be described later in detail. One component of such circuitry is a variable potentiometer 124, shown in FIG. 5. The potentiometer 124 has a control shaft 125 coupled by means of a flexible coupling 126 to the motor drive shaft 121. By this arrangement, the potentiometer 124 serves to sense the position of the carriage 40.

In accordance with one feature of the present invention, the ribbon guide rollers 41, 42 are of a novel configuration. As will be apparent, the portion of the ribbon 34 which is disposed between the rollers 41, 42 is subjected to a great deal of vibration during printing. The ribbon is also oscillated rapidly from side to side by the carriage 40. These ribbon movements have, in the past, resulted both in wrinkling of the ribbon and in "walking" of the ribbon along the guide rollers.

The novel guide rollers of the present invention have enlarged diameter end portions 70 in the form of truncated cones. Extending between the enlarged end portions is a region 71 of constant diameter. The length of the constant diameter region is slightly less than the width of the ribbon 34. By this arrangement the side portions 34a, 34h of the ribbon 34 are caused to ride slightly upwardly on the end portions 70. This serves to keep the ribbon taut and aligned centrally with the rollers 42 and the support 43.

Referring to FIG. 3, a table or platform 55 is provided beneath the ribbon support 43 of the color printer 19. In operation, a piece of paper, not shown, is supported by the table 55 and an image is printed on the paper by the color printer 19. The table 55 is of a novel construction which serves to substantially reduce the noise made by the printer during operation. A base plate 56 extends beneath the entire width and length of the table. The base plate has a planar top surface and serves to provide a rigid planar support. In the preferred embodiment, the base plate 56 comprises an aluminum plate of at least $\frac{3}{4}$ inch thickness.

Atop the base plate 56 is a block 57 of porous, resilient, noise absorbing material. The noise absorbing block 57 serves to prevent the direct transmission of printing noise to the base plate 56. In the preferred embodiment, the block 57 comprises a sheet of polyethylene which is at least $\frac{3}{4}$ inch in thickness.

Atop the noise absorbing block 57 is a sheet 58 of material which provides a relatively hard, flat printing surface. In the preferred embodiment, the sheet 58 comprises polyurethane of approximately 1/64 inch in thickness. The polyurethane sheet 58 is removably and replaceably secured to the block 57 by adhesive. Such an arrangement provides a table construction which substantially reduces the noise of the printing operation without sacrificing a hard printing surface.

In accordance with another feature of the present invention, a stylus assembly 74 is provided including a pair of solenoid-driven stylus units 75, 76. Referring to FIGS. 6 and 7 the stylus assembly includes a mounting bracket 77. The mounting bracket 77 includes a centrally disposed depending projecting 78 which extends in a plane perpendicular to a rearwardly disposed

mounting portion 79. The mounting portion 79 is apertured at 80 to receive suitable fasteners, not shown, for securing the mounting bracket 77 to the mounting plate 66.

The stylus units 75, 76 include solenoids 81, 82. The solenoids 81, 82 are secured to the central projection 78 by threaded fasteners 83. The solenoids 81, 82 include axially movable armatures 85, 86 positioned for movement in vertical directions relative to the mounting bracket 77.

The chisels 91, 92 are of different printing widths. The chisel or stylus 91 is of relatively narrow width, while the chisel or stylus 92 is of relatively wide width. In the preferred embodiment, the chisel 92, is twice as wide as the chisel 91. Such an arrangement corresponds to scanning sequences employing adjacent scan paths which are spaced apart by either a distance X or a distance 2X, where X is the width of the narrower chisel.

The chisels 91, 92 are mounted in identical fashion by the bearing block 93. Accordingly, FIGS. 8 and 9 illustrate in detail the mounting of only one of the chisels, namely the chisel 92. The bearing block assembly comprises a sandwich-like arrangement of three plates 101, 102, 103 secured to the mounting bracket 77 by means of fasteners 104. The plates 102, 103 define channels 105 which slidably receive opposite sides of the stylus 92. By this arrangement, the stylus 92 is mounted so as to be vertically movable relative to the bearing block 93.

Each stylus has a longitudinally extending central slot, within which is carried a spring. For instance, the stylus 92 is provided with a slot 108. A compression coil spring 109 is positioned within the slot. The upper end of the coil spring 109 engages the upper end of the slot 108. The lower end of the spring 109 engages a compression adjusting bracket 110. A rod 111 carried by the stylus extends through the spring 109 to maintain the spring in place and restrain it from deflecting laterally.

As is seen in FIG. 8, the compression adjusting bracket 110 extends through aligned apertures 112 in the plates 102, 103 and the mounting bracket 77. A yoke-shaped end 113 receives the rod 111 and engages the spring 109. The compression adjusting bracket 110 is secured to the mounting bracket 77 by fasteners 114. By loosening the fasteners 114 the bracket 110 is rendered movable within the aligned apertures 112 so as to adjust the compression loading of the spring 109. By such an arrangement, the chisels 91, 92 are adjustably biased into engagement with the armature hammers 95, 96.

[The armature hammers 95, 96 comprise a resilient material such as polyethylene which will serve to dampen chisel vibration relative to the armatures. The resilient nature of the armature hammers also serves to reduce noise of the printing operation.] A significant feature of the stylus units 75, 76 of the present invention is that the solenoid armatures 85, 86 each has a stroke of sufficient length to positively drive its respective chisel or stylus to the printing position. Hence, while the armature hammer and the stylus may part company during a portion of the return stroke of these elements from the printing position, they maintain positive driving engagement during movement toward the printing position. To described the printing action in another way, it can be said that in the preferred em-

bodiment of the present invention, the stylus does not become a free moving projectile during the printing stroke.

Prior art printers of various types employ separate armature and stylus elements designed to move the stylus as a projectile during the printing stroke. While a projectile-type stylus design does facilitate printing speed in some applications, it has a number of drawbacks which the present invention overcomes. In order to attain uniformity in printing, a projectile-type stylus must be uniformly impacted during each printing stroke to assure that it will engage the ribbon and form a uniform image. This substantially means that the stylus must return to its fully retracted position at the end of each cycle so as to be uniformly impacted during each stroke. The present invention assures that a positive printing action will take place no matter what position the stylus may be in when it is impacted by its driving armature. Hence, by positively driving the stylus into its printing position, the need for the stylus to return to its fully retracted position between printing operations is obviated.

