March 19, 1946. S. KHALIL 2,396,705

FACSIMILE SYSTEM AND APPARATUS

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FIG. 1

FIG. 2

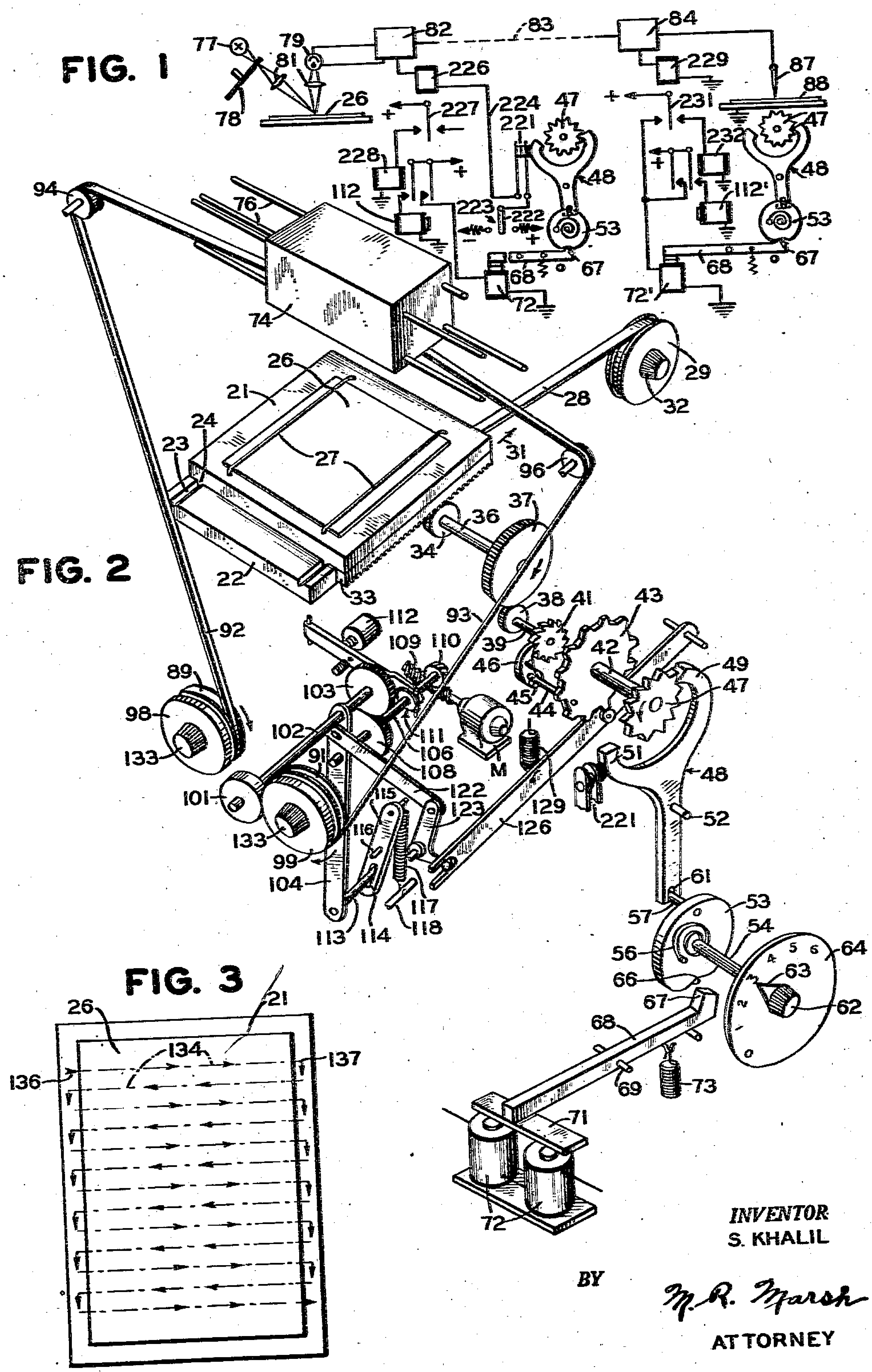

FIG. 3

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FACSIMILE SYSTEM AND APPARATUS

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FIG. 4

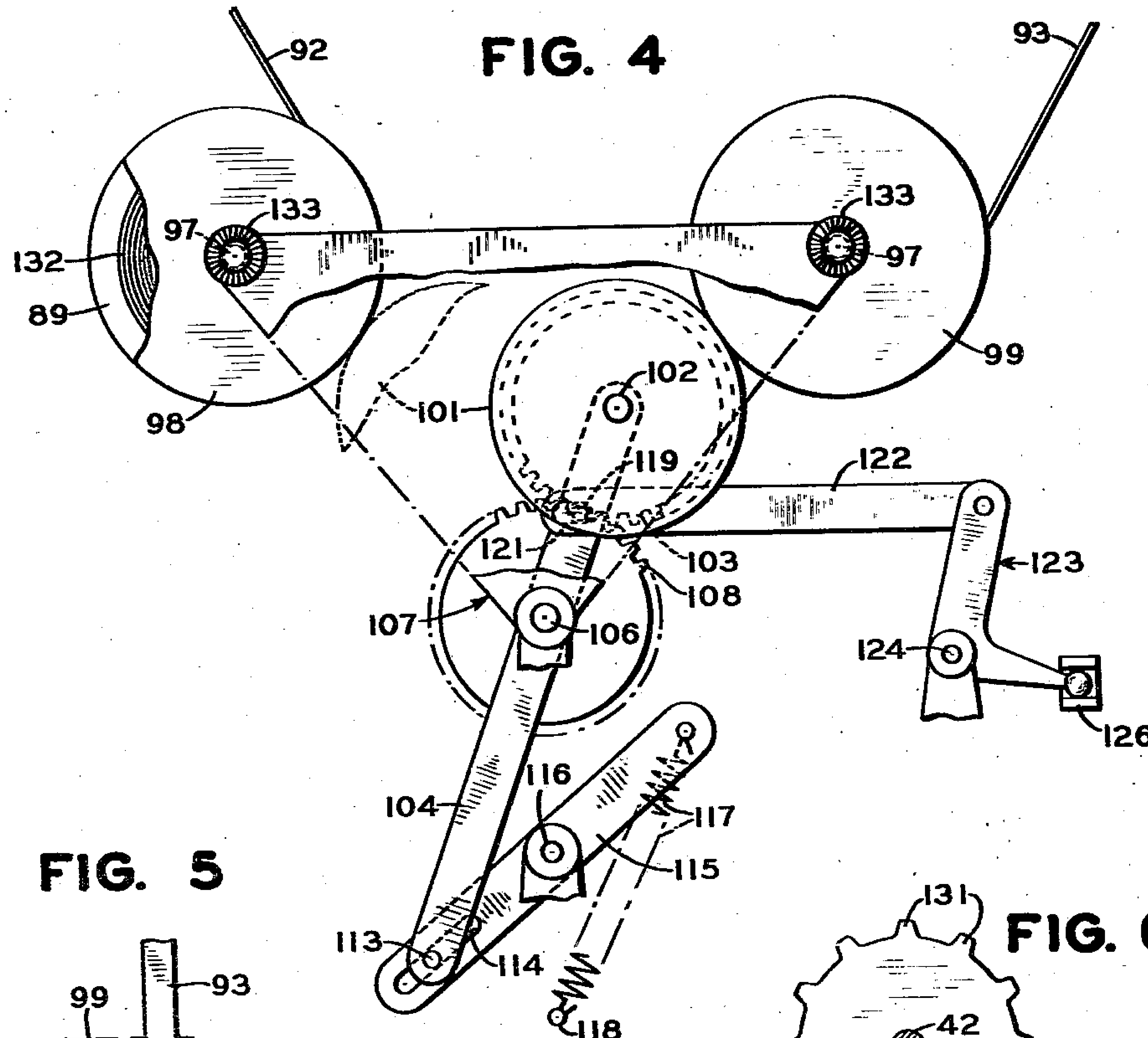

FIG. 5

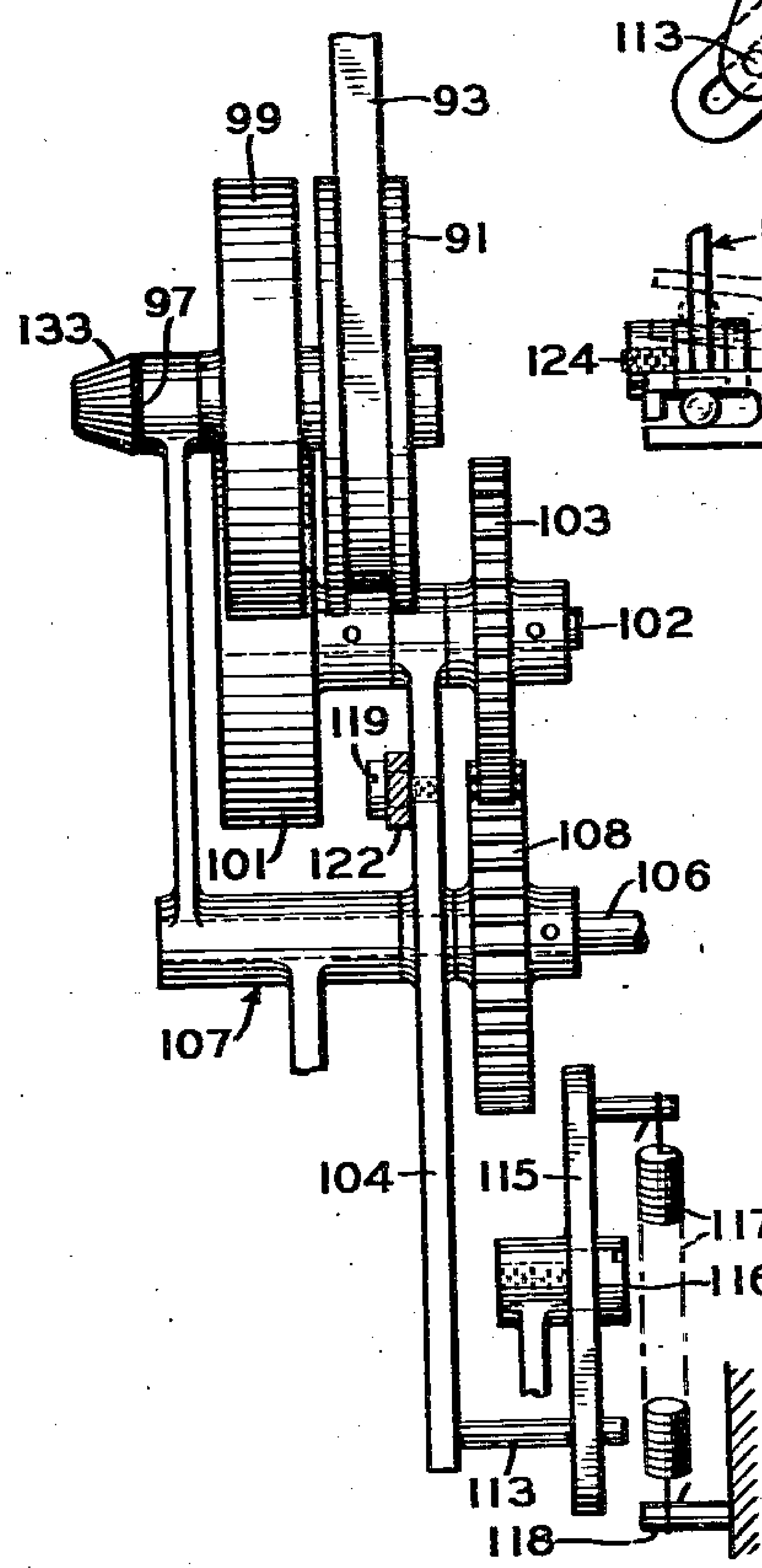

FIG. 6

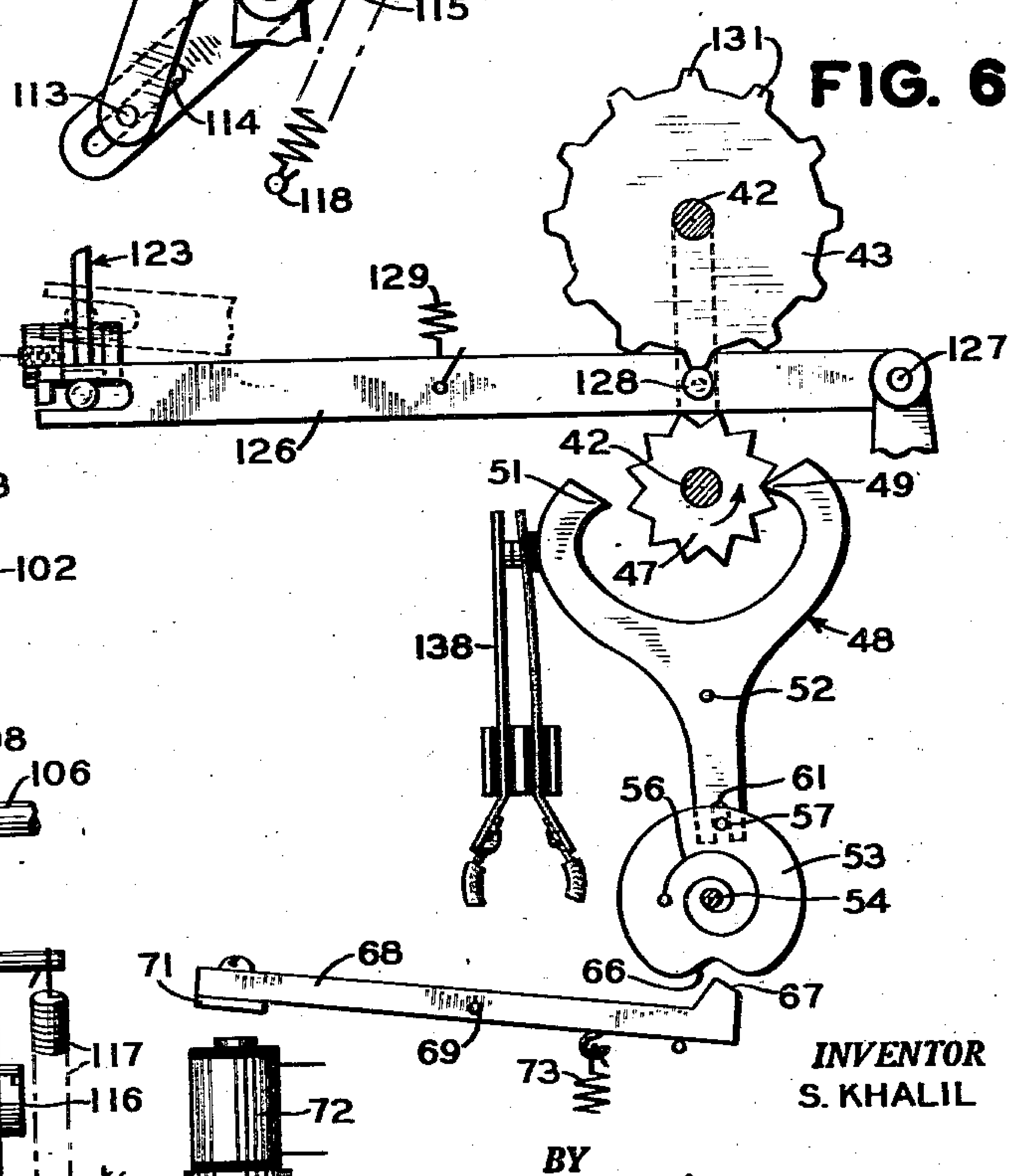

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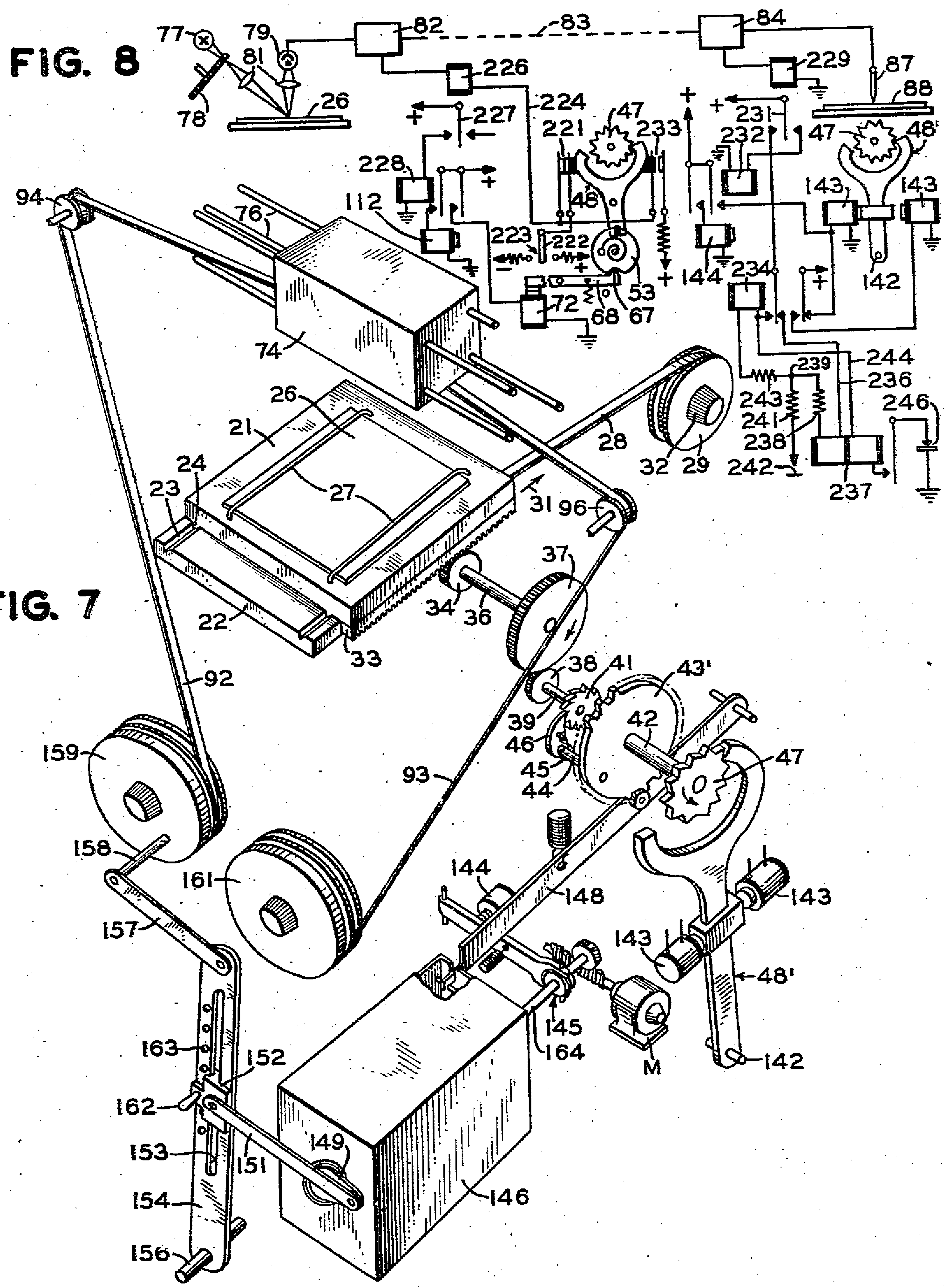
FIG. 8

FIG. 7



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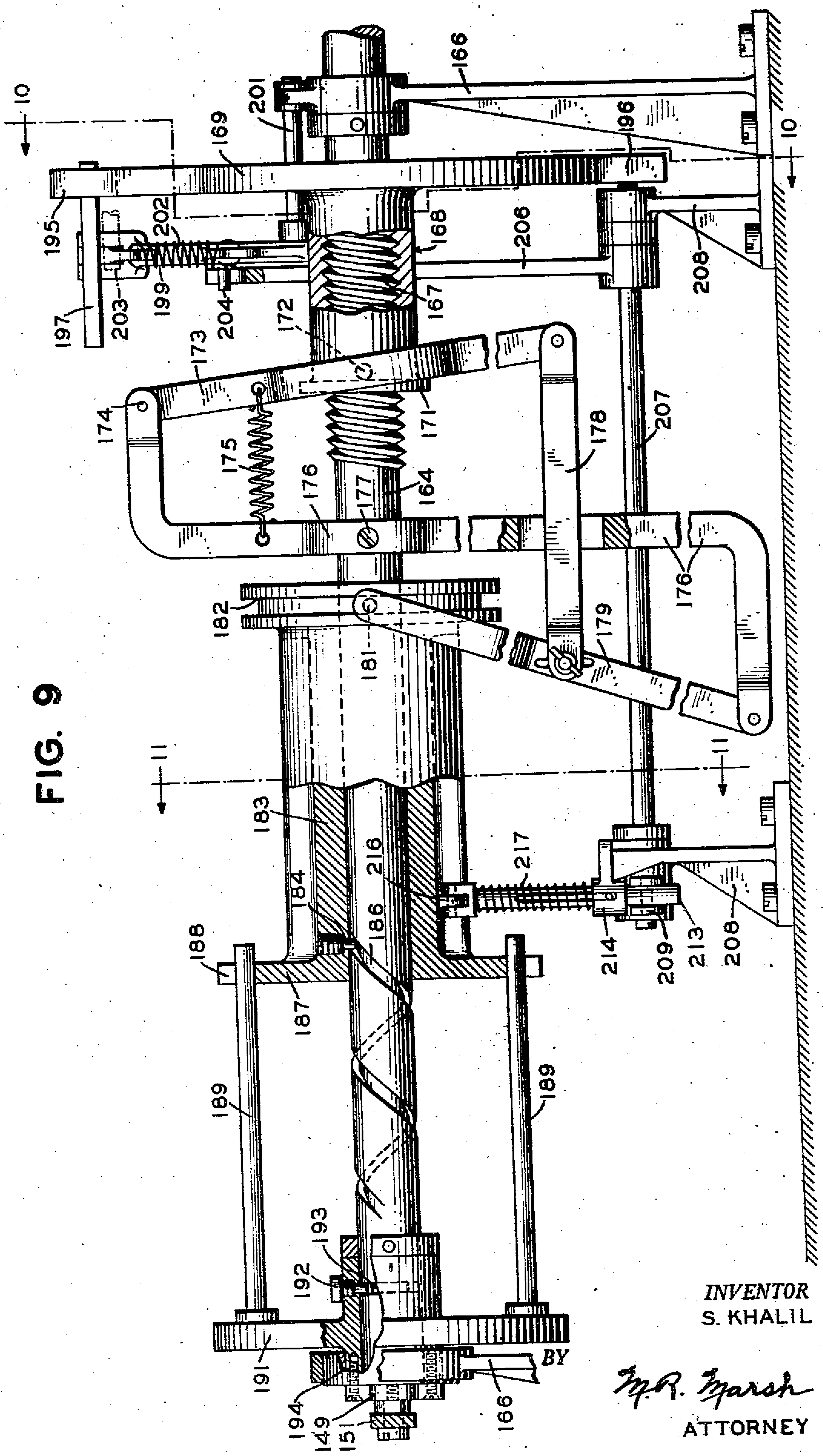