Since the armature and the stylus are separable, the armature is permitted to disengage the stylus during a portion of its return stroke. Hence, the armature may return to and becomes settled in its fully retracted position and reverse to effect another printing operation before the stylus has fully returned to and become settled in its retracted position. By this arrangement, the distance the stylus must move during printing is substantially decreased providing a substantial increase in printing speed.

[The armatures 85, 86, are provided with bumper pads, not shown, to dampen their vibration upon their return to their retracted positions. By such an arrangement, the armatures 85, 86 become settled in their retracted positions much faster than do the chisels 91, 92. In addition to dampening the vibration of the armatures, these bumper pads also serve to reduce the noise of the printing operation.]

B. Description of the Electrical Circuitry for the Color Printer

FIGS. 11, 12 and 13 illustrate the electrical control system of the preferred embodiment in conjunction with a scintillation scanner. The control system generally comprises a data circuit 210, a calibration circuit 212, a mode control circuit 214, a contrast enhancement and intensity control circuit 215, a carriage motor speed control circuit 216 and a data memory circuit 218. More particularly, and with reference to FIG. 11, the input terminal of the data circuit 210 is coupled to the output of a radiation detector probe 220 through a pulse height analyzer 222. The output terminal of the pulse height analyzer 222 is connected to a rate meter 224 and to a pulse duration circuit 226 in the light source control circuit 218. The radiation detector probe 220, pulse height analyzer 222, and rate meter 224 are conventional elements and are described in more detail in the referenced Circuit Patent.

The output of the pulse height analyzer 222 is connected to one of the input terminals of an AND gate 228 having its other input terminal connected to a mode control 230. The output of AND gate 228 is connected to the input terminal of a data counter 232 and the output terminals of the data counter 232 are con-

nected to a data storage register 234 and a reference storage register 236.

The output terminals of the data storage register 234 are connected to a digital-to-analog converter 238 having its output terminal connected to the input terminal of a differential amplifier 240. The output terminals of the reference storage register 236 are connected to the terminals of a normalizing circuit 242 having its output terminal connected to the input of a differential amplifier 244. The output terminal of the differential amplifier 244 is fed back to the digital-to-analog converter 238 and to the normalizing circuit 242 in order to modify the signals developed in these circuits in response to the number of counts stored in the reference storage register 236. The output terminal of the differential amplifier 240 is connected to a differential amplifier 246 in the contrast enhancement and intensity control circuit 215. The contrast enhancement and intensity control circuit 215 also includes a contrast potentiometer 247 having a movable contact coupled to the non-inverting input terminal of amplifier 246 and a stationary contact connected to the output of amplifier 240. The other stationary contact of the contrast potentiometer 247 is connected to a reference voltage source and through a resistor 249 to the inverting input terminal of amplifier 246.

The mode control 230 is generally comprised of circuitry for gating appropriate ones of a plurality of AND gates in response to selected modes of operation, to wit, "calibrate" mode and "normal" mode. The mode control 230 also serves to strobe the reference register 236 at the appropriate time to cause the stored binary-coded-digital information to be transferred from the reference storage register 236 to the normalizing circuit 242.

Accordingly, the mode control circuit 230 in addition to being connected to one of the input terminals of the AND gate 228, is connected to one of the input terminals of the AND gates 248, 250, 252, as well as the transfer terminal of the reference storage register 236. The other input terminal of the AND gate 248 is coupled to the output terminal of a binary point counter 254; the other input terminal of the AND gate 250 is coupled to the output terminal of a delay circuit 256 in the motor drive circuit 198; and the other terminal of the gate 252 is connected to the output of a scaling circuit 260 in the motor drive circuit 198.

The AND gate 248 is shown as a single AND gate in FIG. 11 for purposes of illustration, but in practice takes the form of a plurality of AND gates as will be described subsequently. This AND gate sets the binary point in the data counter 232 in response to the number of counts contained in the binary point counter 254. As illustrated, the output terminal of the AND gate 250 is connected to the reset terminal of the data counter 232 and the output terminal of the AND gate 252 is connected to the input terminal of the binary point counter 254. Thus, the mode control 230 gates the AND gate 228 to allow data to be transferred from the pulse height analyzer 222 to the data counter 232, gates the AND gates represented by the AND gate 248 to allow the transfer of binary point data from the binary point counter 254 to the data counter 232, and gates the AND gate 252 to allow data from the scaling circuit 260 to be transferred to the input of the binary point counter 254. Also, the mode control 230 in conjunc-

tion with the delay circuit 256, gates the AND gate 250 to reset the data counter 232.

A control line connects the binary point counter to the mode control 230. The output terminal of the scaling circuit 260 is connected to the delay circuit 256 and to the transfer terminal of the data storage register 234.

The input terminal of the scaling circuit 260 is connected to the output of a variable oscillator circuit 262. The variable oscillator circuit 262 is also coupled through a motor drive circuit 267 to a stepping motor 266 for controlling the movement of the detector probe 220 along a rectilinear path of travel. As illustrated, the frequency of the oscillator circuit 262 is controlled by a motor speed control 268 in order to vary the rate of travel of the probe 220. Accordingly, the motor speed control 268 not only varies the rate of travel of the probe 220, but also by setting the frequency of oscillation of the oscillator circuit 262, selects the time interval for counting the data representative of radiation activity.

The output of the differential amplifier 246 is connected through a feedback resistor 270 to the juncture point between the reference source and the resistor 249 and is also connected to one of the stationary contacts of an intensity potentiometer 272 having its other stationary contact connected directly to ground. The movable contact of the potentiometer 272 is connected to the non-inverting input terminal of a differential amplifier 274 in the carriage motor speed control circuit 216.

The inverting input terminal of differential amplifier 274 is connected through a variable resistor 276 to ground, and the output terminal of this amplifier is connected through a feedback resistor 278 to the inverting input terminal. Also, the output terminal of amplifier 274 is connected through a resistor 280 to the inverting input terminal of a differential amplifier 282 having its output terminal connected through a feedback resistor 284 to the inverting input terminal. The non-inverting input terminal of the amplifier 282 is connected through a resistor 286 to ground. Also, the output terminal of the differential amplifier 282 is coupled through a resistor 288 to the input terminal of a power amplifier 290.

As discussed earlier, the control shaft of the potentiometer 124 is positioned in accordance with the position of the carriage 40 so that signals developed across this potentiometer are representative of the actual position of the printing ribbon. One of the stationary contacts of the potentiometer 124 is coupled to the reference source and the other stationary contact of this potentiometer is connected directly to ground. The movable contact of potentiometer 124 is connected to the non-inverting input terminal of an amplifier 292 having its output terminal connected through a feedback resistor 294 to the non-inverting terminal of its amplifier. The inverting input terminal of amplifier 292 is also connected through a resistor 296 to ground and through a resistor 298 to the reference supply source. Also, the output terminal of amplifier 292 is connected to the juncture point between the non-inverting input terminal of the amplifier 282 and the resistor 286, and through a resistor 300 to the inverting input terminal of a differential amplifier 302.

The non-inverting input terminal of amplifier 302 is connected to the output terminal of the amplifier 274

and the output terminal of amplifier 302 is connected through a feedback resistor 304 to the inverting input terminal of this amplifier. Also, the output terminal of amplifier 302 is connected through a resistor 306 to the input terminal of a second power amplifier 308.

The juncture point between the non-inverting input terminal of the amplifier 282 and the resistor 286 is connected to the inverting input terminal of a differential amplifier 310 and to the non-inverting input terminal of a differential amplifier 312. As illustrated, the non-inverting input terminal amplifier 310 is connected through a resistor 314 to the inverting input terminal of the amplifier 312, the inverting input terminal of amplifier 312 is connected through a resistor 316 to ground, and the non-inverting input terminal of amplifier 310 is connected through a resistor 318 to the reference supply source.

The output terminal of the differential amplifier 310 is fed back through a feedback resistor 320 to the non-inverting input terminal of this amplifier; is coupled through a capacitor 322 to ground; and is connected to the base terminal of an NPN transistor 324. Similarly, the output terminal of the differential amplifier 312 is fed back through a feedback resistor 326 to the non-inverting input terminal of this amplifier; is coupled through a capacitor 328 to ground; and is connected to the base of an NPN transistor 330.

The collectors of transistors 324, 330 are respectively connected through resistors 332, 334 to a positive 20 volt supply source, the emitters of these transistors 324, 330 are connected directly to ground, and the collectors of the transistors 324, 330 are respectively connected to the base terminals of a PNP transistor 336 and a PNP transistor 338.

Additionally, the collector of the transistor 338 is connected through a diode 340, polarized as shown in FIG. 12, to the input terminal of the power amplifier 290, and the collector of transistor 336 is connected through a diode 342, polarized as shown in FIG. 12, to the input terminal of the power amplifier 308. The emitter of transistor 338 is connected through a resistor 344 to the cathode of a diode 346 having its anode connected to the input terminal of the power amplifier 308, and the emitter of transistor 336 is similarly connected through a resistor 348 to the cathode of a diode 350 having its anode connected to the input terminal of the power amplifier 290.

The output signals developed by the power amplifiers 290, 308 are connected to a carriage motor control circuit 352 having its output terminal connected to the carriage positioning motor 120.

Reference is now made to FIG. 13 which illustrates the data memory circuit 218. More particularly, the memory circuit 218 is comprised of a scaling circuit 354 having its input terminal connected to the output terminal of the pulse height analyzer 222 and its output terminal connected to one of the input terminals of a dual NAND gate flip-flop 356 which includes the NAND gates 358, 360. The output terminal of the NAND gate 358 is coupled to one of the input terminals of a NAND gate 362 having its output terminal connected to a variable frequency bistable multivibrator 364.

The bistable multivibrator 364 includes a pair of NPN transistors 366, 368 having common grounded emitters. The collector of the transistor 366 is connected to the output terminal of the AND gate 362 and

is also coupled through a capacitor 370 to the base of the transistor 368. As illustrated, the collector of transistor 368 is connected through a resistor 372 to the base of transistor 366, is connected through a resistor 374 to a positive 5 volt supply source, and is connected to the input terminal of an inverter 376. The base of transistor 366 is connected through a resistor 378 to ground and the base of the transistor 368 is connected through a series connected resistor 380 and variable resistor 382 to a positive 20 volt supply source. Thus, the frequency of the bistable multivibrator 364 may be controlled by varying the resistance of the variable resistor 382.

The output of the inverter 276 is fed back to one of the input terminals of the NAND gate 360 or the set terminal of the flip-flop 356. Additionally, the output of inverter 376 is coupled through an inverter 384 to a second variable frequency bistable multivibrator 386.

The bistable multivibrator 386 generally includes a pair of NPN transistors 388, 390 having common grounded emitters. The collector of transistor 388 is connected to the output terminal of the inverter 384 and is coupled through a capacitor 392 to the base of the transistor 390. The collector of transistor 390 is connected through a resistor 394 to the base of transistor 388, is connected through a resistor 396 to the positive 5 volt supply source, and is connected to the input terminal of an inverter 398. Additionally, the base of transistor 388 is connected through a resistor 400 to ground and the base of transistor 390 is connected through a series-connected resistor 402 and variable resistor 404 to a positive 20 volt supply source. As before, the frequency of oscillation of the bistable multivibrator 386 may be controlled by varying the resistance and the variable resistor 404.

The output terminal of inverter 398 is fed back to one of the input terminals of the NAND gate 362.

The output terminal of the inverter 376 is also connected to the base of an NPN transistor 416.