FIG. 9

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FIG. 10

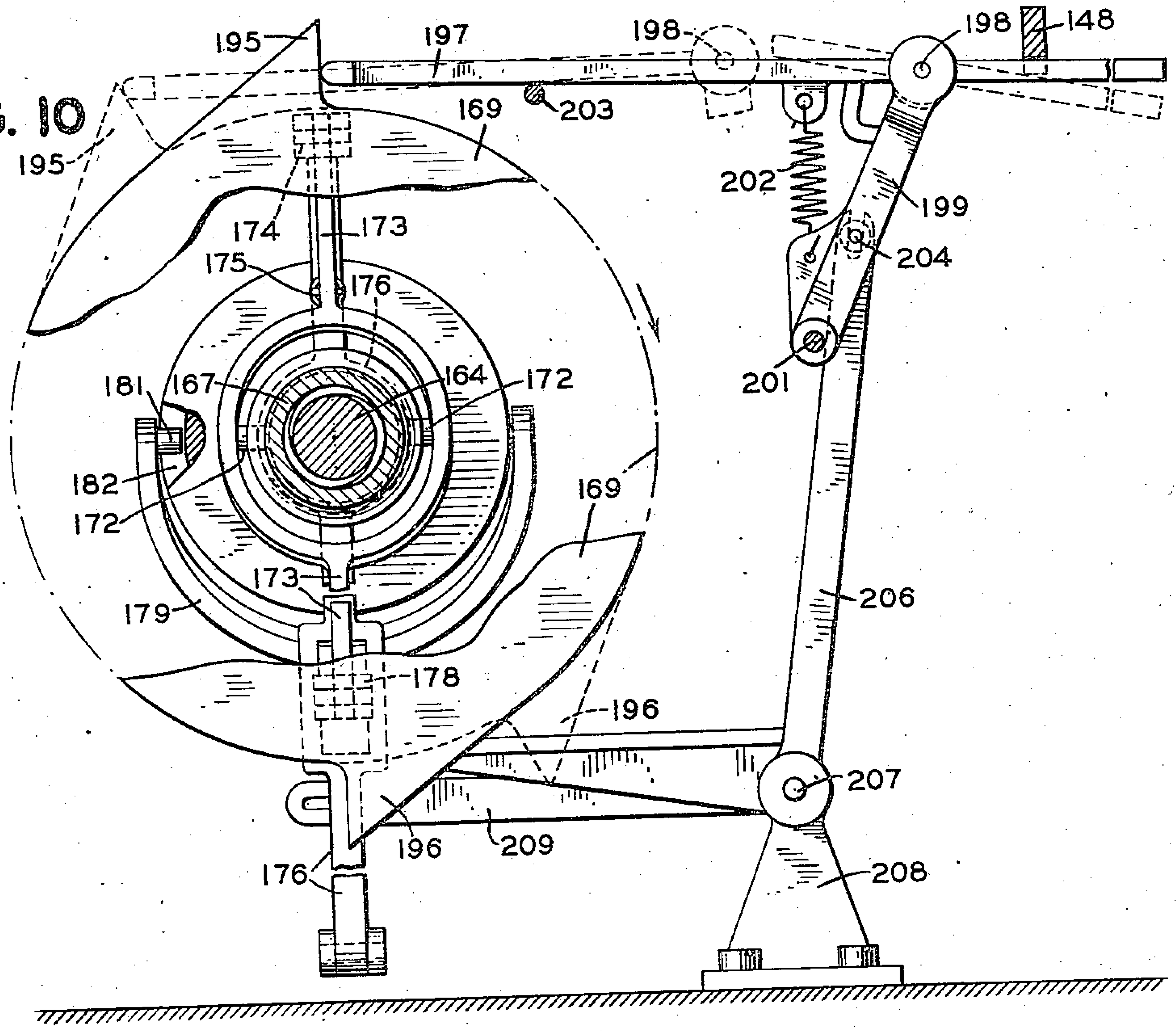

FIG. 11

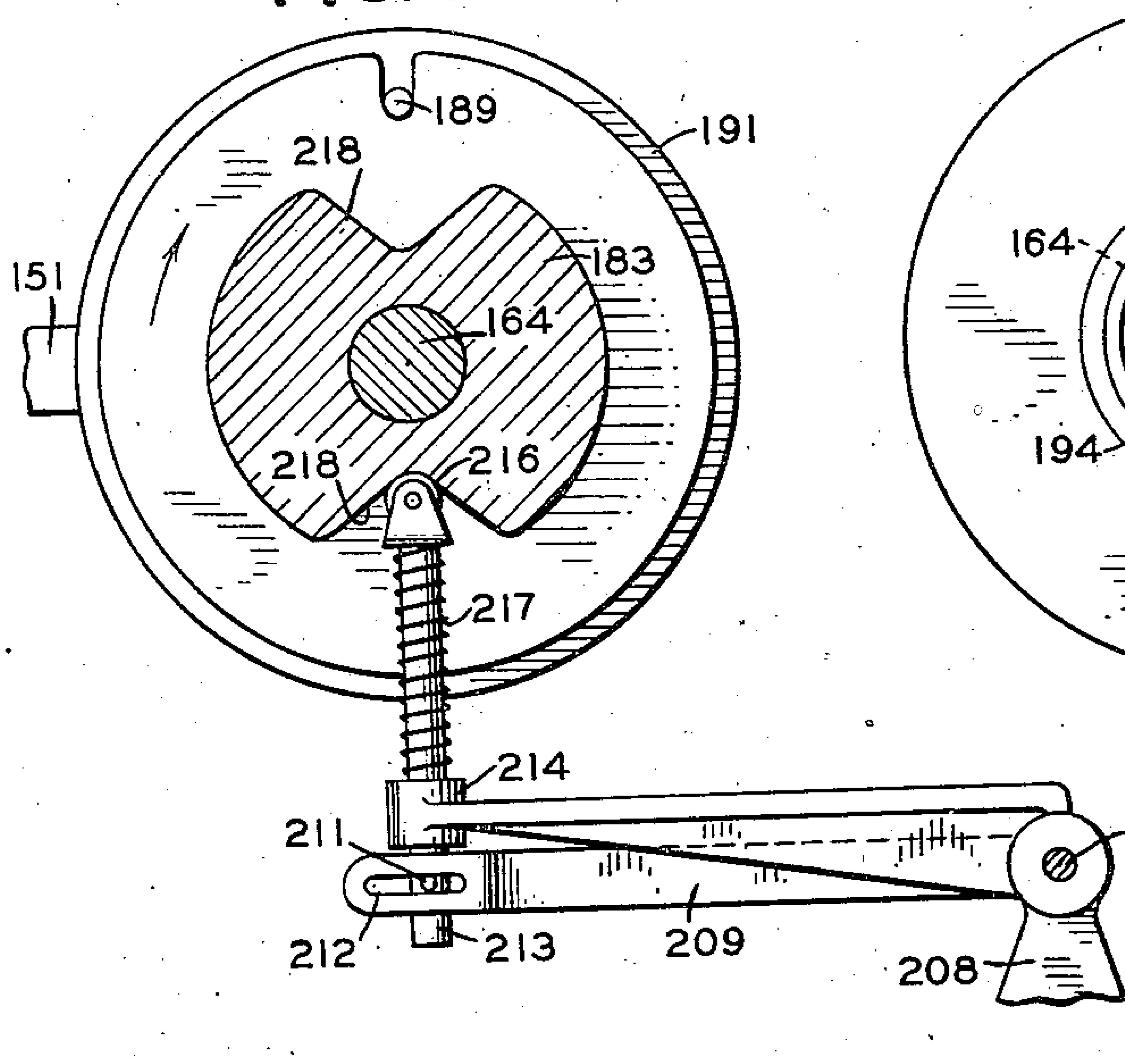

FIG. 12

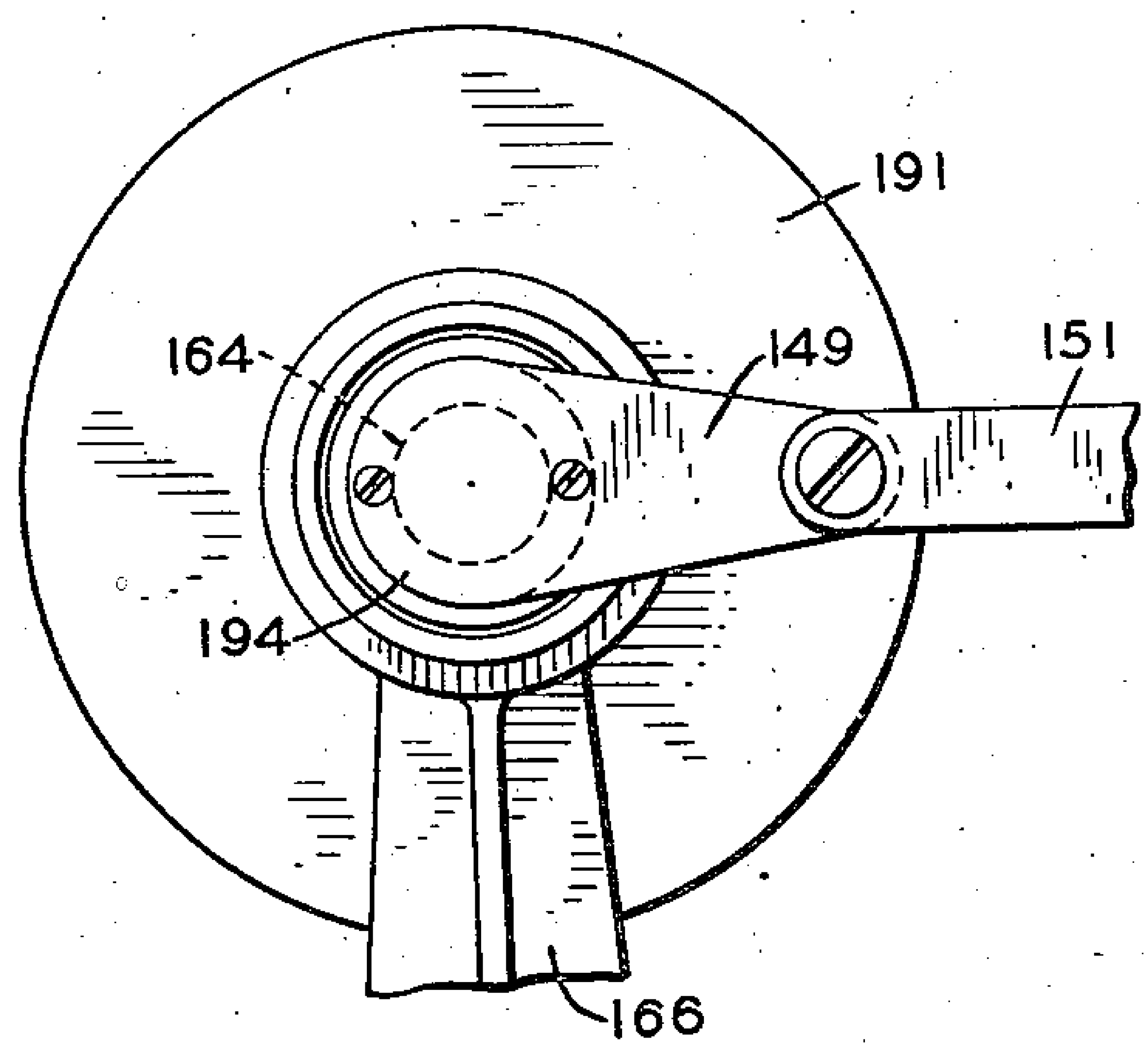

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FIG. 13

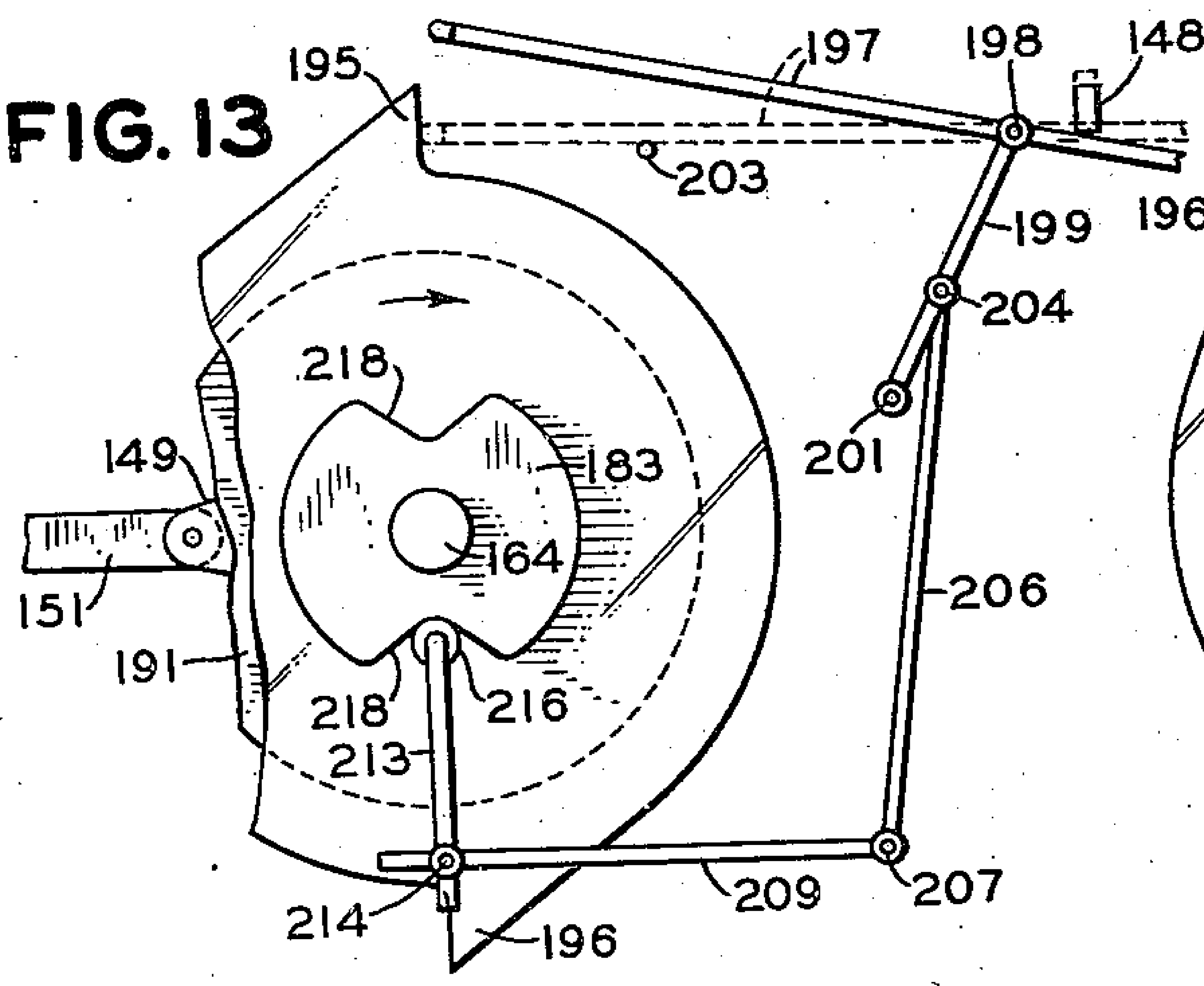


FIG. 14

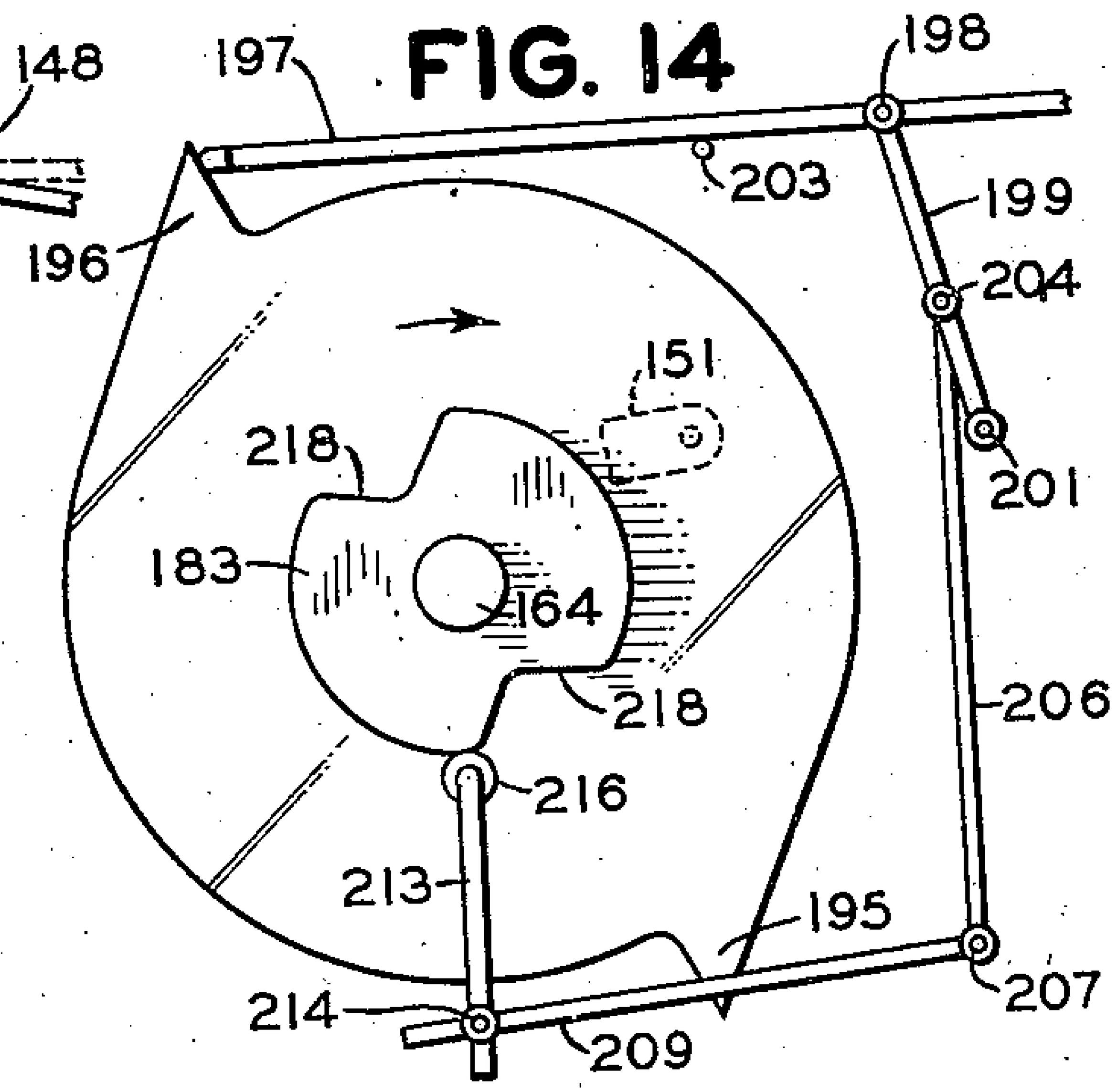


FIG. 15

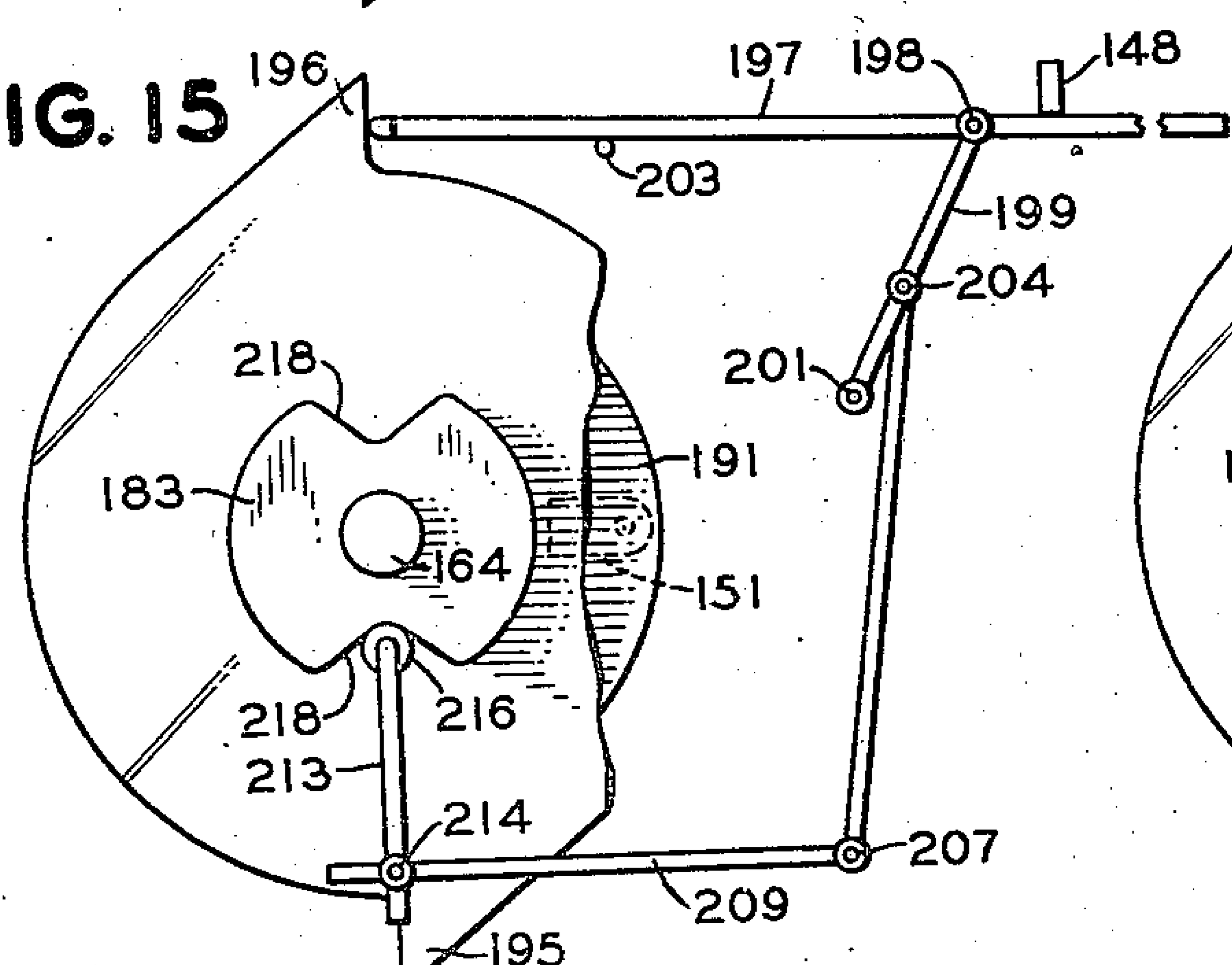


FIG. 16

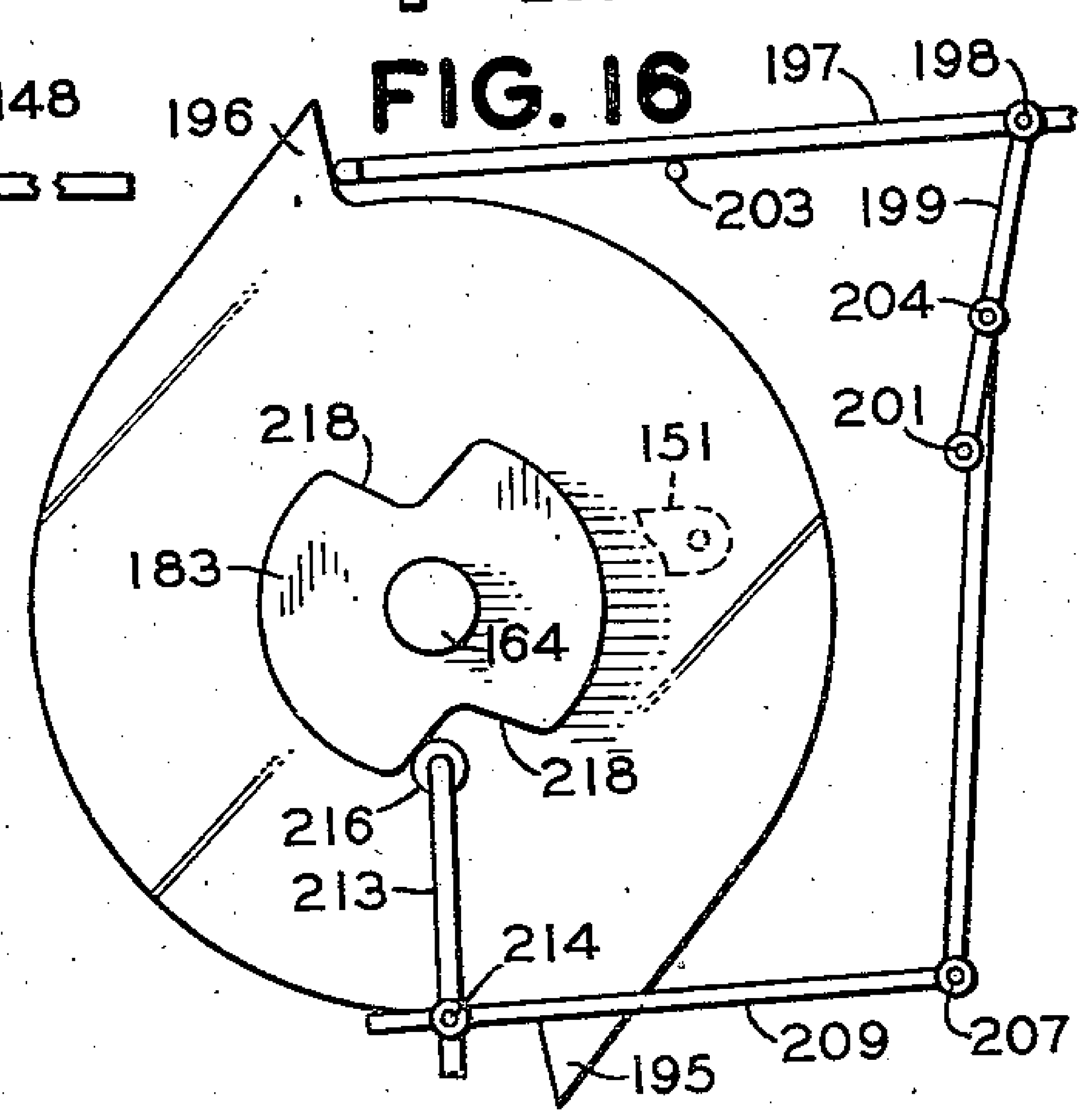


FIG. 17

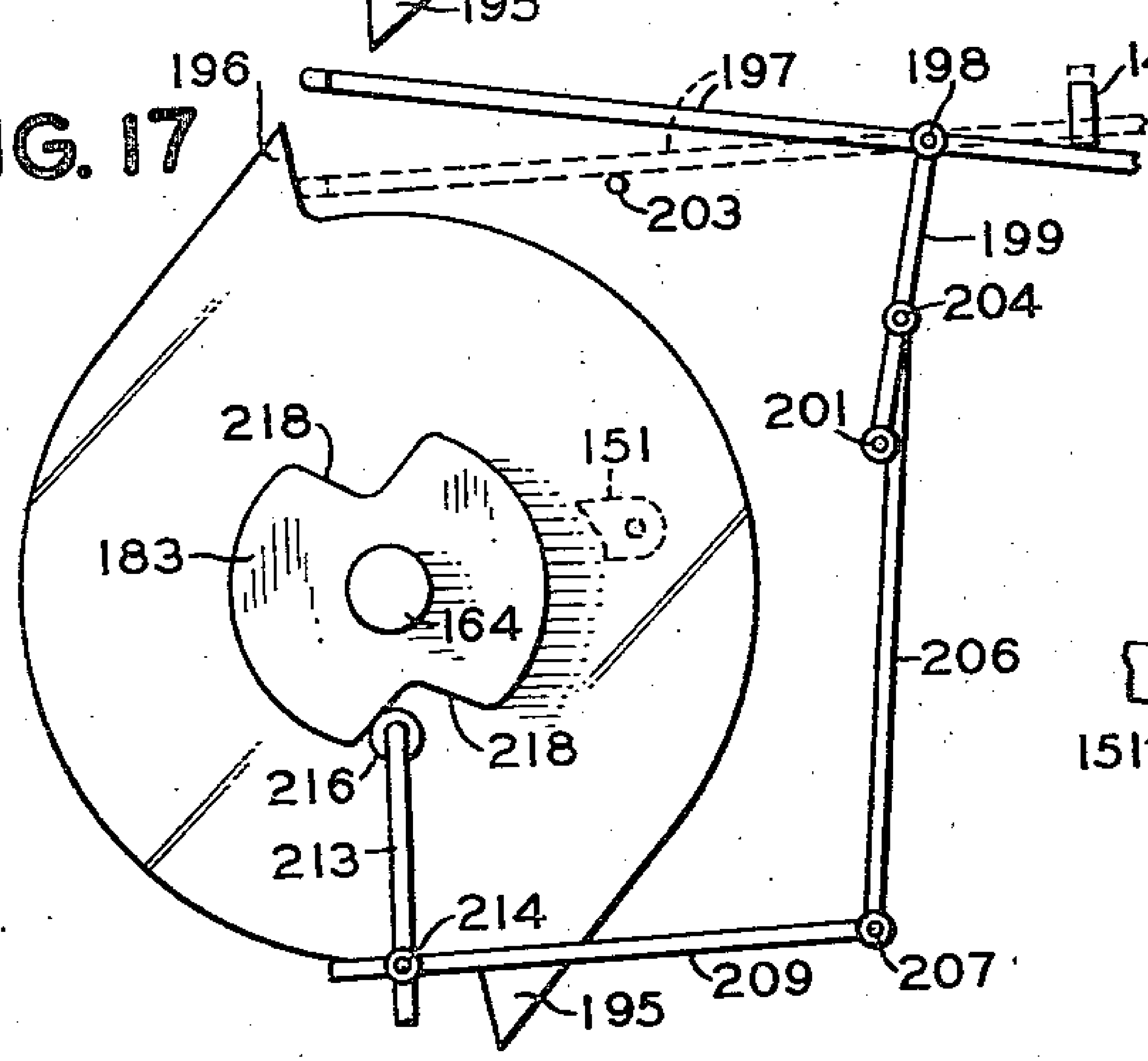
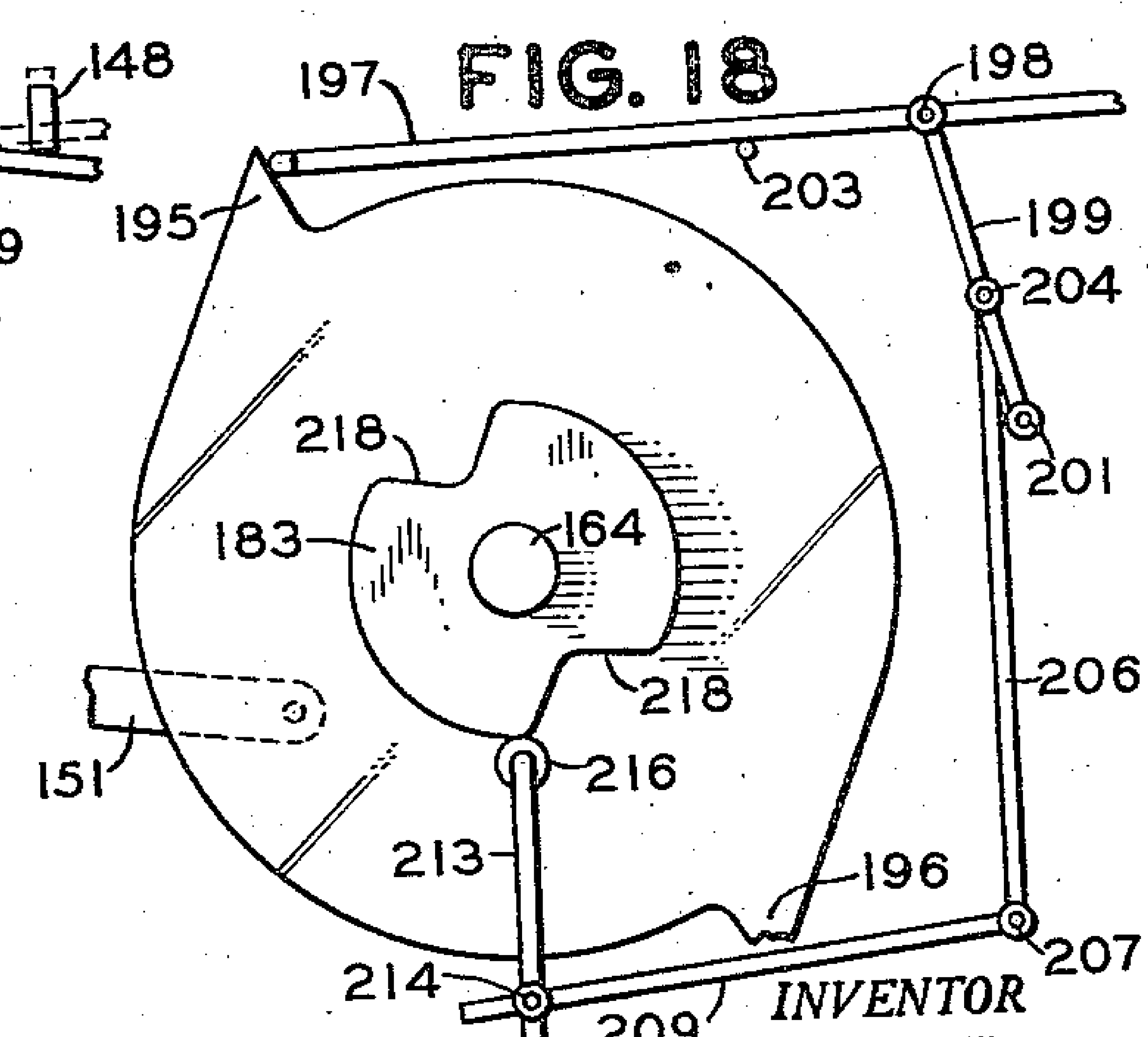


FIG. 18



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Patented Mar. 19, 1946 2,396,705

UNITED STATES PATENT OFFICE

2,396,705

FACSIMILE SYSTEM AND APPARATUS

Seyed Khalil, New York, N. Y., assignor to The Western Union Telegraph Company, New York, N. Y., a corporation of New York

Application January 29, 1943, Serial No. 473,896

33 Claims. (Cl. 178—11)

The present invention relates primarily to facsimile systems and apparatus therefor and more particularly to novel and improved transmitting and receiving facsimile machines and a novel synchronizing system employing the same for transmitting and receiving subject matter such as pictures and messages in facsimile.

There have been several types of facsimile machines proposed heretofore and they may be classified in two general classes, the unilateral or unidirectional type wherein the direction of movement of the scanning element relative to the material scanned is always in the same direction, and the bilateral or back-and-forth type wherein the scanning element moves back-and-forth or in two directions relative to the material scanned. The so-called cylinder machine is the most general of the first type wherein the subject matter sheet in the transmitter and the recording blank in the receiver are wrapped around cylinders and a scanning element in the transmitter and a recording element in the receiving machine move axially of the cylinders as the same rotate. A lead screw is usually provided to produce relative movement between the rotating cylinders and the scanning or recording elements, and accordingly the movement of the scanning and reproducing elements relative to their respective cylinders is unidirectional and the elements trace a continuous helix on the cylinders. Inasmuch as no correction or synchronization is ordinarily applied to the rotating drums during the scanning and reproducing of a subject matter sheet, any difference in speeds of the drums will have an accumulative adverse effect on the fidelity of the reproduction. In addition to the above, the cylinder type of facsimile machine has the disadvantage that considerable care must be exercised in placing the subject matter sheets and the recording blanks on the cylinders.

Another type of unidirectional facsimile machine sometimes employed, primarily as a receiving instrument, is the type wherein the recording blank is maintained flat and a plurality of recording styli arranged on an endless belt to successively contact the recording blank one at a time to reproduce the subject matter. This type of machine has the disadvantage that it can only be used as a receiving instrument and like the cylinder type any speed difference between the driving means for it and the transmitter will adversely affect the reproduction.

In this type of machine, as in the cylinder type, if the transmitter and receiver are going at different speeds, the received copy will be skewed, that is, a vertical line for example or one substantially at right angles to the direction of the movement of the scanning element will be reproduced as a slanting line. If the transmitter is faster, the line will slope in one direction and if the receiver is faster, the line will slope in the other direction. If the speed of either the transmitter or receiver varies with respect to one another during the scanning of a subject matter sheet, and the speeds are different, vertical lines will be reproduced as sloping lines with various degrees of curvature, the degree of curvature depending upon the variation of relative speeds.

In the bilateral type of machine, the scanning element moves back and forth and performs a scanning operation during each direction of its travel. The scanning element is usually driven by a cam and in some types of machines the cam is released at the beginning of the scanning of a subject matter sheet while in others the cams for controlling the scanning elements are synchronized periodically or after each forward and back stroke of the elements. In this type of machine wherein the driving means for the scanning elements are not synchronized after each forward and back stroke, any speed difference between the receiver and transmitter would have an accumulative adverse effect on the reproduction. If the speed of the transmitter and receiver are different and constant, a single vertical line for example on the subject matter in this type of machine will be recorded as two broken or dotted lines at an angle to each other, so that the two dotted lines will form a V. In a bilateral type of machine that is synchronized with the transmitter after each stroke or after each combined forward and back stroke of the scanning element, if there is a speed difference between the transmitter and receiver, a single vertical line on the subject matter will be recorded either as a zig-zag line or as two broken or dotted parallel lines on the reproduction. The varying of the speed of the driving means during a recording operation of either the transmitter or receiver in the above mentioned bilateral types of machines will also have an adverse effect on the reproduction, the distortion indicated above being modified by curvature of the two broken lines or by an increase in the amount of deviation of the zig-zag line.

From the above it is seen that any speed difference or variation in the driving means for a transmitter and receiver in a facsimile system has an adverse effect on the fidelity of the reproduction and it is accordingly one of the primary objects of this invention to provide a facsimile system and apparatus wherein these adverse effects are entirely eliminated or if not eliminated, reduced to a negligible minimum and as is the case with machines which are not periodically synchronized, to provide a machine wherein the speed difference and variation does not have an accumulative adverse effect on the faithfulness or fidelity of the reproduction.

The present invention is illustrated in the accompanying drawings and hereinafter described as being applied to a facsimile transmitting machine wherein the subject matter is held flat and the scanning element moved back and forth relative thereto to perform a scanning operation during each direction of its travel. In a similar manner the recording stylus or element in the receiving instrument moves back and forth relative to a flat recording paper to perform a recording function during each direction of its travel. Although the invention is shown and described in conjunction with one particular type of machine, it will be apparent that it is not so limited but that the principles thereof may be applied to various other types. In the described embodiment of the invention, the subject matter in the transmitting instrument and the recording paper in the receiving instrument preferably move in a direction perpendicular to the direction of movement of the scanning and recording elements intermittently at the end of each stroke of their respective elements.

In the present invention synchronization between the transmitting and receiving mechanisms is maintained in a novel and improved manner, and as will be obvious hereinafter has many advantages over prior art devices and systems. In the present arrangement the scanning elements or the scanning heads of the two machines, the transmitter and the receiver, are started in the same direction at the same instant. Some time during the first scanning stroke the direction of movement of the scanning heads is simultaneously reversed and, as the speed of the individual driving means of the scanning heads will not vary appreciably and can be assumed to remain substantially constant during a single oscillation of the scanning heads, they will reach their initial position at exactly the same time. However, should the speed of either one or both of the driving means vary during an oscillation of the scanning elements, there would not be an accumulative adverse effect on the reproduction, as will be apparent hereinafter. With the present arrangement the speed of movement of the two individual scanning heads may be substantially different from one another, but since they are started simultaneously and the direction of movement of the two heads is reversed at the same time they will reach their initial positions at substantially the same time even though one head may travel a greater distance than the other. In other words, the scanning heads start together and move in one direction distances that are proportional to the speed of the individual driving means, and after a certain length of time the direction of movement of the two scanning heads is simultaneously reversed. Since the speed of the driving means of the two heads may be assumed to remain constant, they will reach their initial position simultaneously so as to start the scanning of the following line together. Any speed difference between the driving means for the two heads or the speed of movement of the two heads will not with the above arrangement adversely affect the reproduction of the subject matter. The only effect of a difference in speed between the scanning element and the reproducing element would be a difference in one dimension of the size of the reproduction relative to the subject matter.