The emitter of transistor 416 is connected directly to ground and the collector of this transistor is connected through a resistor 418 to the positive 20 volt supply source. Also, the collector of transistor 416 is connected through a resistor 420 to the base of a PNP transistor 422 having its emitter connected directly to the positive 20 volt supply source. The emitter of transistor 422 is also coupled through a capacitor 424 to ground, and the collector of this transistor is connected through a resistor 426 to the input of a solenoid drive circuit 428. The output terminal of the solenoid drive circuit 428 is connected to one of the terminals of the printer solenoid 81 and the other terminal of this solenoid is connected directly to ground.

A circuit (not shown) similar to the circuitry including transistors 416, 422 and solenoid drive circuit 428 is employed to drive the printer solenoid 82.

In the operation of the control system, the mode control 230 is set to "calibrate" which causes signals to be applied to the AND gates 228 and 252 thereby causing these gates to open and allow data to be transferred through the gates. During the calibrate mode, the AND gates 248 and 250 remain closed thereby preventing the transfer of data through these gates.

For automatic calibration, the detector probe 220 is manually positioned over the organ under examination until a maximum reading is obtained by the indicator on the rate meter 224. The electrical pulses developed

by the detector probe 220 are then applied through the pulse height analyzer 222 and the AND gate 228 to the data counter 232. The data counter 232 begins counting electrical pulses in the train of pulses for a predetermined integration interval or integration distance.

The integration interval terminates on the occurrence of two events, to wit, the data counter has completed a count of at least 256 counts and the binary points counter 254 has reached a count of 2^N where N is an integer. In other words, the data counter 232 continues to count data representative of radiation activity at the "hot spot" until the number of counts in the data counter 232 and binary point counter 254 have satisfied the required conditions. The operation of the data counter 232 and the binary point counter 254 is described in more detail in the referenced application.

Once the required conditions have been satisfied, AND gates 228 and 252 are closed thereby preventing additional data from being transferred into the data counter 232 and the binary point counter 254. The binary data in the data counter 232 is then transferred to the reference storage register 236 where that information is then stored. Signals representative of the data count stored in the reference storage register 236 are then applied to the normalizing circuit 242, which in turn applied an analog signal through the amplifier 244 to the digital-to-analog converter 238 to modify the signals developed by the digital-to-analog converter 238 during the normal scanning operation.

For normal scanning operation, the mode control 230 is set at "normal operation" which causes the AND gates 228, 248 and 250 to open and the AND gates 252 to remain closed. During normal scanning operation, data from the pulse height analyzer 222 is applied through the AND gate 228 to the data counter 232. The data counter 232 is allowed to count for an integration interval or integration distance which is selected by the motor speed control 268. Thus, after a predetermined number of oscillations by the oscillator circuit 262, the scaling circuit 260 develops a pulse which causes data to be transferred from the data storage register 234 to the digital-to-analog converter 238. After a preselected interval of time, the delay circuit 256 develops a pulse which is applied through the AND gate 250 to reset the data counter 232 for another counting operation over a second time interval. Each time interval is equal to the time the detector probe 220 remains in a given position before being moved by the stepping motor 66 an incremental distance. The data counter 252 is reset at a predetermined delay time after actuation of the stepping motor 266 to the next incremental position.

The binary information from the data storage register 234 is applied to the digital-to-analog converter 238. The converter 238 develops an analog signal having a value representative of the pattern of binary signals applied to the converter. The analog signal developed by the digital-to-analog converter 238 is modified by the signal developed by the amplifier 244 in the calibration circuit 212 so that the analog signal developed by the converter 238 remains within a predetermined range of values even though this signal has a value representative of the data applied to the converter by the data storage register 234. The operation of the digital-to-analog converter 238 and the normalizing circuit 242 is also described in more detail in the referenced Calibration System Patent.

The analog signal developed by the digital-to-analog converter 238 is applied through an amplifier 240 to the contrast enhancement and intensity control circuit 215.

The contrast of the output presentation developed by the high speed printer may be either increased or decreased by varying the potentiometer 247 in order to vary the signal applied to differential amplifier 246. The output signal developed by the differential amplifier 246 when applied through the carriage motor speed control circuit 216 shifts the color ribbon such that an appropriate color band is beneath the stylus. Thus, as the position of the potentiometer 247 is varied, the maximum output signal developed by the differential amplifier remains equal to the reference voltage source coupled to the input terminal of the amplifier, however, the overall amplification of the amplifier may be varied. Accordingly, by increasing the gain of this amplifier, the net effect is that the color bands on the ribbon are shifted to respond to higher or lower levels of radiation intensity. In this manner, the contrast of a desired range of radiation levels may be substantially enhanced. Since the potentiometer 247 is coupled to the reference voltage source, the position of the potentiometer has no effect on the intensity of the light source at the "hot spot" or the calibration point.

The intensity potentiometer 272 serves to attenuate the signals developed by the amplifier 246 so that the relative intensity of the output presentation developed by the color printer may be controlled. Accordingly, once the scanner has been calibrated at a "hot spot" or a calibrate point, the instrument remains calibrated regardless of variations in color enhancement or intensity.

The signal developed by the position sensitive potentiometer 124 which is representative of the actual position of the carriage 40, is applied to the amplifier 292. The amplifier 292 serves to amplify this signal, and in turn applies this signal to two comparator circuits including the differential amplifiers 282, 302.

The signal developed by the potentiometer 272 in the contrast enhancement and intensity control circuit 215 is an analog signal representative of a ribbon carriage position representative of the measured radiation intensity. This signal is amplified by the amplifier 274 and is also applied to the input terminals of the two comparator circuits including the differential amplifiers 282, 302.

The comparator circuits comprised of amplifiers 282, 302 serve to compare the value of the signal representative of the actual carriage position, the signal developed by the amplifier 292 to the value of the signal representative of a desired carriage position, i.e., the signal developed by the amplifier 274, and develop output signals which are applied to the power amplifiers 290, 308. The signals applied to the amplifiers 290, 308 may take the form of a positive signal being applied to the amplifier 290 with respect to the amplifier 308, a negative signal applied to the amplifier with respect to the signal applied to the amplifier 308, or a 0 potential signal. These signals, when amplified, are applied to the ribbon motor control circuit 352 for driving the carriage drive motor 120 in either a forward or a reverse direction until the actual carriage position equals the desired or programmed carriage position.

The carriage motor speed control circuit 216 also includes an attenuating circuit comprised of the compar-

ator circuits including the differential amplifiers 310, 312. The resistors 314, 316, 318 serve to set the reference voltage potentials applied to the non-inverting input terminal of amplifier 310 and the inverting input terminal of amplifier 312. The signal representative of the actual carriage position, i.e., the signal developed by amplifier 292, is then applied to the inverting input terminal of amplifier 310 and to the non-inverting input terminal of amplifier 312. The amplifiers 310, 312 are biased such that when the ribbon position is approximately one-fourth inch from either extremity of travel, a corresponding one of the two comparators will change states. Then the comparator including the amplifier 310 changes state, the transistor 324 is forward biased causing transistor 336 to become forward biased to thereby couple an attenuating network including the diodes 342, 350 and resistor 348 across the input terminal of the power amplifiers 290, 308. Similarly, when the comparator including the amplifier 312 changes state, the transistor 330 becomes forward biased thereby forward biasing the transistor 338. When the transistor 338 becomes forward biased, an attenuating network including the diodes 340, 346 and the resistor 344 is coupled across the input terminals to the power amplifiers 290, 308.

As an example, if the ribbon is positioned such that the gray color band is under the stylus, the voltage developed by the amplifier 292 will be approximately zero voltage causing the output signal developed by amplifier 312 to take the form of a binary 1 signal, or "high" signal. This binary 1 signal will cause transistor 330 to become forward biased, and in turn forward bias transistor 338. When the carriage 40 is being driven toward the gray band, or that extremity, the signal applied to power amplifier 308 will be positive with respect to the signal applied to power amplifier 290. Thus, the attenuating network including the diodes 340, 346 and the resistor 344 will attenuate this signal. In the case of the carriage being driven away from the gray band, or that extremity, the signal developed by the power amplifier 308 will be negative with respect to the signal applied to power amplifier 290, and accordingly, the attenuating network will have no effect on the signal.

Thus, with the carriage motor speed control circuit 216, the carriage 40 is driven very rapidly to a desired position, however, as the carriage begins approaching either of its extremities of travel, the signal applied to the carriage motor is attenuated thereby causing the motor to decelerate. This deceleration prevents the carriage from slamming against the carriage stops which are positioned at the extremities of travel.

The data memory circuit 218, as illustrated in FIG. 13, generally serves to prevent the signals developed by the pulse height analyzer 222 from driving the printer solenoid 81 at a rate of speed beyond the capabilities of the solenoid. The flip-flop 356 receives pulses from the pulse height analyzer 222 through the scaling circuit 354 and, upon receipt of a pulse, applies the signal to one of the input terminals of the AND gate 362. This signal is applied through the AND gate and in turn actuates the bistable multivibrator 364 from a first state to a second state. When the multivibrator 364 is actuated to the second state, a signal is applied through the inverters 376, 406 to thereby cause the solenoid drive circuit 428 to actuate the printer solenoid 81.

The signal developed by the inverter 376 is then fed back to reset the flip-flop 356 and is also fed back through the inverter 384 to actuate the bistable multivibrator 386 from a first state to a second state. When the multivibrator 386 is actuated to the second state, a signal is applied through the inverter 398 to the AND gate 362 thereby causing this AND gate to close. The AND gate 362 remains closed until the multivibrator 386 reverts to its first state. The time required for the multivibrator 386 to revert to its first state is controlled by the variable resistor 404 to thereby vary the "delay" time.

After the multivibrator 386 has reverted to its first state, a second pulse signal may be applied through the AND gate 362 and the multivibrator 364 to the solenoid drive circuit 428. Also, the flip-flop 356 serves to store a signal indicative of the receipt of a pulse signal during the period of time that the AND gate 362 is in a closed condition. Thus, there is no loss of data even though the signals applied to the printer solenoid 81 never exceed a predetermined pulse rate which would exceed the capabilities of the solenoid.

Although one embodiment of the invention has been described and illustrated, it is apparent to one skilled in the art that various changes and modifications may be made without departing from the spirit and scope of the invention.

What is claimed is:

1. A scintillation scanner comprising:

- a. a frame structure;
- b. a scintillation responsive structure for providing a signal response to radioactivity detected;
- c. a drive assembly interposed between said structures for driving said scintillation responsive structure over an area to be studied;
- d. media support means carried by one of said structures and adapted to carry a media upon which an image may be printed;
- e. color printer means including housing means carried by the other of said structures, said color printer means being electrically coupled to said scintillation responsive structure for printing a composite image on a media which varies in color in accordance with the intensity of radiation sensed by said scintillation responsive structure, said color printer means comprising:
 - i. an elongate printing ribbon having a plurality of color bands extending longitudinally thereof in side-by-side relation;
 - ii. ribbon support means carried by said housing means and adapted to support spaced portions of said ribbon;
 - iii. carriage means movably carried by said housing means and adapted to receive and laterally position a portion of said ribbon intermediate said spaced portions such that said portion has one side positioned adjacent said media support means;
 - iv. printing stylus means disposed adjacent the other side of said portion of said ribbon and including chisel means extensible from a retracted position to a printing position wherein said chisel means engages said portion of said ribbon and moves said ribbon into engagement with a media carried by said media support means to print an image thereon; and,
 - v. said carriage means comprising a relatively light mass structure adapted to laterally move only

portions of said ribbon which are intermediate said spaced portions in order to selectively align said color bands with said printing stylus means.

2. The scintillation scanner of claim 1 wherein said color printer additionally includes:

a. ribbon feed means for feeding said ribbon longitudinally along a feed path extending from said ribbon support means through said carriage means; and,

b. bearinged support means interposed between said housing means and said carriage means for constraining the movement of said carriage means to a transitory movement in directions perpendicular to said ribbon feed path.