With a facsimile machine wherein the line scanning is performed as above and the line feed effected intermittently with the scanning operation, a vertical line, for example, on the subject matter will be reproduced on the recording blank as a vertical line with no distortion thereof or drift. Also, any horizontal line, for example, will be reproduced as a horizontal line on the recording blank, and lines perpendicular to one another on the subject matter, as for example, vertical and horizontal lines, will be reproduced exactly perpendicular to one another on the recording blank. Such a system of facsimile reproduction has many obvious advantages and uses over the systems employed heretofore.

With a machine and system such as described above, enlargements or reductions of the subject matter may readily be made on the recording blank by changing the speed of the scanning head of the receiving mechanism relative to the speed of the scanning head of the transmitter together with an appropriate change in the line feeding mechanism.

In view of the inherent limitations and disadvantages of prior art facsimile machines and systems, it is one of the objects of the present invention to provide facsimile transmitting and receiving equipment wherein exact synchronism between the driving means is not essential for the proper operation of the machines and the reproduction of a reasonably exact facsimile of the subject matter.

Another object of the present invention is to provde transmitting and recording facsimile machines and control means therefor to operate and control the scanning and recording elements in the proper time relation to one another whereby substantially exact reproduction of the subject matter is produced at the receiver.

Another object of the invention is to provide transmitting and receiving facsimile mechanism wherein the subject matter to be transmitted such as pictures or messages may be maintained in a flat condition during transmission and in which the recording medium may also be maintained in a flat condition during reception.

Another object of the present invention is to provide facsimile mechanism wherein the subject matter scanned moves in a direction perpendicular to the scanning movement and preferably during non-scanning condition of the scanning element.

A still further object of the invention is to provide mechanism whereby the recording medium is moved perpendicularly relative to the direction of the recording movement of the recording element and preferably during a non-recording condition thereof.

Another object of the present invention is to provide a facsimile system wherein the time consumed in performing a certain operation in the transmitting mechanism, for example, such as the scanning of a line, is equalized with the time consumed in performing a similar operation in the receiving mechanism irrespective of the length of the lines scanned in both machines.

Another object of the invention is to provide facsimile transmitting and receiving mechanisms adapted to operate in accordance with a system as outlined above.

Another object of the invention is to provide facsimile machines adapted to operate on the above arrangement wherein the scanning elements have a bi-lateral or back and forth scanning movement relative to the subject matter and recording sheets.

Another object of the invention is to provide a correcting mechanism for a bi-lateral scanning facsimile machine whereby the time elapsing between the beginning of the scanning of successive lines is equalized.

Another object of the invention is to provide a correcting mechanism for a bi-lateral scanning facsimile sytem wherein correction is applied to a scanning element of either a receiver or transmitting instrument at the end of one stroke, for example, in proportion to the speed difference between the two scanning elements so that with the speeds remaining constant the said scanning elements reach the end of their next respective strokes together.

A further object of the invention is to provide a correcting mechanism for a bi-lateral scanning facsimile machine wherein correction may be applied to both the transmitter and receiver scanning elements at the end of the first strokes thereof, for example, in proportion with the speed difference between the two elements and a given standard so that with the speeds remaining constant the scanning elements reach the ends of the next strokes in synchronism with the given standard.

Another object of the invention is to provide a rotating facsimile scanning element driving means arranged, for example, to make one-half revolution in one scanning stroke of the machine and correct the rotation of the driving element at the end of one-half revolution in proportion to the speed difference thereof and a given standard during the said one-half revolution to enable the rotating element with the speed thereof remaining constant to reach an initial position in synchronism with the given standard.

In accordance with the above, it is a still further object of the invention to provide means for rotating the facsimile scanning element driving means in a reverse direction after one-half revolution thereof an amount proportional to the speed difference between it and a given standard during the said one-half revolution.

A still further object of the invention is to provide a facsimile system and transmitting and receiving instruments to operate in conjunction therewith in such a manner that any speed difference, whether variable or constant, between the driving means for the said instruments does not have an accumulative effect on the reproduction, correction being applied to either one or both of the instruments periodically as, for example, at the end of a scanning line, when the speed thereof varies from each other or from a given standard.

The above and further objects of the invention will be more apparent in the following description thereof.

The transmitting mechanism employed in the preferred embodiment of the invention employs a photocell in its scanning element, and a pencil or beam of light is directed on the subject matter so as to reflect on the photocell to excite the same in accordance with the tonal densities of the subject matter as elemental areas thereof are successively scanned. A lens system is employed in conjunction with the light beam in the usual manner and also a chopper disc which interrupts the light beam at a certain frequency to generate a carrier frequency. The tonal densities of the subject matter modulate the carrier frequency in proportion to the amount of light reflected from the scanned subject matter. In the preferred embodiment of the transmitting and receiving mechanisms, the scanning element and the recording element move back and forth in a scanning and recording movement relative to the subject matter and the recording medium, while the so-called line feed of the subject matter and recording medium is in a direction perpendicular to the scanning and recording movements.

The recording element in the recording mechanism preferably consists of a stylus which duplicates the movement of the scanning element in the transmitting machine and reproduces a facsimile of the subject matter. The recording medium itself preferably is of the type which is adapted to change the color characteristic thereof on the passage of an electric current therethrough, the current passing through the paper being modulated in accordance with the subject matter scanned.

The preferred embodiment of the invention employs a reversing clutch for reversing the direction of movement of the scanning element in the transmitter and the recording element in the receiver. The reversing mechanisms may be controlled by any suitable means such as clock works which may be maintained in synchronism and corrected periodically from the transmitter or receiver or from a control point. A modified reversing or correcting mechanism employs a so-called differential arrangement whereby differences in speed of the driving means of the transmitter and receiver are corrected in amounts proportional to the difference in speed of the two driving means, or in amounts proportional to their speed and a given standard. The correction occurs periodically, and there is no accumulative effect on the reproduction of speed difference between the receiving and transmitting mechanisms or a given standard.