3. The scintillation scanner of claim 2 wherein said bearinged support means comprises:

a. first bearing surface means carried by said housing means;

b. second bearing surface means carried by said carriage means;

c. one of said bearing surface means comprising a plurality of guide tracks; and,

d. the other of said bearing surface means comprising a plurality of bearings in engagement with said guide tracks.

4. The scintillation scanner of claim 3 wherein said first bearing surface means comprises a pair of guide rods carried by said housing means and extending in parallel relation to each other and in a direction perpendicular to said ribbon feed path.

5. The scintillation scanner of claim 4 wherein said second bearing surface means comprises three bearings carried by said carriage and positioned to engage said guide rods to movably mount said carriage for translation along said guide rods.

6. The scintillation scanner of claim 2 wherein said carriage means comprises:

a. a ribbon support structure for receiving and positioning said ribbon in a planar fashion adjacent said printing stylus means; and,

b. a pair of spaced ribbon guide rollers positioned one on either side of said ribbon support structure.

7. The scintillation scanner of claim 6 wherein said guide rollers comprise:

a. a central region of generally uniform diameter;

b. tapered end portions of truncated conical shape having a minor diameter equal to said uniform diameter and connected smoothly to said central region, and having a major diameter greater than said minor diameter and being disposed axially outwardly of said minor diameter;

c. said central region extending axially for a length which is slightly less than the width of said ribbon, whereby the side portions of said ribbon are caused to deflect into engagement with at least a portion of said end portions, whereby the ribbon is maintained centered on the guide rollers during movement of the carriage.

8. The scintillation scanner of claim 1 additionally comprising:

a. electrically controlled ribbon feed means for reversibly feeding said ribbon longitudinally along a feed path extending from said ribbon support means through said carriage means;

b. permanent magnet means carried at spaced points on said ribbon; and,

c. magnetically responsive electrical switch means positioned adjacent said feed path for reversing said ribbon feed means in response to one of said permanent magnet means being fed by said ribbon to a position adjacent said switch means.

9. The scintillation scanner of claim 8 wherein said switch means comprise a pair of reed switches disposed along feed path portions on opposite sides of said printing stylus means, and said permanent magnet means comprise a pair of permanent magnets carried adjacent opposite ends of said ribbon.

10. The scintillation scanner of claim 1 wherein said media supporting means comprises a platform structure having a base plate, a sheet material having relatively hard planar printing surface, and a block of relatively porous noise absorbing material interposed between said sheet and said base plate.

11. The scintillation scanner of claim 10 wherein said sheet is removably and replaceably secured to said block by adhesive.

12. The scintillation scanner of claim 11 wherein said block comprises polyethylene and said sheet comprises polyurethane.

13. The scintillation scanner of claim 1 wherein said printing stylus means comprises:

a. an electrically actuatable solenoid means having an axially movable armature;

b. a printing chisel movable reciprocally axially with said armature between a retracted position and a printing position;

c. biasing means biasing said printing chisel into engagement with said armature;

d. said armature having a stroke of sufficient length to positively drive said printing chisel to said printing position;

e. said armature being adapted to disengage said chisel and withdraw to and become settled in its retracted position in less time than is required for said printing chisel to return to and become settled in its retracted position;

f. whereby said armature may be reactivated to drive said printing chisel to said printing position before said printing chisel has entirely returned to and become settled in its retracted position.

14. The scintillation scanner of claim 13 wherein said printing stylus means additionally comprises:

a. bearing block means slidably supporting said chisel for reciprocal movement; and,

b. adjustment means for adjusting the biasing force of said biasing means.

15. The scintillation scanner of claim 12 wherein said printing stylus means comprises a pair of printing stylus assemblies disposed side-by-side along said ribbon feed path, each of said assemblies including a separately actuatable printing chisel means for printing an image on a media carried by said media support means, the printing chisel of one of said printing stylus assemblies being of a wider width than the printing chisel of the other of said printing stylus assemblies, whereby relatively wide or narrow images may selectively be printed by selectively actuating one or the other of said printing stylus assemblies.

16. The scintillation scanner of claim 15 wherein each of said printing stylus assemblies comprises:

a. an electrically actuatable solenoid means having an axially movable armature;

- b. a printing chisel movable reciprocally axially with said armature between a retracted position and a printing position;
- c. biasing means biasing said printing chisel into engagement with said armature;
- d. said armature having a stroke of sufficient length to positively drive said printing chisel to said printing position;
- e. said armature being adapted to disengage said chisel and withdraw to and become settled in its retracted position in less time than is required for said printing chisel to return to and become settled in its retracted position;
- f. whereby said armature may be reactivated to drive said printing chisel to said printing position before said printing chisel has entirely returned to and become settled in its retracted position.

17. The scintillation scanner of claim 16 wherein said printing stylus means additionally comprises:

- a. bearing block means slidably supporting both of said printing chisels for reciprocal movement; and,
- b. adjustment means for adjusting the biasing force of each of said biasing means.

18. The scintillation scanner of claim 2 additionally including power drive means interposed between said housing means and said carriage means to position said carriage means relative to said housing means, said power drive means including a drive motor carried by said housing and positioning means coupling the output shaft of said drive motor to said carriage to vary the position of said carriage in response to the rotation of said drive shaft.

19. The scintillation scanner of claim 18 additionally including electrical circuit means electrically interconnecting said scintillation responsive structure and said motor to actuate said motor so as to position said carriage in response to the intensity of the radiation detected by said scintillation responsive structure.

20. The scintillation scanner of claim 18 wherein said circuit means comprises:

- a. detector and computing circuit means electrically coupled to said scintillation responsive structure for developing a train of electrical pulses representative of the value of radiation activity measured by said scintillation responsive structure, and for converting said train of electrical pulses to an output signal having a value representative of the number of electrical pulses developed in a predetermined time interval;
- b. motor control circuit means coupled to said computing circuit means for developing a motor control signal having a value representative of the value of said output signal; and,
- c. feedback circuit means for developing a feedback signal having a value representative of the actual position of said carriage means.

21. The scintillation scanner of claim 20 wherein said circuit means additionally comprises speed control circuit means coupled to said control circuit means and said feedback circuit means for attenuating said control signal when said feedback signal reaches a predetermined value.

22. A scintillation scanner comprising:

- a. a frame structure;
- b. a scintillation responsive structure for providing a signal in response to radioactivity detected;

- c. a drive assembly interposed between said structures for driving said scintillation responsive structure over an area to be studied;
- d. media support means carried by one of said structures and adapted to carry a media upon which an image may be printed;
- e. color printer means including housing means carried by the other said structures, said color printer means being electrically coupled to said scintillation responsive structure for printing a composite image on a media which varies in color in accordance with the intensity of radiation sensed by said scintillation responsive structure;
- f. said media support means comprising a platform assembly structure for supporting a media while simultaneously serving to attenuate the noise occasioned by the printing operation, the platform comprising:
 - i. a rigid base plate
 - ii. a block of relatively porous noise absorbing material carried by said base plate; and,
 - iii. a sheet of material having a relatively hard planar printing surface carried by said block;
 - iv. said sheet and said base plate serving to sandwich said block therebetween to absorb printing noise and attenuate its transmission to said base plate from said sheet.

23. The scintillation scanner of claim 22 wherein said block comprises polyethylene and said sheet comprises polyurethane.

24. The scintillation scanner of claim 22 wherein said sheet is removably and replaceably secured to said block by adhesive.

25. A scintillation scanner comprising:

- a. a frame structure;
- b. a scintillation responsive structure for providing a signal in response to radioactivity detected;
- c. a drive assembly interposed between said structures for driving said scintillation responsive structure over an area to be studied;
- d. media support means carried by one of said structures and adapted to carry a media upon which an image may be printed;
- e. printer means including housing means carried by the other of said structures, said printer means being electrically coupled to said scintillation responsive structure for printing a composite image on a media in response to radiation sensed by said scintillation responsive structure;
- f. said printer means including a printing ribbon and an electrically controlled ribbon feed means for reversibly feeding said ribbon along a feed path;
- g. said ribbon carrying permanent magnet means at spaced points along said ribbon; and,
- h. magnetically responsive electrical switch means positioned adjacent said feed path for reversing said ribbon feed means in response to one of said permanent magnet means being fed by said ribbon to a position adjacent said switch means.

26. The scintillation scanner of claim 25 wherein said switch means comprises a pair of reed switches disposed along spaced feed path portions, and said permanent magnet means comprise a pair of permanent magnets carried adjacent opposite ends of said ribbon.

27. A scintillation scanner comprising:

- a. a frame structure;

- b. a scintillation responsive structure for providing a signal in response to radioactivity detected;
 - c. a drive assembly interposed between said structures for driving said scintillation responsive structure over an area to be studied;
 - d. media support means carried by one of said structures and adapted to carry a media upon which an image may be printed;
 - e. printer means including housing means carried by the other of said structures, said printing means being electrically coupled to said scintillation responsive structure for printing a composite image on a media in response to radiation sensed by said scintillation responsive structure;
 - f. said printer means including a printing ribbon having a portion positioned with one side adjacent said media support means;
 - g. printing stylus means disposed adjacent the other side of said portion of said ribbon and including chisel means extensible from a retracted position to a printing position wherein said chisel means engages said portion of said ribbon and moves said ribbon into engagement with a media carried by said media support means to print an image thereon;
 - h. said printing stylus means comprising:
 - i. an electrically actuatable solenoid means having axially movable armature;
 - II. a printing chisel movable reciprocally axially with said armature between a retracted position and a printing position;
 - III. biasing means biasing said printing chisel into engagement with said armature;
 - IV. said armature having a stroke of sufficient length to positively drive said printing chisel to said printing position;
 - v. said armature being adapted to disengage said chisel and withdraw to and become settled in its retracted position in less time than is required for said printing chisel to return to its retracted position;
 - VI. whereby said armature may be reactivated to drive said printing chisel to said printing position before said printing chisel has entirely returned to and become settled in its retracted position.
- 28.** The scintillation scanner of claim 27 wherein said printing stylus means additionally comprises:
- bearing block means slidably supporting said chisel for reciprocal movement; and,
 - adjustment means for adjusting the biasing force of said biasing means.
- 29.** The scintillation scanner of claim 27 wherein said printing stylus means comprise a pair of printing stylus assemblies disposed side-by-side along said ribbon feed path, each of said assemblies including a separately actuatable printing chisel means for printing an image on a media carried by said media supporting means, said chisel of one of said printing stylus assemblies being of a wider width than the printing chisel of the other of said printing stylus assemblies, whereby relatively wide or narrow images may selectively be printed by selectively actuating one or the other of said printing stylus assemblies.
- 30.** The scintillation scanner of claim 29 wherein each of said printing stylus assemblies comprises:
- a. an electrically actuatable solenoid means having an axially movable armature;

- b. a printing chisel movable reciprocally axially with said armature between a retracted position and a printing position;
 - c. biasing means biasing said printing chisel into engagement with said armature;
 - d. said armature having a stroke of sufficient length to positively drive said printing chisel to said printing position;
 - e. said armature being adapted to disengage said chisel and withdraw to and become settled in its retracted position in less time than is required for said printing chisel to return to and become settled in its retracted position;
 - f. whereby said armature may be reactivated to drive said printing chisel has entirely returned to and become settled in its retracted position.
- 31.** The scintillation scanner of claim 30 wherein said printing stylus means additionally comprises:
- a. bearing block means slidably supporting both of said printing chisels for reciprocal movement; and,
 - b. adjustment means for adjusting the biasing force of each of said biasing means.
- 32.** In a scintillation recording apparatus, a radiation detector including circuitry for developing a train of electrical pulses representative of the value of radiation activity measured by the detector, computing circuit means coupled to said detector circuitry for converting said train of electrical pulses to an output signal having a value representative of the number of electrical pulses developed in a predetermined time interval, the improvement comprising:
- a. color means having a plurality of color bands extending longitudinally and in side-by-side relation;
 - b. carriage means for supporting said color means for movement so that the position of the color bands may be varied in accordance with the value of measured radiation activity;
 - c. drive means for, upon receipt of a control signal, positioning said carriage means at a position representative of the value of said control signal;
 - d. motor control circuit means coupled to said computing circuit means for developing a motor control signal having a value representative of the value of said output signal;
 - e. feedback circuit means for developing a feedback signal having a value representative of the actual position of said carriage means; and,
 - f. speed control circuit means coupled to said control circuit means and said feedback circuit means for attenuating said control signal when said feedback signal reaches a predetermined value.
- 33.** An apparatus as defined in claim 32 wherein said feedback circuit means includes circuitry for developing a signal of a said predetermined value when said carriage means moves within a predetermined distance of its extremity of travel.
- 34.** An apparatus as defined in claim 33 wherein said speed control means includes circuit means for preventing the attenuation of said control signal when said carriage means is traveling in a direction away from its extremity of travel.
- 35.** In a scintillation recording apparatus, a radiation detector including circuitry for developing a train of electrical pulses representative of the value of radiation activity measured by the detector, computing circuit means coupled to said detector circuitry for converting said train of electrical pulses to an output signal having