A more thorough understanding of the invention may be had from the following detailed description of the preferred and one modified embodiment thereof when taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a diagrammatic view of a facsimile sytem employing the mechanism of the present invention;

Fig. 2 is a perspective view of the principal elements of a facsimile machine constructed and controlled in accordance with the present invention;

Fig. 3 is a view showing the path of relative movement between the scanning element and the subject matter in the transmitting mechanism or the recording element and the recording medium in the receiving mechanism;

Fig. 4 is a detail view of some of the elements of the reversing clutch employed to reverse the direction of movement of the scanning element such as employed in Fig. 2;

Fig. 5 is a right hand view of the elements shown in Fig. 4;

Fig. 6 is a detail view of the control mechanism employed to operate the reversing mechanism;

Fig. 7 is a perspective view of the invention adapted to be controlled in accordance with the operation of the modified reversing mechanism employing the so-called differential correcting mechanism;

Fig. 8 is a diagrammatic representation of a modified control circuit for a facsimile system embodying mechanisms of the present invention;

Fig. 9 is a detail view partly in section of the differential correcting mechanism;

Fig. 10 is a detail view taken substantially on line 10—10 of Fig. 9;

Fig. 11 is a vertical sectional view taken substantially on line 11—11 of Fig. 9;

Fig. 12 is a left hand end view of some of the mechanism shown in Fig. 9; and

Figs. 13 to 18 are diagrammatic views of the differential correcting mechanism shown in Figs. 9 to 11 illustrating the principles of operation thereof.

Referring first to Fig. 2 there are shown the elements included in the embodiment chosen to illustrate the invention. As will be pointed out hereinafter, and as will be apparent from the appended claims, the invention is not limited to the particular arrangement shown in the drawings but may be incorporated in many other arrangements. In the arrangement shown in Fig. 2 a flat table 21 is supported on a base 22 and arranged to move longitudinally relative to the base being guided by means such as 23 in the base and projections 24 on the underside of the table.

The table 21 has thereon the subject matter sheet 26 to be scanned, and it may be a message, map or picture, etc. Clamping members 27 may be employed to hold the sheet 26 to the top of the table. As will be apparent, the mechanism disclosed in Fig. 2, while being described primarily as a transmitting machine, may be employed equally well as a recording machine, in which case the subject matter sheet 26 would be replaced by a recording blank. Attached to the table 21 is one end of a flexible band 28, the other end of which is arranged to wind up about a spring drum 29. The spring drum 29 may be of the type employed to advance the carriage in an ordinary typewriter and contains a spring (not shown) normally tending to rotate the drum in a clockwise direction, as shown in Fig. 2. The spring drum 29 through the flexible band 28 tends to move the table 21 in the direction indicated by the arrow 31 but is normally prevented from doing so by means hereinafter described. The spring drum 29 is provided with some means such as the knob 32 whereby the tension of the spring drum tending to advance the table may be varied.

Depending from the right hand side of the table 21 and extending the full length thereof is a rack 33 which is engaged by a pinion 34. The pinion 34 is mounted on a shaft 36 suitably supported in bearings (not shown) and has fixed to the forward end thereof a gear 37. The gear 37 meshes with a smaller gear 38 on a shaft 39 which also has fixed thereto a toothed ratchet disc 41. In axial alignment with the shaft 39 is a second shaft 42 which carries a multi-toothed cam disc 43. Extending axially from the back side of the cam disc 43 is a pin 44 which carries a pawl 46 held by a spring 45 in engagement with the teeth of the ratchet wheel 41. The spring drum 29 tends to advance the table 21 in a line spacing direction and at the same time tends to rotate the toothed ratchet wheel 41 through the described gear train including gears 38, 37, the pinion 34 and rack 33. Because of the pawl 46 and ratchet wheel 41, the table 21 may be moved either manually or by suitable automatic means in a direction opposite to the arrow 31 for the purpose of resetting the table without effecting rotation of the shaft 42. This operation will, of course, be performed prior to the beginning of the scanning of a subject matter sheet 26 and restores the tension to the spring in the spring drum 29.

Fixed to the forward end of the shaft 42 is a toothed escapement wheel 47 which has in operative relation therewith an escapement yoke, indicated generally by reference numeral 48, having arms 49 and 51 positioned on the right and left hand sides, respectively, of the escapement wheel. The escapement yoke 48 is pivotally mounted on a pin 52, and a complete oscillation comprising movement in one direction and then in the opposite direction permits rotation of the escapement wheel 47 one tooth. A stroke or half oscillation of the yoke 48 permits rotation of the escapement wheel 47 an amount equal to one-half the distance between adjacent teeth in the manner commonly employed in clock works.

The timing of the oscillations of the yoke 48 is controlled by a timing means including a flywheel 53 loosely mounted on a shaft 54. The flywheel 53 has one end of a hair spring 56 attached thereto, the opposite end of which is secured to the shaft 54. The flywheel 53 also carries a pin 57 extending axially therefrom which engages the bifurcation 61 in the lower end of the escapement yoke 48. The escapement wheel 47, tending to rotate from power derived from the spring drum 29, causes the escapement yoke 47 to oscillate, and the timing of the oscillations is controlled by the flywheel 53 and attached spring 56. For each half oscillation of the escapement yoke 48 the table 21 is advanced a predetermined distance in the direction of the arrow 31, and this advancement of the table is hereinafter referred to as the line feed advancement. The distance the table 21 advances for each half oscillation of the escapement yoke 48 is determined by the relative size of the gears 37 and 38 and the pinion 34. Preferably this advancement of the table is in steps of approximately one one-hundredth of an inch so as to give scanning lines one one-hundredth of an inch apart. Obviously the distance the table advances for each half oscillation of the escapement yoke may readily be varied by changing the relative size of the gears 37 and 38 or by changing other elements of the advancing mechanism. It will also be obvious that the above-described mechanism effects advancement of the table 21 in intermittent steps, and these preferably occur, as will hereinafter be pointed out, during the non-scanning part of the movement of the scanning head or scanning element. The timing period of the escapement yoke 48 is determined primarily by the tension of the hair spring 56 and the flywheel 53, and the tension of the hair spring 56 may be varied by rotating the shaft 54 through suitable means such as the thumb wheel 62 on the forward end thereof. A pointer 63 adapted to rotate with the thumb wheel 62 cooperates with a dial 64 to indicate the adjustment of the shaft 54.

The flywheel 53 has in the periphery thereof a notch such as 66 cooperable with a wedge-shaped projection 67 on the right hand end of an armature lever 68. The armature lever 68 is pivotally supported on a pin 69 and has an armature 71 at its left hand end in operative relation with electromagnets 72. A spring 73 normally pivots the armature lever 68 so that the wedge-shaped projection 67 is out of operative relation with the flywheel 53. However, energization of the electromagnet 72 raises the wedge-shaped projection 67 to engage the flywheel 53, and if at this time the center of the notch 66 is anywhere else but directly over the wedge-shaped projection 67, the flywheel will be rotated in either direction as the projection 67 enters the notch 66. Such operation of the electromagnets 72 corrects the position of the flywheel 53 in a manner more fully described hereinafter and effects this correction to advance the flywheel if it is slow or to reset the same if it is fast. The amount the flywheel 53 may be fast or slow is determined by the portion of the periphery of the flywheel that the notch 66 includes. While this portion is shown in the drawings to comprise only a small portion of the periphery of the flywheel 53, as it is expected only a small correction will be necessary, the design of the flywheel could be changed so that the correction could effect substantial parts of a revolution thereof.

The actual scanning operation of the subject matter sheet in the transmitter and the recording blank in the receiver preferably occur alternately with a line feed operation, and in the embodiments shown herein the scanning elements are arranged to move relative to the table 21 to perform a scanning operation. However, as will be apparent, the scanning element could be maintained stationary and the table moved back and forth in one direction for scanning movement and longitudinally in a different direction for line feeding. In Fig. 2 the scanning element is represented by the so-called scanning head 74 and it is adapted to move transversely of the subject matter sheet 26 on guide rods such as 76. The scanning head 74 of Fig. 2 would preferably include as shown in Fig. 1, a source of light 77, a chopper disc 78, and the photocell 79 together with the lens system which would include lenses such as 81. As shown in Fig. 1, the light beam from the source 77 is directed at the subject matter sheet 26 to successively illuminate elemental areas thereof and the light is reflected onto the photocell 79 in accordance with the tonal densities of the subject matter. The chopper disc 78 interrupting the light beam at a uniform rate generates a carrier frequency which is modulated in accordance with the tonal densities of the subject matter.

The output of the photocell which varies in accordance with the tonal densities of the elemental areas of the subject matter is applied to an amplifier represented by the rectangle 82 of suitable design which controls the transmission of signals representing the subject matter over the line circuit such as 83. The line circuit 83 may be of any of the well known types and for the sake of simplicity only the single connection is shown. At the receiving end of the line circuit 83 is another amplifying means 84 which operates in the usual manner to apply modulated electrical potential over the conductor 86 to a recording means such as a stylus 87. The amplifier 84 applies the modulated potential to the stylus 87 in accordance with the modulated carrier frequency. The recording medium 88 has the elemental areas successively scanned by the stylus such as 87 and is supported on a conducting plate which in the arrangement shown in grounded. The recording medium 88 may be of the well known type such as disclosed in a patent to R. J. Wise et al. No. 2,294,147, issued August 25, 1942, that changes color or produces a mark on the passage of an electric potential therethrough. Thus as a potential is applied to the stylus as the elemental areas of the recording medium are scanned by the stylus, there will be reproduced thereon an image similar to that on the subject matter sheet 26. Obviously, either of the amplifiers 82 or 84 would contain a signal inverter if desired so that the reproduction would not be a negative of the subject matter scanned. The diagrammatic showing in Fig. 1 also includes various control elements hereinafter described in detail which are employed to maintain the proper relation between the transmitting and receiving machines.

If the machine shown in Fig. 2 were a receiving instrument, the scanning head 74 thereof would contain a recording stylus such as 87 of Fig. 1 instead of the light beam, photocell and related elements. Preferably, the scanning head of a machine would contain both the scanning light beam and photocell with its related equipment and a recording element or stylus such as 87 so that the machine could be used either as a transmitter or a receiver, of course, only one of the elements, the scanning element or the recording element, being used at a time.

The mechanism for moving the scanning head 74 back and forth over the table will now be described. This mechanism includes two spring drums 89 and 91, Fig. 2, normally tending to rotate in the direction of the arrows adjacent thereto to wind up about the circumferences thereof associated flexible bands 92 and 93. The flexible band 92 passes over an idler pulley 94 and has the end thereof attached to the left hand side of the scanning head 74 while the flexible band 93 attached to the right hand side of the scanning head passes over an idler pulley 96 and then to its associated spring drum 91. As shown in more detail in Figs. 4 and 5, the spring drums 89 and 91 are pivotally mounted on independent shafts such as 97 and rotatable with the spring drums 89 and 91 are associated wheels 98 and 99 respectively. Adapted to engage the wheels 98 and 99 one at a time is a drive wheel 101. During the scanning of a subject matter sheet the drive wheel 101 is arranged to be constantly rotated through elements hereinafter described and is brought into engagement first with one wheel 98 or 99 and then the other to rotate the same independently and wind the flexible bands 92 and 93 about the associated spring drums. The winding of the band 92 about the spring drum 89 causes the scanning head 74 to move to the left and during such time the band 93 unwinds from its associated spring drum 91. The subsequent engagement of the drive wheel 101 with the wheel 99 causes the flexible band 93 to wind up about its spring drum 91 and move the scanning head in the opposite direction to the right while the band 92 is unwinding from its drum. The movement of the drive wheel 101 from engagement with one wheel such as 98 to the other such as 99 is controlled by the escapement mechanism which also controls the line feed movement of the table.

The drive wheel 101 is mounted on a shaft 102 which also has thereon a gear 103. The shaft 102 is supported in the upper end of a lever 104 pivotally mounted adjacent its center on a shaft 106. The shaft 106, as shown in Figs. 2, 4 and 5, is suitably journaled in a stationary part of the framework indicated generally by reference numeral 107. Mounted on the shaft 106 is a gear 108 which meshes with the previously mentioned gear 103 and drives the same. The shaft 106 is driven from a motor drive shaft pinion 109 of a motor M and a gear 110 through an electromagnet-controlled clutch indicated in general by reference numeral 111. The magnet 112 controls the clutch 111 in a manner hereinafter described.

The lower end of the lever 104 has a pin 113 extending therefrom which engages a slot 114 in a jockey lever 115. The jockey lever 115 is pivotally mounted adjacent its center on a fixed pivot 116 and has attached to the upper end thereof the upper end of a jockey spring 117. The lower end of the spring 117 is anchored on a pin 118 in vertical alignment with the shaft 106 and the fixed pivot 116. The jockey lever in conjunction with the spring 117 biases the drive wheel 101 into either one of its operative positions.

A pin 119 located in the lever 104 above the center pivot point engages a slot 121 in the left hand end of a link 122. The link 122 is attached at its right hand end to the upwardly extending arm of a bell crank 123 which is pivotally mounted in a fixed pivot 124. The rightwardly extending arm of the bell crank 123 is engaged by a bifurcated left hand end as shown in Fig. 6 of a lever 126. The lever 126 is pivoted at its right hand end on a fixed pivot 127 and has to the left of the pivot a cam follower 128 in operative relation with the periphery of the cam disc 43. A spring 129 holds the cam follower 128 in engagement with the disc 43.

The cam disc 43 is stepped in the manner hereinbefore described amounts equal to one-half the distance between successive teeth on the escapement disc 47. The cam disc 43 has projections such as 131 equal in number to the teeth on the escapement disc and after each step of the disc 43 either a projection 131 or a notch between two projections will be in engagement with the cam follower 128. Accordingly, the lever 126 will be oscillated up and down so as to make one movement for each step of the escapement disc 47. The movement of the lever 126 from its lower position as shown in Fig. 6 to its upper position as shown by the dot-dashed outline thereof will rock the bell crank 123, Fig. 4, in a counter-clockwise direction. This causes the link 122 to push on the pin 119 and rock the lever 104 in a counter-clockwise direction. During this movement of the lever 104 the jockey lever 115 is also rocked in a counter-clockwise direction to increase the tension in the jockey spring 117 and when the end of the jockey lever to which the spring is attached is just beyond dead center, the spring is effective to snap the jockey lever to its other position. Thus the movement of the lever 104 which is initiated by the link 122 is completed by the jockey lever 115 and attached spring 117, the slot 121 in the left hand end of the lever 122 permitting movement of the lever 115 independently of the link 122. In a similar manner the rocking of the bell crank 123 in a clockwise direction by the lever 126 pivots the lever 104 in a clockwise direction to the position shown in Fig. 4. In this position the drive wheel 101 carried in the upper end of the lever 104 is in engagement with the wheel 99 associated with the spring drum 91, whereas when the lever 104 is pivoted in the opposite direction, the drive wheel 101 is in its other position and engages the wheel 98 as shown by the fragmentary dotted portion thereof in Fig. 4.

When the drive wheel 101 is in engagement with the wheel 99, the band 93 is wound up about the associated spring drum 91 to move the scanning head 74 to the right and in a similar manner engagement of the drive wheel with the wheel 98 moves the scanning head to the left. The springs such as 132, Fig. 4, in the spring drums 89 and 91, preferably are arranged so that the tensions thereof may be varied by well known suitable means such as manually positionable members 133. The tensions of the springs in said drums are preferably adjusted so that they exert an equal tension on their associated flexible bands when the scanning head 74 is in substantially the center of its travel. When the flexible band winds up about one spring as controlled by the drive wheel 101, the tension of the spring in the spring drum from which the band is unwinding is increased. This difference in tension of the springs in the spring drum which will occur when the scanning head 74 is near either end of its travel, assists in overcoming the inertia necessary to start the scanning head for the beginning of a scanning movement in an opposite direction to its last scanning stroke. However, the drive wheel 101 is arranged to move from one position to the other extremely fast and during such movement the difference in tensions of the springs in the spring drums 89 and 91 preferably do not cause any independent movement of the scanning head 74.

From the above arrangement it is obvious that reciprocating movement of the scanning head 74 is produced and that during its movement it will have, within the limitations of the driving motor, substantially uniform speed in each direction. Accordingly, a scanning function may be performed during each movement of the scanning head and time is not lost as is the case in some facsimile machines wherein the scanning element returns to a normal position at the beginning of a line by a non-scanning return movement following each scanning movement. It will also be obvious that the above arrangement has the advantage that by changing the sizes of the wheels such as 98 and 99, the length of a line scanned in each scanning function may be varied while the time characteristics of the control mechanism are maintained constant. The length of the scanning line may also be varied by maintaining the proportions of the scanning head driving elements fixed and varying the time characteristics of the escapement control mechanism.

The advancement of the table 21, Fig. 2, in a line spacing direction, preferably occurs during the operation of the reversing mechanism which includes the drive wheel 101, or while the scanning element in the scanning head is scanning the margin of the subject matter sheet and table, and is adapted to occur substantially instantaneously. This arrangement produces a scanning of the subject matter sheet 26 as exemplified in Fig. 3 where the dot-dashed line 134 represents the relative movement between the scanning head such as 74 and the subject matter sheet 26. If the scanning head 74 is assumed to start at a point 136 and then travel to the right across the subject matter sheet to the point 137, at which time the table 21 is advanced one scanning line, then the return scanning stroke of the scanning head will traverse the second dot-dashed line on the sheet 26, Fig. 3. This produces scanning lines which are exactly parallel with one another and in a direction perpendicular to the direction of movement of the subject matter sheet. This arrangement has many obvious advantages over the method and mechanisms employed wherein the subject matter sheet is wrapped around a cylinder and scanned in one continuous helix or methods wherein the subject matter sheet is scanned by prior art arrangements.

The modified arrangement of the invention employs a so-called differential reversing mechanism, and this mechanism will now be described. The application of the differential mechanism to a machine such as disclosed in Fig. 2 is shown in Fig. 7, and as will be apparent many of the elements of Fig. 7 are identical with those of Fig. 2 and, accordingly, bear and are referred to by the same reference numerals. The differential mechanism itself may be enclosed within the box 146, Fig. 7, and the power therefor supplied from a constantly rotating motor M of suitable speed characteristics through an electromagnet controlled clutch 145 including a control magnet 144. The control of the reversing mechanism is effected through a lever 148 which is operated from a cam disc 43' included in the escapement mechanism. The escapement mechanism of the arrangement shown in Fig. 7 is somewhat the same as that of Fig. 2, with the exceptions hereinafter pointed out. The cam disc 43' in Fig. 7 has twice as many projections thereon as the teeth on its associated escapement wheel 47, and the escapement yoke 48' is pivotable on a pivot pin 142 at the lower end thereof under the control of separate electromagnets 143. With this arrangement the escapement yoke 48' is operated as the magnets 143 are alternately energized to escape the wheel 47 a half tooth for each movement of the yoke or one tooth for each complete back and forth oscillation thereof. The lever 148 is operated momentarily by the disc 43' once for each half tooth advancement of the escapement wheel 47.

The reversing mechanism will be described in detail hereinafter, but for the present it is believed desirable to describe the connection thereof with the scanning head 74. As shown in Fig. 7, the reversing mechanism has a crank arm 149 at the forward end thereof to which is connected a link 151. The link 151 is pivotally attached to a block 152 adjustable along a slot 153 in a lever 154. The lever 154 is pivoted at its lower end on a pivot pin 156, and the upper end has connected thereto a link 157. The other end of the link 157 is attached to a pin 158 extending from a spring drum 159. The spring drum 159, together with a second spring drum 161, is preferably of larger diameter than the spring drums 89 and 91 of Fig. 2, and the reason for this will be obvious hereinafter. Bands 92 and 93 connect the scanning head 74 to the spring drums 159 and 161 and tend to wind up about the spring drums due to the action of the springs contained therein.

As the crank arm 149 of the reversing mechanism rotates, the link 151 attached thereto causes the lever 154 to pivot back and forth, and it through the link 157 turns the spring drum 159 a predetermined amount in one direction and then an equal amount in the opposite direction. As the spring drum 159 is turned in one direction as, for example, a counterclockwise direction, the scanning head 74 will move to the right due to the action of the tension on the flexible band 93. The rotation of the spring drum 159 in the opposite direction causes its flexible band 92 to wind up about the circumference thereof to move the scanning head 74 to the left. The diameter of the spring drums, and especially the spring drum 159, is such that approximately 120° rotation thereof effects a complete scanning movement in one direction of the scanning head 74. As in the preferred embodiment, the tension of the springs in the spring drums 159 and 161, Fig. 7, is such that they exert substantially equal forces on the scanning head 74 when it is in the middle of its travel. With such an arrangement the unequal tensions of the springs in the spring drums when the scanning head reaches the end of a stroke tends to overcome the inertia thereof in initiating a return stroke. By adjusting the position of the block 152 along the slot 153 in the lever 154, the amount of oscillation of the lever 154 may be varied, which in turn will vary the stroke of the scanning head 74. The pin 162 in the block 152 is adapted to engage holes such as 163 in the lever 154 to lock the block in an adjusted position.

Referring now to Figs. 9 to 12, the details of the elements of the reversing mechanism will now be described. Included in this mechanism is a shaft 164 which is driven from the motor M through suitable reduction gearing, if desired, and through the electromagnet clutch 145 which includes the control magnet 144, Fig. 7. The shaft 164 is suitably journaled in bearing supports such as 166 and has adjacent its right hand end. as shown in Fig. 9, a threaded portion 167 preferably having a multiple lead. Mounted on the threaded portion 167 of the shaft 164 is a sleeve 168 which has formed integrally therewith a so-called stop disc 169. A radial flange 171 is formed in the left hand end of the sleeve 168 and adapted to engage the right hand side of this flange are two diametrically opposite pins 172 carried in a yoke 173. The upper end of the yoke 173 is pivoted at 174 in a rightwardly extending arm of a member 176 attached by means of a screw 177 to the shaft 164 for rotation therewith. A spring 175 anchored in the member 176 and attached to the yoke 173 tends to pivot the yoke in a clockwise direction and keeps the pins 172 against the flange 171. The lower end of the yoke 173, as shown in Fig. 9, is pivotally connected to the right hand end of a link 178, the left hand end of which is pivotally and adjustably connected adjacent the center of a lever 179. The lever 179 is pivotally mounted at its lower end on a leftwardly extending arm of the member 176, which arm is diametrically opposite to the rightwardly extending arm thereof to which the upper end of the yoke 173 is pivotally attached. The upper end of the lever 179 is U-shaped and carries pins 181 which are located in a circular groove 182 in the right hand end of a cam member 183.

The cam member 183 is loosely mounted on the shaft 164 and is axially movable thereon in a manner hereinafter described. The cam member carries a pin 184 which engages a helical groove 186 formed in the shaft 184 so that axial movement of the cam member along the shaft produces relative rotation between the two elements. The lead of the groove 186 is not the same as the lead of the threaded portion 167 of the shaft 164 for reasons that will be apparent. Formed integrally with the cam member 183 adjacent the left hand end is a disc 187 with diametrically opposite notches 188 in the periphery thereof which engage pins 189. The pins 189 extend axially from the right hand side of a disc 191 loosely mounted on the left hand end of the shaft 164 and rotatable independently thereof. The pin shaped end of a screw 192 in the disc 191 engages a circular groove 193 in the shaft 164 to prevent axial movement of the disc 191 on the shaft. The sleeve portion of the disc 191 extends through the bearing 166, and secured to the left hand end thereof by screws such as 194 is the hereinbefore-mentioned crank arm 149, which has attached thereto the link 151.

As shown more clearly in Fig. 10, the stop disc 169 has extending from the periphery thereof two diametrically opposite stop surfaces or projections 195 and 196. In operative relation with the stop surfaces 195 and 196 is a T-shaped stop member 197 which is pivotally mounted on a pin 198 in the upper end of a lever 199 pivotally mounted on a fixed pivot 201. A spring 202 normally biases the stop member 197 to a stop disc stopping position or in the path of the stop surfaces or projections 195 and 196, as limited by a stop pin 203.

Extending from the lever 199 is a pin 204 which is engaged by the upper bifurcated end of a lever 206 secured at its lower end to a rock shaft 207 supported in brackets 208. Also secured to the rock shaft 207 is a leftwardly extending arm 209 which, as best shown in Fig. 11, has a slot 212 in the left hand end thereof which engages a pin in the lower end of a rod 213. The rod 213 is guided for vertical movement in a portion 214 of the bracket member and has at its upper end a roller cam follower 216 engageable with the central surface of the cam member 183. A spring 217 surrounding the rod 213 tends to elevate the said rod to keep the cam follower 216 in engagement with the periphery of the cam member 183. As shown in Fig. 11, the cam member 183 has two diametrically opposed notches or recesses 218 therein so that, as the same rotates, the rod 213 is moved in a downward direction twice for each complete revolution of the cam member 183.

In addition to the rocking of the stop member 197, Fig. 10, about the pivot 198 due to the operation of the lever 148, as hereinafter described, the stop member moves back and forth in the direction of its length twice for each revolution of the cam member 183 through the instrumentalities of the above-described elements including the notches in the cam member 183, the rod 217, arm 209, lever 206 and lever 199. Thus, the stop projections 195 and 196 on the stop disc 169 are engageable with the stop member 197 at a point variable distances ahead of the normal zero position shown in Fig. 10. In accordance with the proportions of the various elements, the stop projections 195 and 196 may engage the stop member 197 at any point between the normal stop position shown by the full outline thereof in Fig. 10 and the dot-dashed position shown.

The correcting mechanism or the differential reversing mechanism in the box 146, Fig. 7, is so designed that when associated with a receiving instrument for example, and the shaft 164 in exact synchronism with the driving shaft on a transmitting mechanism and/or the clock control elements, there is no functional or correcting operation of the elements comprising the differential reversing mechanism, as will be evident. The cam surfaces or notches 218 in the cam member 183 and the operating element for the stop member 197 are so arranged that the above-described lateral movement of the stop member from left to right and right to left is at the same speed as the peripheral speed of the stop projections 195 and 196 when rotating with the shaft 164. If the receiver is in exact synchronism with the transmitter or the synchronizing mechanism, the stop member 197 is pivoted by the lever 148 about the pivot point 198 just as the stop projection 195 rotates into its so-called zero position, as shown in Fig. 10. At the same time a notch 218 in the cam member 183 begins to move the stop member 197 laterally toward the left. The stop member 197 reaches the position shown by the dot-dashed outline thereof after approximately 30° rotation of the cam member 183 from its zero position and remains in this position for the time being. If it is assumed that it requires 30° rotation of the cam member to move the stop member to some such position as shown by the dot-dashed outline thereof in Fig. 10, then it will require 150° rotation of the stop disc 169 from its zero position before the stop projection 196 rotates to a position where it is engageable with the end of the stop member 197.

Just as the stop projection 196 reaches the left hand end of the stop member 197, the other notch 218 of the cam member 183 is operative to effect movement of the stop member to the right. As the notch 218 is designed to produce lateral movement of the stop member toward the right at a speed substantially equal to the peripheral speed of the stop projections 195 and 196, the stop member will have no effect in reducing the speed of rotation of the stop disc 169. Accordingly, the stop projection 196 and the stop member 197 will move to the right together with no functional engagement between the two. With the assumed condition of exact synchronism between the receiving and transmitting instrument, the lever 148 will pivot the stop member 197 about the pivot 198 just as the stop projection 196 reaches the position occupied by the stop member 195 in Fig. 10, and there will be no stopping or reduction in speed of the stop disc 169 during the first half revolution thereof. If the speed of the shaft 164 remains in synchronism with the transmitting mechanism, there will be no stopping or reduction in speed of the stop disc 169 during the second half revolution thereof or at the end of the second half revolution, as the stop member 197 operates in exactly the same manner as it did during rotation of the stop disc 169 through its first half revolution. Thus, as long as the shaft 164 remains in synchronism with the transmitting mechanism, there is no stopping or slowing down of the stop disc 169 once it is initiated into rotation until the completion of the scanning of a subject matter sheet. For the above-described operation there is no functional operation of the correcting mechanism, and obviously the scanning heads of the transmitting and receiving mechanisms are in exact synchronism with each other and both scan respective elemental areas of the subject matter and recording blank, respectively. With such an arrangement any vertical line, for instance, on the subject matter would be produced as a vertical line on the recording blank, and there will be no drift or sloping of the reproduced line on the recording blank. In addition, such a mechanism as described, wherein the line feeding of the subject matter and recording blank is effected during non-scanning operation of the mechanism, all horizontal lines, for example, are reproduced strictly horizontal on the recording blank. Furthermore, it will be obvious that lines which are perpendicular to each other on the subject matter, such as vertical and horizontal lines, are produced exactly perpendicular to each other on the recording blank. If the scanning strokes of the transmitting and receiving machines are equal and the line feeding mechanisms adapted to advance the subject matter sheet and recording blank the same amount on each operation, the recording blank will be an exact reproduction in all dimensions of the subject matter.

The operation of the differential mechanism is considerably different from that described above when there is a speed difference between the transmitting and receiving mechanisms. The manner of operation of the reversing mechanism will now be described when, for example, the speed of rotation of the shaft 164 is faster than the speed of rotation of the shaft employed to operate the transmitting mechanism. It will be assumed for the following description that the shaft 164, which is rotating faster than the similar shaft on the transmitting mechanism where the synchronizing impulses originate, is at constant speed.

In Figs. 13 to 18 there is diagrammatically shown the operation of various elements of the correcting mechanism, and in these figures like reference numerals refer to like elements shown in Figs. 9 to 12. The stop disc 169 is shown in its zero position in Fig. 13, and the stop member 197 by the full outline thereof in the position it will assume after it has been pivoted by the escapement mechanism including the lever 148. After 150° rotation of the stop disc 169 from its zero position with the proportions of the elements as shown, the stop projection 196 reaches the position shown in Fig. 14 in operative relation with the end of the stop member 197 which has been moved to the left. Thereupon or during the next 30° rotation of the stop disc 169, the stop projection 196 rotates to the position shown in Fig. 15, while the left hand end of the stop member 197 moves from its left hand position into the position shown in Fig. 15. As previously described, the notches 218 in the cam member 183 effect movement of the stop member 197 to the right at a speed substantially equal to the peripheral speed of a stop projection such as 196, and accordingly there is no operative engagement between the stop projection 196 and the end of the stop member 197 during the said rightward movement. If it is assumed that the rotation of the stop disc 169 from the position shown in Fig. 13 to the position shown in Fig. 15 occurred while the corresponding element on the transmitting mechanism rotated but 170°, then the receiving stop disc 169 at this time would be 10° ahead of the transmitting stop disc. Accordingly, the stop disc 169 on the receiving mechanism should be corrected while the transmitting disc rotates 10° and, in addition, should be operated upon to effect a correction for the next or second half revolution of the stop disc of the transmitting mechanism. Correction is effected by rotating the stop disc 169 on the receiving mechanism in a reverse direction an amount proportional to the speed difference between the two rotating elements or in proportion to the amount the receiving stop disc was ahead of the stop disc on the transmitting mechanism in the first half revolution of the stop disc of the transmitting mechanism. Thus the stop disc 169 on the receiving mechanism will have to, in its second half cycle of operation, rotate 180° plus an amount proportional to the speed difference between the receiving and transmitting mechanisms.

With the shaft 164, for example, on the receiving mechanism rotating fast or at such a rate that it completes a revolution before the operation of the synchronizing mechanism, the stop disc 169 will be in the position such as that shown in Fig. 15 before the stop member 197 has been pivoted about the pivot point 198. The stop disc 169 will reach the position shown in Fig. 15 after 180° revolution thereof and for obvious reasons the correcting mechanism operates at that time in such a manner that the amount of correction applied to the disc is proportional to the amount that the stop disc was fast in the first half cycle. With this arrangement the stop disc will complete a revolution and reach its zero position in exact synchronism with the synchronizing mechanism, it being assumed that the speed of the shaft 164 remains substantially constant for one revolution or that the speed variation is such as to be of no consequence.

As the stop disc 169 reaches the position shown in Fig. 15, the stop projection 196 will engage the left hand end of the stop member 197 to be stopped thereat. As the shaft 164 continues to rotate, the collar 168, Fig. 9, immediately begins to thread along the threaded portion 167 of the shaft 164. Preferably the threaded portion 167 is multiple threaded and the movement of the collar 168 axially of the shaft 164 permits the spring 175 through the yoke 173, link 178 and lever 179 to slide the cam member 183 in a leftward direction along the axis of the shaft. The leftward movement of the cam member 183 produces rotation thereof relative to the shaft 164 by means of the pin 184 engaging the helix 186 in the left hand end of the shaft. The lead of the helix 186 is different from that of the threaded portion 167 of the shaft 164 so that as the cam member 183 moves to the left, the same will be caused to rotate in a direction opposite to the direction of rotation of the shaft 164. As the cam member 183 rotates in the reverse direction, the mechanism comprising the rod 213, arms 209 and 206, and lever 199 moves the pivot point 198 for the stop member 197 to the left as shown in Figs. 10 and 13 to 18. The leftward movement of the stop member 197 rotates the stop disc 169 in a reverse direction relative to the direction of rotation of the shaft 164 so as to produce more axial movement thereof relative to the shaft which in turn through the described linkage produces further axial movement of the cam member 183. The various elements above mentioned are so designed and arranged that the leftward movement of the stop member begins substantially instantaneously with the stopping of the stop disc 169 in the position shown in Fig. 15 or its position after 180° rotation. The elements are also so arranged that the rate of rotation of the stop disc 169 in a reverse direction is exactly the same as the rate of rotation of the shaft 164 in the opposite direction.

The rotation of the stop disc 169 in a reverse direction will continue until the stop member 197 is operated so as to pivot about the pivot point 198 in response to the synchronizing mechanism by some means such as the operating lever 148. When the stop member 197 is thus operated, the stop disc 169 and the cam member 183 will rotate with the shaft 164, and assuming the speed of the shaft 164 remains constant, the stop disc will reach its zero position in exact synchronism with the tripping mechanism or just as the stop member 197 is operating the next time. The spring 175 tending to move the sleeve 168, Fig. 9, to the left insures that the sleeve will rotate with the shaft 164 when not stopped by the engagement of a stop projection 195 or 196 with the stop member 197.

Let it be assumed, for example, that the movement of the stop member 197 to the left before being operated by the lever 148 was such as to rotate the stop disc 169 in a reverse direction, to some such position as shown in Fig. 16. The subsequent operation of the lever 148 moves the stop member 197 to the position shown by the full outline thereof in Fig. 17 and releases the disc 169. The above amount of reverse rotation of the stop disc is merely chosen to illustrate the principles of operation of the correcting mechanism and actually only a small fraction of such an amount would normally be required. However, the correcting mechanism could operate in such amounts or more if required. If the stop member 197 operates when the stop disc 169 is in some position such as shown in Figs. 16 and 17, then the cam follower 216 will be in some position other than in the bottom of the notch 218 in the cam member 183. Therefore, as the cam member 183 resumes its rotation with the shaft 164, the stop member 197 while still in a releasing position will move to the right the same distance it moved to the left to correct the rotation of the stop disc and then will move to the left to its extreme left hand position such as shown in Fig. 18. When the stop projection 195 reaches the stop member 197, then it will move to the right and as the stop projection 195 reaches its zero position, the stop member will be operated in the manner hereinbefore described without retarding the rotation of the stop disc at this time.

The amount of correction applied to the stop disc 169 or the amount it is rotated in a reverse direction is such that it will complete a revolution and be in its zero position at exactly the time of the operation of the synchronizing mechanism or at the time the member 148 is operated to pivot the stop member 197 a second time. Since the stop disc 169, the cam member 183 and the crank arm 149 all rotate together, the amount of correction applied to the stop disc 169 is carried through to the crank arm 149. The elements operated by crank arm 149 are so arranged that they are in one extreme position when the stop disc 169 is in its zero position and in their other extreme position when the stop disc has rotated half a revolution. Thus, the scanning head of the associated instrument will be in one extreme position when the stop disc 169 is in its zero position and in its other extreme position after the stop disc has rotated half a revolution.

The movement of the scanning head is so arranged that it moves a substantial distance greater than the width of the subject matter being scanned, or the width of the recording medium, and accordingly during the first and last parts of each stroke or movement of the scanning head no scanning or recording function is being performed. With this arrangement the correction to the stop disc 169 is applied during the over travel of the scanning head or during a non-scanning or non-recording interval. In addition the correction to the crank arm 149 is applied when it is in dead center position relative to the elements operated thereby and it may be moved or corrected a considerable amount before having appreciable effect on the scanning head.

In the above described operation of the correcting mechanism it was assumed that the synchronizing impulses originated at the transmitting mechanism which was operating without correction being applied thereto or was operating at such a speed that it completed a half revolution in exact synchronism with the operation of the synchronizing mechanism. The correction applied to the receiving mechanism was such that it completed a complete revolution in exactly the length of time required for the transmitting mechanism to complete a revolution. Thus, the two mechanisms start a cycle of operation or a cycle in which the scanning head moves forward and back at exactly the same time and finish a cycle of operation at exactly the same time. Thus, while the transmitting mechanism is scanning an elementary area on the subject matter, the recording mechanism is scanning a representative area on the recording blank, and this is true during both the forward and backward movement of the scanning heads.

Should both the transmitting and receiving mechanisms be going faster than the synchronizing mechanisms, they will both be corrected in amounts proportional to the amount they are faster than the synchronizing mechanism in the manner described above. Thus, regardless of the respective speeds, the scanning heads of both machines will start their forward strokes and finish their backward strokes together.

In the above description it was assumed that the speed of the driving means for the receiver, while being faster than the speed of the driving means for the transmitter, was constant. For this condition the amount of correction applied after one-half revolution of the stop disc 169 in the receiving instrument, Fig. 9, was such that it completed the next half revolution in exact synchronism with the transmitting instrument, it being assumed that the transmitting instrument was in exact synchronism with the synchronizing impulse transmitting means or that the synchronizing mechanism was operated in conjunction with the transmitting instrument. The differential mechanism will function, however, if the speed of the driving means varies with respect to the speed of the synchronizing impulse transmitting means or with respect to the driving means for the instrument where the synchronizing signals originate. If, for example, the speed of the stop disc 169 during the second half of a revolution thereof is faster than the speed of rotation during the first half revolution, the stop disc will reach its zero position, such as shown in Fig. 13, prior to the releasing operation of the stop member 197. The stop member 197, as hereinbefore described, will immediately begin to move to the left to correct the stop disc an amount proportional to the difference in speed between the first and second half revolutions thereof. For the above condition the amount of correction applied to the stop disc 169 after a complete revolution thereof, or with the disc 169 in its zero position, will not correct for the entire speed difference the driving means of the transmitting and receiving instruments, or the speed difference between the shaft 164 and the synchronizing impulse transmitting means, but for the speed difference between the first and second half revolution of the stop disc 169. Thus, the stop disc 169 would be corrected when the speed of the driving means is increasing relative to the synchronizing impulse transmitting means at its zero and one-half revolution positions. The correction to the disc 169 will continue to be applied in its zero position as the same continues to increase in speed relative to the synchronizing impulses and in its one-half revolution position because of the speed difference between the synchronizing impulses and the driving means of the disc 169.

If the disc 169 is rotating faster than the synchronizing mechanism and begins to lose speed relative thereto, the stop projection 195 will not quite reach its zero position when the stop member 197 is operated, and accordingly the stop disc will reach its zero position a little late or by an amount proportional to the decrease in speed between the first and second half revolutions thereof. Accordingly, it will take it a slightly longer interval for the disc 169 to reach its next half revolution position, and the correction ordinarily applied at this point, provided the speed of the disc is still faster than the synchronizing impulses, will not be so much as it would be if the speed had remained constant. This decrease in the amount of correction applied at the half revolution point accounts for the decrease in speed of the disc 169, and the decrease in speed will not have an accumulative effect on the position of the stop disc 169 relative to the time of transmission of the synchronizing impulse. Thus, as long as the speed of the stop disc 169 remains faster than the synchronizing impulses, it may vary in either direction, and the correcting mechanism will operate to effect a correction in the position of the stop disc relative to the synchronizing impulses.

The above correction prevails on the receiving instrument whether the synchronizing impulses originate with the transmitting instrument or from a separate control point. Where the synchronizing signals originate from a synchronizing impulse transmitting means separate from the transmitting and receiving instruments, they both will be corrected in the above-described manner when the speeds thereof are different from that of the synchronizing mechanism or when the speeds are varying relative to the synchronizing mechanism. When the synchronizing impulses originate independently of either the transmitting or receiving instruments, the speed of the driving means of one instrument may be increasing while the speed of the driving means of the other instrument is decreasing, and appropriate corrections will be applied to their respective stop discs such as 169.

Mention has been made hereinbefore in connection with the description of the various elements of the invention of synchronizing impulses which are employed to maintain proper synchronism between the transmitting and receiving instruments of a facsimile system as disclosed herein. As will be apparent hereinafter, these synchronizing impulses may originate at the transmitter, the receiving, or at a point independent of both the transmitter and receiver. The description of the control circuits included in the present invention will now be given as they are arranged when the synchronizing impulses originate in conjunction with the operation of the transmitting mechanism. Referring to Fig. 1, there are shown the control elements of a transmitting instrument and those of a receiving instrument connected by the line conductor 83. The escapement yoke 48 on the transmitting instrument, as shown, has associated therewith a set of contacts 221 which are adapted to be closed when the escapement yoke oscillates into its left hand position and to be open with the yoke in any other position. One of the terminals of the contacts 221 is connected to the movable arm 222 of a manually operable switch 223, and the other terminal of the contacts is connected by a conductor 224 through the coil of a three-position polar relay 226 to the amplifier 82. The relay 226 is of the type that on the passage of current of one polarity therethrough the associated tongue 227 is operated to contact one stop, and with the passage of current of opposite polarity therethrough, the tongue is operated to contact the other stop, and with the passage of no current through the relay the tongue 227 assumes a central position in contact with neither of its associated stops. The left hand stop of the tongue 227 of relay 226, to which stop the tongue is moved on the passage of negative current through the relay, is connected through the coil of a relay 228 to ground. The relay 228 has two tongues connected to positive potential, and the make stop of the inner tongue is connected through the coil of the clutch control magnet 112 to ground, while the make stop of the outer tongue of relay 228 is connected through the coil of magnet 72 to ground. The movable arm 222 of the switch 223 has two associated stops, the left hand one of which is connected to negative potential and the right hand one to positive potential. With the movable arm 222 on its right hand stop a positive impulse will be transmitted therefrom through the contacts 221 over conductor 224 through the coil of relay 226, the amplifier 82, to the line circuit 83, each time the contacts 221 are closed.

The grounded relay 229 connected to the amplifier 84 at the receiving station is similar in operation to the relay 226 at the transmitting station and responds to control impulses transmitted over the line circuit 83. The tongue 231 of relay 229 contacts its right hand stop on the passage of negative potential through the winding and its left hand stop on the passage of positive potential through the winding. When there is no current through the winding of the relay 229, the tongue 231 assumes a central position in contact with neither of its stops. The tongue 231 of relay 229 is connected to positive potential, and its associated left hand stop is connected to the make stop of the outer tongue of a relay 232 in parallel with the winding of the magnet 72′ to ground. The right hand stop of the tongue 231 of relay 229 is connected through the coil of relay 232 to ground. The tongues of relay 232 are connected to positive potential, and the make stop of the inner tongue is connected through the coil of a clutch control magnet 112′ to ground.

Let it be assumed that the arm 222 of the switch 223 is on its left hand stop and that the contacts 221 are closed by the yoke 48 being in its left hand position. The yoke 48 is held in this position by means hereinafter described. Accordingly, negative potential from the left hand stop of switch 223 will be applied through the contacts 221 and through the relays 226 and 229 to ground. As hereinbefore described, negative potential operates the tongues of relays 226 and 229 to their left and right hand stops, respectively. With the tongue 227 of relay 226 on its left hand stop, relay 228 will be energized, causing its tongues to complete circuits through magnets 112 and 72 to energize the same. The energization of the clutch control magnet 112 operates the clutch 111, Fig. 2, to disconnect the drive wheel 101 from the motor M. The energization of magnet 72 operates the armature lever 68 to force the projection 67 into the notch in the flywheel 53. This holds the flywheel 53 and escapement yoke 48 at rest in a non-operating position, and in this position the contacts 221 are held closed. In addition to disconnecting the drive wheel 101 from the motor M, the operation of the magnetic clutch 111 preferably prevents further rotation of the drive wheel.

With the tongue 231 of relay 229 at the receiving station on its right hand contact, relay 232 will be energized. The energization of relay 232 through its tongues completes circuits to the coils of the clutch control magnet 112′ and the magnet 72′. The energization of magnet 72′ causes the associated escapement yoke 48 to stop in its non-operating position, while the energization of the clutch control magnet 112' disengages the drive motor from the associated drive wheel at the receiving instrument in a similar manner, as the energization of magnet 112 at the transmitting station controls the clutch 111 thereat. The instruments at both the transmitting and receiving stations are thus held in non-operating conditions with the respective elements thereof in the same relative positions. To initiate the operation of the two machines to scan a subject matter sheet and reproduce a facsimile thereof at the receiving instrument, the tables and scanning heads, if not already in a starting position, may be so placed and the switch 223 operated to place its movable arm in contact with its right hand stop. This operation impresses positive potential on the windings of relays 226 and 229, whereupon the tongues thereof move to their right and left hand stops, respectively. As tongue 227 of relay 226 contacts its right hand stop, the circuit through relay 228 is interrupted, whereupon the tongues thereof open the circuit to the clutch control magnet 112 and the magnet 72. The deenergization of the clutch control magnet 112 renders the associated clutch 111, Fig. 2, operative to connect the motor M with the drive wheel 101, and the deenergization of magnet 72 releases the flywheel 53 to permit the escapement yoke 48 to oscillate. The escapement yoke 48 will continue to oscillate as timed by the flywheel 53, and at the end of each complete oscillation or as it moves into its left hand position, the contacts 221 will be closed momentarily to reapply positive potential over the line circuit 83, Fig. 1, to the relay 229 at the receiving station.

The movement of the tongue 231 of relay 229 from its right hand stop opens the circuit to relay 232, which in turn opens the circuits completed on the energization thereof to magnets 112' and 72'. Preferably, the relay 232 does not release until after the tongue of relay 229 has reached and left its left hand stop. Accordingly, magnets 72' and 112' remain energized until the contacts 221 open to transmit a no-current impulse. The deenergization of the clutch control magnet 112' connects the drive wheel such as 101 at the receiver with the motor M and initiates scanning movement of the associated scanning head containing the recording stylus 87. The deenergization of magnet 72' releases the flywheel 53 at the receiving instrument and permits the escapement yoke 48 to oscillate and shift the drive wheel 101 from engagement with one wheel such as 98 to the other such as 99. The following positive impulses which are transmitted over the line circuit 83 each time the escapement yoke 48 at the transmitting station closes contacts 221 momentarily energize the relay 229 at the receiving station, causing its tongue 231 to periodically engage its left hand stop. As the tongue 231 engages the left hand stop, a circuit to the magnet 72' is completed to reenergize the same. The periodic energization of the magnet 72' operates the armature lever 68 so that the projection 67 engages the flywheel 53 to correct the position thereof, as hereinbefore described, should it be in some other than the desired position. The positive synchronizing impulses will continue to be transmitted as long as the arm 222 of the switch 223 remains in its right hand stop. The movement of the arm 222 to its left hand stop causes transmission of negative potential of the line conductor 83 the next time the contacts 221 are closed. This negative potential is effected, as hereinbefore described, to operate relays 226 and 229 to move the tongues to their left and right hand stops, respectively, and complete circuits to the clutch control magnets 112 and the magnets 72. This stops further operation of the transmitting and receiving instruments with their respective elements in the same relative position.

If desired, the amplifiers 82 and 84 could be arranged to delete predetermined of the regular positive synchronizing impulses so that the magnet 72' at the receiving instrument would not be energized each time the contacts 221 were closed. In this manner a synchronizing impulse would be transmitted, for example, on each tenth oscillation of the escapement yoke 48 of the transmitting mechanism, or after any desired number as found necessary.

Another control circuit is shown in Fig. 8 which may be employed in conjunction with the differential correcting mechanism of Fig. 7. If it is assumed that the mechanism shown in Fig. 7 is a receiving instrument, that part of the circuit of Fig. 8 associated directly with the receiving amplifier 84 would be employed to control the same. However, as will be evident hereinafter, mechanisms such as disclosed in Fig. 7 may be employed as either a receiving or transmitting instrument. In Fig. 8 the circuits at the transmitting end are substantially similar to those at the transmitting station in Fig. 1 and like elements bear similar reference numerals. In Fig. 8 an additional set of contacts 233 is added which are arranged to be closed when the escapement yoke 48 is in its right hand position. One of the springs of the contact set 233 is connected to positive potential and the other in parallel with one of the springs of the contact set 221 is connected over the conductor 224 to the coil of the relay 226. With the arm 222 of switch 223 on its right hand stop, a positive impulse will be transmitted over the line circuit 83 for each stroke or movement of the escapement yoke 48. Thus for each complete back and forth oscillation of the escapement yoke two positive impulses are transmitted instead of the one impulse as in the system disclosed in Fig. 1. At the receiving station these positive impulses are effective on the relay 229, Fig. 8, to cause the tongue 231 thereof to periodically moved from its center open line circuit position and engage its left hand stop. Such operation of relay 229 causes positive potential from its tongue to be periodically applied to the inner tongue of a relay 234. The break stop associated with the inner tongue of relay 234 is connected by a conductor 236, through the left hand winding of a double coil relay 237 and a resistance 238 to a point 239, and thence through another resistance 241 to negative potential at 242. The make stop of said inner tongue of relay 234 is connected through the winding of relay 234 and a resistance 243 to the point 239 and over a parallel circuit including a conductor 244, the right hand winding of relay 237 to a make stop thereof. The tongue associated with said make stop of relay 237 is connected through a rectifier 246 to ground. The outer tongue of relay 234 is connected to positive potential and the associated break and make stops are connected over individual circuits through the windings of the left and right hand magnets 143 associated with the yoke 48' to ground.

The right hand stop of the tongue 231 of relay 229 in Fig. 8 is connected through the winding of relay 232 to ground, the associated tongues of which have positive potential applied thereto. On the energization of relay 232 a circuit is completed to the associated clutch control magnet 144 to energize the same and also the left hand magnet 143 associated with the escapement yoke 48'.

The energization of the clutch control magnet 144 operates the clutch 145, Fig. 7, to disengage the shaft 164 from the motor M and also prevents further rotation of the shaft. The energization of the left hand magnet 143 moves the escapement yoke 48' to its left hand position and holds the same there. With the magnets 143 and 144 energized, the associated instrument is held in an unoperating condition. This condition prevails when negative potential is applied over the line circuit 83 from the left hand stop of the switch 223 at the transmitting station.

The positive impulses transmitted from the contacts 221 and 233 as the escapement yoke 48 at the transmitting station oscillates are effective to operate the escapement yoke 48' at the receiving station in a manner hereinafter pointed out. These positive impulses move the tongue of relay 229 from its center open line circuit position to its left hand stop, causing positive impulses to be applied to the inner tongue of relay 234. If relays 234 and 237 are assumed to be in a deenergized condition on the receipt of such a positive impulse as the first at the inner tongue of relay 234, a circuit will be completed from said tongue through the left hand coil of relay 237, the resistances 238 and 241 to negative potential at 242. The completion of the above circuit energizes the left hand coil of relay 237, causing its tongue which is connected through the rectifier 246 to ground to engage its make stop and complete a circuit from ground through the rectifier 246, the tongue, make stop and right hand coil of relay 237, conductor 244, the coil of relay 234, the resistance 243 to the point 239 and thence through resistance 241 to negative potential at 242. By choosing suitable values for the resistances 238, 241 and 243 in connection with the resistances of the coil of relay 234 and the left hand coil of relay 237, the potential at the point 239 when the above described circuit from negative potential at 242 to positive potential at the tongue 231 of relay 229 is completed will be zero or slightly positive with respect to ground. As the above circuit includes the rectifier 246, no current will flow through the coil of relay 234 so long as the above mentioned condition exists. However, when the tongue 231 of relay 229 leaves its left hand contact in response to the next open line condition, point 239 will become negative with respect to ground, causing current to pass through the rectifier 246, the tongue of relay 237, the right hand coil thereof and coil of relay 234 to operate the relay 234 and to hold relay 237 operated. The above circuit through the right hand coil of relay 237 and the coil of relay 234 is a locking circuit and maintains the said relays in an energized condition until conditions hereinafter described occur to deenergize the relays. Thus, the first positive impulse for example transmitted over the line circuit 83 causes the relays 234 and 237 to become energized and locked up. Such a positive impulse transmitted over the line circuit 83 over which negative potential is transmitted during a non-operating condition also causes the tongue of relay 229 to move from its right hand stop to open the circuit to relay 232. The deenergization of relay 232 opens the circuit to the clutch control magnet 144 and the circuit from positive potential at the inner tongue of relay 232 to the left hand magnet 143 of the escapement yoke. With relay 234 deenergized a parallel circuit to the left hand magnet 143 is completed from the inner tongue of relay 232 and make stop thereof. However, the operation of relay 234 practically simultaneously with the deenergization of relay 232 opens the two parallel circuits to the left hand magnet 143. The outer tongue of relay 234 contacting its make stop completes a circuit to the right hand coil 143, energizing the same and causing the escapement yoke to move to the right. This operation of the escapement yoke 48' permits the associated ratchet wheel 47' to advance a half a tooth, whereupon operations hereinbefore described are performed. Thus, in response to a positive impulse transmitted over the line circuit 83 following the transmission of negative potential, the escapement yoke 48' at the receiving instrument moves from its normal left hand position into its right hand position. This movement of the escapement yoke 48' is in timed relation to the first movement of the escapement yoke 48 at the transmitting station, and hence the receiving and transmitting instruments are initiated into operation in phase with one another.

As long as the escapement yoke 48 at the transmitting station is free to oscillate, positive impulses will continue to be transmitted over the line circuit 83, and if it is assumed that the first positive impulse caused relays 234 and 237 to operate and lock up the next positive impulse will effect deenergization of these relays in a manner hereinafter described. As relay 234 is deenergized, positive potential at its outer tongue is removed from the circuit to the right hand magnet 143 of the escapement yoke 48' and applied to the left hand magnet 143. This causes the escapement yoke to move to the left and permits rotation of the associated ratchet wheel 47 another half tooth.

With relays 234 and 237 locked up, as hereinbefore described, the next application of a positive impulse to the inner tongue of relay 234 establishes a circuit through the associated make stop and coil of relay 234, resistance 243 to the point 239, through resistance 241 to negative potential at 242. This circuit holds the relay 234 energized while at the same time the application of positive potential to the make stop of the inner tongue of relay 234 is effective to neutralize the locking current through the right hand coil of relay 237, whereupon it releases and breaks the above mentioned locking circuit through the right hand coil of relay 237. The circuit through the coil of relay 234 is maintained until the tongue 231 of relay 229 leaves its left hand stop, whereupon the relay 234 is deenergized and the tongues thereof return to their break stops. Thus, by means of the relays 234 and 237 connected in the manner described they are effective to cause energization of first one of the relays 143 and then the other in definite timed relation to the receipt of the positive impulses over the line circuit 83. The alternate energization of the magnets 143 in timed relation to the oscillation of the escapement yoke 48 at the transmitting station maintains the receiving instrument in synchronism with the transmitting instrument.

Obviously, by arrangements such as described above a single transmitting mechanism could be employed to control a plurality of receiving instruments, and although the synchronizing impulses were described as originating at the transmitting instrument the functions of the machines under the above-described circuits could be reversed, or the receiving station could be employed for transmitting and the transmitting station for receiving. Furthermore, both transmitting and receiving stations could function as receiving stations with respect to the synchronizing impulses which might originate independently of either.

From the preceding paragraphs it can be seen that the present invention provides a novel facsimile system and two modifications of apparatus that may be employed in conjunction with the novel system. The preferred embodiment of the apparatus includes a reversing mechanism or clutch for reversing the direction of movement of the scanning element at the desired time, while the modified embodiment of the apparatus provides a differential clutch or mechanism for correcting a scanning element driving means whenever necessary. Both embodiments of the apparatus function on a time basis whereby the operations of the transmitting and recording machines occcur in a timed relationship. The differential clutch operates in such a manner as to retard the back stroke of the faster scanning element for an interval of time equal to twice the interval that the faster scanning element completed its forward stroke ahead of the corresponding stroke on the other machine. For instance, if, as explained, the scanning element of a recorder driven through a differential mechanism reaches the end of its forward stroke before the scanning element on the transmitter reaches the end of its corresponding forward stroke, the differential mechanism of the recorder operates in a reverse direction until the transmitter scanning element reaches the end of its forward stroke. At the beginning of the return stroke of the transmitter scanning element the differential mechanism of the recorder resumes its forward direction, and the scanning element driven thereby will reach the end of its back stroke at the same time that the transmitter scanning element reaches the end of its back stroke. This has the effect of stopping the recorder scanning element driving means at dead center for an interval equal to twice the length of time it completed its forward stroke ahead of the forward stroke of the transmitter, and in this manner each line scanning stroke of the transmitter scanning element is justified with each corresponding line scanning stroke of the recorder scanning element. The justification of a scanning line in the transmitting apparatus included in the preferred embodiment of the invention with a corresponding line at the associated recording apparatus is accomplished as described by reversing the direction of the scanning elements in a timed relation.

It will be obvious, of course, that various modifications other than those shown, described and suggested herein may be made without departing from the spirit or essential attributes of the invention, and it is desired, therefore, that only such limitations be placed thereon as are imposed by the prior art or are specifically set forth in the appended claims.

What is claimed is:

1. In a facsimile machine, a scanning element, means for moving said scanning element in opposite directions through a predetermined path, and means for reversing the direction of movement of said scanning element at any point in said predetermined path.

2. In a facsimile machine, a scanning member, means for moving said scanning member in opposite directions through the same path, a control means, and means including said control means for reversing the direction of movement of said scanning member following the movement thereof in either direction in said path for predetermined lengths of time.

3. In a facsimile system, a transmitting machine, a recording machine controlled thereby, scanning and recording elements respectively included in said machines, means for moving each of said elements to and fro in opposite directions through respective paths of movement, means at each of said machines for reversing the direction of movement of respective elements at any point in said paths, and means for operating the two reversing means in a predetermined time relationship.

4. In a facsimile system, a transmitting machine, a receiving machine controlled thereby, scanning and recording members respectively included in said machines, means for moving each of said members back and forth through the same respective paths of movement, means for initiating the movement of said members in one direction in respective paths in timed relation, and means for reversing the direction of movement of said members in said paths in the same timed relation regardless of the length of travel of said members in said paths.

5. In a facsimile system, a transmitting instrument and a receiving instrument controlled thereby, scanning elements included in said instruments with associated rotatable driving means therefor, means for transmitting synchronizing signals concomitantly with each revolution of said transmitting scanning element driving means, means at said receiving instrument controlled by said synchronizing impulses and effective after a predetermined part of a revolution of said receiving instrument driving means to retard the same in amounts proportional to the amount it is faster than the driving means for said transmitting instrument whereby both of said rotatable driving means complete revolutions in the same length of time.

6. In a facsimile machine, a scanning member movable in opposite directions in the same path as the scanning progresses and a control means for reversing the direction of movement of said member at predetermined intervals.

7. In a facsimile machine, a scanning member movable to and fro in opposite directions in the same path as the scanning progresses, and means dependent upon the length of time of movement of said member in one direction to terminate movement thereof in said direction and initiate movement in the opposite direction.

8. In a facsimile system, a transmitting machine and a receiving machine controlled thereby, scanning elements included in said machines, driving means to move said elements in back and forth strokes along scanning lines, and synchronizing means associated with said machines to control the application of said driving means to said elements to move the same in said back and forth strokes in such a manner that the lengths of each corresponding scanning stroke of said machines is justified.

9. In a facsimile system, a transmitting machine and a receiving machine controlled thereby, scanning elements included in said machines, a rotatable scanning element driving means in each of said machines for moving said elements in back and forth strokes along scanning lines during each revolution of said driving means, and means for neutralizing one of said driving means

after a predetermined part of a revolution thereof whenever said driving means has a greater rotational speed than the rotational speed of the other by an amount proportional to the difference in rotational speed of said two driving means.

10. In a facsimile machine, a scanning element, a rotatable scanning element driving member, a rotatable element for rotating said driving member, said driving member and said rotatable member normally rotating together, means for stopping rotation of said driving member independently of said driving element, and means operative on the stopping of said driving member for rotating the same in an opposite direction at a predetermined speed relative to the speed and direction of rotation of said driving element and from power derived from said driving element.

11. In a facsimile system, a transmitting machine including a scanning element and a rotatable driving means for moving said scanning element forward and back relative to a subject matter sheet once for each revolution thereof, a receiving machine including a recording element and a rotatable driving means for moving said recording element forward and back relative to a recording sheet once for each revolution thereof, and means operative with one of said driving means rotating at such a speed as to move its associated element through a forward and back movement in less time than that required for a similar movement of the other element to retard the said faster driving means at the completion of the forward movement of the associated element whereby said elements end their backward movements in the same time relation at which they started their forward movements.

12. In a facsimile system, a transmitting mechanism and a receiving mechanism controlled thereby, scanning and recording elements in said mechanisms, a rotatable driving means for moving said elements through forward and back strokes to perform scanning and recording operations during each of said strokes, means operative whenever one of said driving means is faster than the other to act upon said faster driving means following a forward stroke of the associated element to delay the beginning of the back stroke thereof by an interval equal to twice the interval it completed its forward stroke ahead of the forward stroke of the scanning element associated with the slower driving means.

13. In a facsimile recording machine, a member to hold recording paper, a recording head, a driving mechanism to produce relative motion between said member and said head in a succession of recording strokes, and reversing means to justify each of said strokes in relation with the preceding recording strokes.

14. In a facsimile system, means for scanning a subject matter by a scanning element moving in opposite directions along the same straight line and recording a facsimile of the same by a recording element also moving in opposite directions along the same straight line, means for controlling both ends of said recording lines, with respect to both ends of said scanning lines by a common unit of time whereby said recording lines begin in a time relationship with the beginning of the scanning lines and end in a time relationship with the ending of said scanning lines.

15. In a facsimile machine, a scanning element, a table for supporting a subject matter or a recording blank, means for moving said scanning element to and fro in straight scanning lines relative to said table, means for moving said table in a predetermined direction relative to the direction of said scanning lines, an escapement mechanism, and means controlled by said escapement mechanism to regulate the operation of said two last-mentioned means whereby said relative movements occur in a predetermined timed relation.

16. In a facsimile machine, a scanning element alternately movable to and fro relative to a table to perform a scanning operation, a driving means for said scanning element, a periodically timing mechanism for controlling said driving means to reverse the direction of movement of said scanning element in accordance with the operation of said timing mechanism, a source of synchronizing signals and means controlled by said synchronizing signals to alter the operation of said timing mechanism whenever said timing mechanism is out of synchronism with signals.

17. In a facsimile system, a transmitting machine and a receiving machine controlled thereby, scanning elements included in said machine, driving means for moving said elements in back and forth scanning strokes along scanning lines, timing mechanisms at said machines for timing said strokes, means associated with the timing mechanism at a first one of said machines to transmit synchronizing impulses in accordance with the operation thereof to the other of said machines, and means controlled by said synchronizing impulses at the said other machine to synchronize the operation of the timing mechanism thereat with that at the first one of said machines.

18. In a facsimile system, a transmitting machine and a receiving machine controlled thereby, scanning elements included in said machine, driving means for moving said elements in back and forth scanning strokes along scanning lines, and means to control said driving means to initiate said scanning elements into predetermined respective strokes in a timed relation and to disable said driving means to further operate said scanning elements following other predetermined strokes.

19. In a facsimile machine, a scanning element, means for moving said scanning element in opposite directions through a predetermined path, a control means, and means including said control means for reversing the direction of movement of said scanning element at any point in said predetermined path independently of the amount of movement of said scanning element.

20. In a facsimile machine, a scanning member movable in opposite directions through the same predetermined path as the scanning progresses and means dependent upon the length of time said scanning member moves in one direction to reverse the direction of movement thereof.

21. In a facsimile system, a signal transmitting instrument, a receiving instrument for recording signals transmitted from said transmitting instrument, scanning and recording elements respectively included in said transmitting and receiving instruments, means for moving said scanning and recording elements forward and backward to transmit and record said signals during said movements, means to initiate said elements into said forward motion in timed relation, and means for initiating said elements into said backward motion in the same time relation independently of the distance traveled by said elements in said forward motion.

22. In a facsimile machine, a scanning unit

movable in opposite directions through a predetermined path to scan a subject matter sheet or a recording blank, a driving mechanism for moving said unit, and control means for said driving mechanism to enable the same to reverse the direction of movement of said unit at any and every point along said path.

23. In a facsimile machine, a scanning unit movable in opposite directions through a predetermined path to scan a subject matter sheet or a recording blank, a driving mechanism for moving said unit, and control means for said driving mechanism to enable the same to reverse the direction of movement of said unit after the expiration of predetermined lengths of time.

24. In a facsimile machine, a scanning member movable through the same path in to and fro strokes along scanning lines as the scanning progresses, and means operative at predetermined intervals to terminate each of said strokes and initiate a following stroke.

25. In a facsimile machine, a scanning element movable to and fro in opposite directions to scan a subject matter sheet or a recording blank, a driving mechanism for moving said element, a control means operative at predetermined intervals, and means including said control means and said driving mechanism for terminating the movement of said scanning element in each of said directions and initiating movement thereof in the opposite direction.

26. In a facsimile machine, a scanning element, a rotatable scanning element driving member, a rotatable element for rotating said driving member, said driving member and said rotatable member normally rotating together, means for stopping rotation of said driving member independently of said driving element, and means operative on the stopping of said driving member for rotating the same in an opposite direction to the direction of rotation of said driving element.

27. In a facsimile system, a transmitting mechanism and a receiving mechanism controlled thereby, scanning and recording elements in said mechanisms, rotatable driving means for moving said elements through forward and back strokes to perform scanning and recording operations during each of said strokes, means operable with one of said driving means faster than the other to rotate the same in a reverse direction after the completion of the forward stroke of the associated element such an amount that the scanning and recording elements complete their respective back strokes in the same time relation that they began their forward strokes.

28. In a facsimile recording machine controlled by a transmitting machine, each including a recording member, a platen member, a source of power adapted to cause at least one of said members to move back and forth in each cycle in relation to the other of said members along scanning lines, a reversing mechanism associated with said source of power to alternately reverse the direction of said scanning lines as the recording progresses, and controlling means for said reversing mechanism of said recording machine to reverse the direction of motion of said moving member at such time that said member can reach its original starting position at the expiration of a cycle period of said transmitting machine.

29. In a facsimile machine, a scanning element, a table for supporting a subject matter or a recording blank, means for moving said scanning element to and fro in a straight line along scanning lines relative to said table to scan the subject matter or the recording blank thereon, resilient means tending to advance said table in a direction substantially perpendicular to the direction of movement of said scanning element, and means including said resilient means to advance said table step-by-step in timed relation to the to and fro movements of said scanning element.

30. In a facsimile machine, a scanning element, a table for supporting a subject matter or a recording blank, means for moving said scanning element to and fro in opposite directions along a straight line relative to said table to scan the subject matter or the recording blank thereon, a control mechanism, resilient means controlled by said control mechanism for advancing said table step-by-step in a predetermined direction relative to the direction of movement of said scanning elements, and means including said control mechanism to time the to and fro movement of said scanning element with the step-by-step advancing movements of said table.

31. In a facsimile machine, a platen member for supporting a subject matter or a recording blank, a platen member advancing mechanism, a scanning element, a scanning element moving mechanism, first and second sources of power, a control means, and means including said control means to apply said first source of power to said scanning element moving mechanism to move the same back and forth relative to said platen to scan the subject matter or recording blank thereon, and to apply said second source of power to said platen member advancing mechanism to advance said platen in a predetermined direction relative to the back and forth movement of said scanning element.

32. In a facsimile machine, a scanning element, a table for supporting a subject matter or a recording blank, means for moving said scanning element to and fro in straight scanning lines relative to said table, means for moving said table in a predetermined direction relative to the direction of said scanning lines, a periodically operating escapement timing mechanism and means controlled by said timing mechanism to time the relative movements of said scanning element and said table.

33. In a facsimile system, a transmitting machine and a receiving machine controlled thereby, scanning elements included in said machines, driving means for moving said elements in back and forth scanning strokes along scanning lines, escapement timing mechanisms at said machines for timing the duration of said strokes, means associated with either one of said machines for transmitting synchronizing impulses to the other, and means associated with the other machine and controlled by said synchronizing impulses to synchronize said timing mechanisms thereat with the timing mechanism at the first.

SEYED KHALIL.