a value representative of the number of electrical pulses developed in a predetermined time interval, the improvement comprising:

- a. color printer means including a printing ribbon having a plurality of color bands extending longitudinally and in side-by-side relation;
- b. carriage means for supporting said color means for movement so that the position of the color bands may be varied in accordance with the value of measured radiation activity;
- c. drive means for, upon receipt of a control signal, positioning said carriage means at a position representative of the value of said control signal;
- d. printing stylus means disposed adjacent said printing ribbon;
- e. second drive means for, upon actuation, driving said stylus means to a printing position wherein said stylus means engages a portion of said ribbon;
- f. memory circuit means for, upon receipt of said electrical pulse from said detector circuit, storing a signal indicative that an electrical pulse has been received;
- g. gating circuit means for actuating said second drive means at a predetermined period of time after a signal has been stored in said memory circuit means to thereby cause said stylus to be driven to a printing position; and,
- h. reset circuit means for, upon actuation of said second drive means, resetting said memory circuit means for storage of another signal indicative that another electrical pulse has been received.

36. An apparatus as defined in claim 35 wherein said memory circuit means includes bistable circuit means for storing another signal indicative of another electrical pulse during a period of time when said second drive means is being actuated to cause said stylus to be driven to a printing position.

37. In a scintillation recording apparatus, a radiation detector including circuitry for developing a train of electrical pulses representative of the value of radiation activity measured by the detector, computing circuit means coupled to said detector circuitry for converting said train of electrical pulses to an output signal having a value representative of the number of electrical pulses developed in a predetermined time interval, the improvement comprising:

- a. color means having a plurality of color bands extending longitudinally and in side-by-side relation;
- b. carriage means for supporting said color means for movement so that the position of the color bands may be varied in accordance with the value of measured radiation activity;
- c. drive means for, upon receipt of a control signal, positioning said carriage means at a position representative of the value of a said control signal;
- d. motor control circuit means coupled to said computing circuit means for developing a said motor control signal having a value representative of the value of said output signal; and,
- e. contrast enhancement control means including variable circuit means for altering the relative position of the color bands with respect to the value of measured radiation activity.

38. An apparatus as defined in claim 37 wherein said contrast enhancement means includes a differential amplifier for amplifying said output signal and having

one input terminal coupled to said computing circuit means, another input terminal connected to a source of reference potential, and an output terminal for developing a motor control signal, and variable circuit means for varying the gain of said differential amplifier with reference to said reference potential in order to vary the amplification of signals applied to said motor control circuit means without causing said signals to exceed a maximum level established by said reference potential.

39. An apparatus as defined in claim 38 including an intensity control having a variable control means for attenuating the value of the signal applied by said amplifier to said motor control means.

40. A scintillation scanner comprising:

- a. signal emitting means for producing a signal in response to incident radiation stimuli;
- b. a frame structure and a signal emitting means support structure movably carried by said frame structure and carrying the signal emitting means;
- c. a drive assembly interposed between said structures for effecting relative movement of said structures along a preselected drive path;
- d. media support means carried by one of said structures and adapted to receive and support an imprintable media;
- e. color printer means carried by the other of said structures and being operably connected to said signal emitting means for printing a sequence of images on a media which vary in color in accordance with the sensed intensity of incident radiation; and,
- f. said color printer means including a printing stylus, a pair of spools, a printing ribbon having a plurality of color bands extending longitudinally thereof having opposite end portions wound on said spools and having an intermediate portion extending between said spools, and carriage means for laterally shifting said intermediate portion, at least in part, relative to said spools and relative to said printing stylus to selectively align said color bands one at a time with said printing stylus.

41. The scintillation scanner of claim 40 wherein:

- a. said color printer means additionally includes a housing structure movably mounting said printing stylus and said carriage means;
- b. said carriage means includes a pair of guide rollers each of which have tapered end regions separated by a central region, the end regions being of a greater diameter than is the central region; and ,
- c. said printing ribbon is supported by said guide rollers for lateral movement relative to said printing stylus.

42. The scintillation scanner of claim 40 wherein said color printer means additionally includes:

- a. a housing structure movably mounting said printing stylus and said carriage means;
- b. drive means interposed between said housing structure and said carriage means for laterally shifting said ribbon in response to signals from said signal emitting means;
- c. attenuation means for attenuating the speed of movement of said carriage as it approaches the ends of its travel.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 3,890,355
DATED : June 17, 1975
INVENTOR(S) : Brunnett et al.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 1, line 68, "printed" should be "printing"

Col. 4, line 11, before "l", "of" should be "to"

Col. 5, line 6, insert "a" before "myriad"

Col. 14, line 14, "276" should be "376"

Col. 20, claim 13, paragraph e), "E." should be "e."

Col. 20, claim 15, line 1, "12" should be "2"

Col. 23, claim 29, line 9, "assmeblies" should be "assemblies"

Signed and Sealed this

sixteenth **Day of** *September 1975*

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks