

[54] **DRAWING APPARATUS**

[75] Inventor: **Osamu Shimizu**, Tokyo, Japan

[73] Assignee: **Mutoh Industry Ltd.**, Tokyo, Japan

[22] Filed: **Jan. 17, 1974**

[21] Appl. No.: **434,112**

[30] **Foreign Application Priority Data**

Jan. 31, 1973 Japan..... 48-12039

[52] **U.S. Cl.**..... **33/75 R; 33/76 R**

[51] **Int. Cl.²**..... **B43L 13/00**

[58] **Field of Search**..... **33/79, 76 R, 75 R**

[56] **References Cited**

UNITED STATES PATENTS

3,339,285 9/1967 Baker et al..... 33/79 R
3,638,320 2/1972 Baker..... 33/79 R

Primary Examiner—Richard E. Aegerter

Assistant Examiner—Michael H. Thaler

Attorney, Agent, or Firm—Wenderoth, Lind & Ponack

[57]

ABSTRACT

A drawing apparatus comprising a head adapted to be placed in any position on the surface of drawing board through the agency of no outside supporter, a pair of rulers disposed at right angles to each other and pivotally connected to the head, and direction control means for automatically causing a predetermined one of the rulers to orient itself in a predetermined direction. If one haphazardly places the head in any position on the drawing board without paying attention to the direction in which it is oriented the rulers are controlled by the direction control means such that the predetermined one of the rulers orients itself in a predetermined direction. Accordingly, if the head is shifted on the drawing board, the rulers automatically orients itself in slaved relationship as if they moved in translation motion on the drawing board.

18 Claims, 27 Drawing Figures

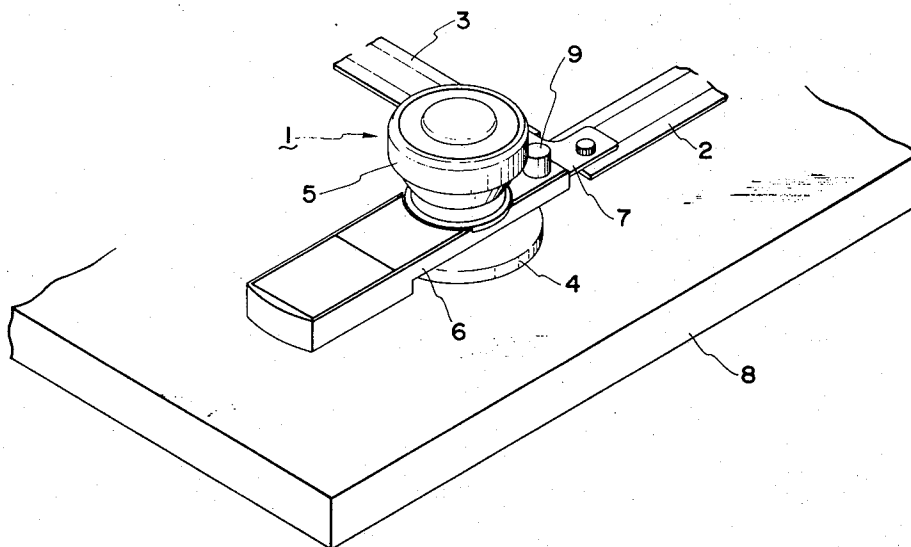
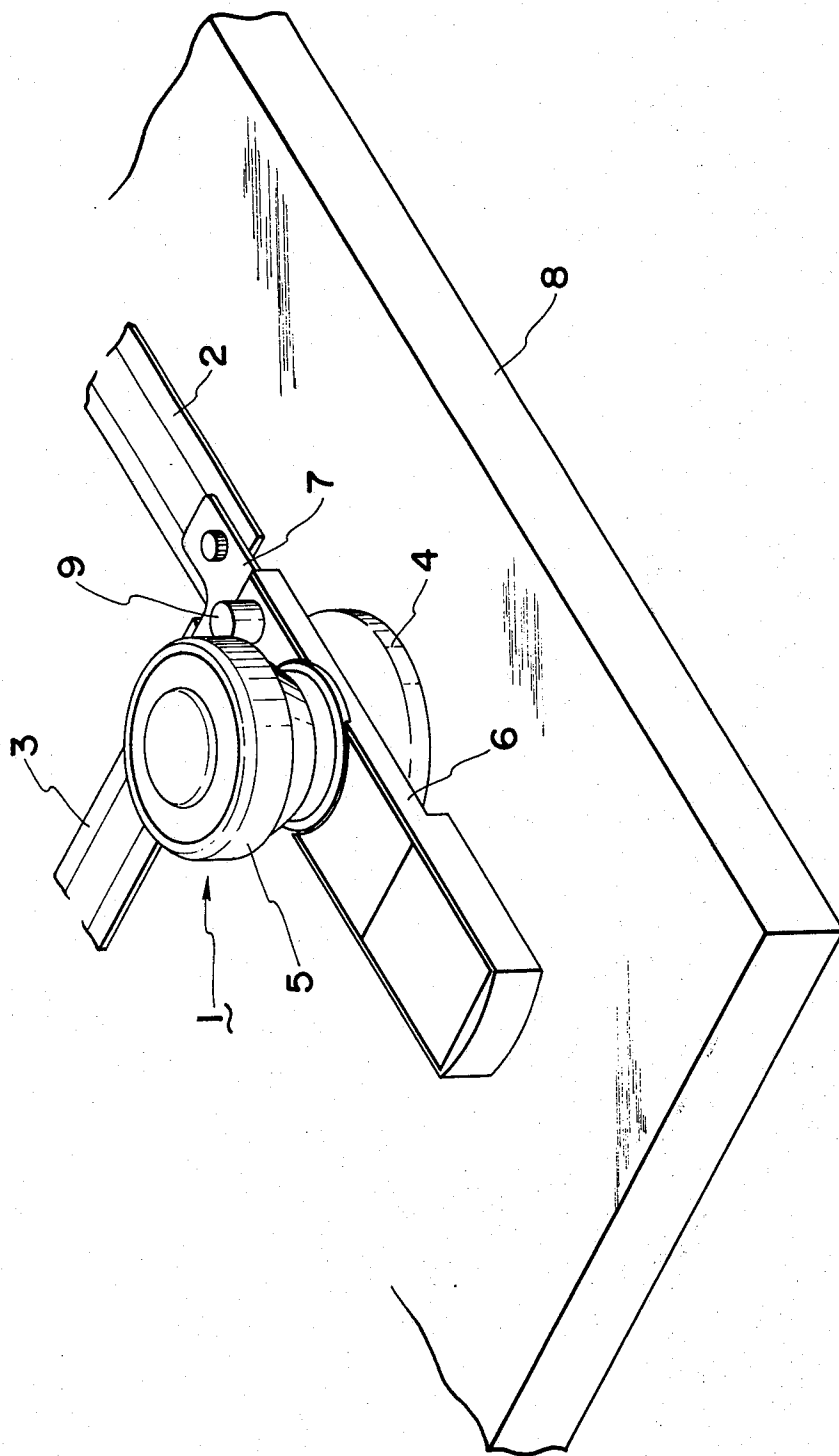
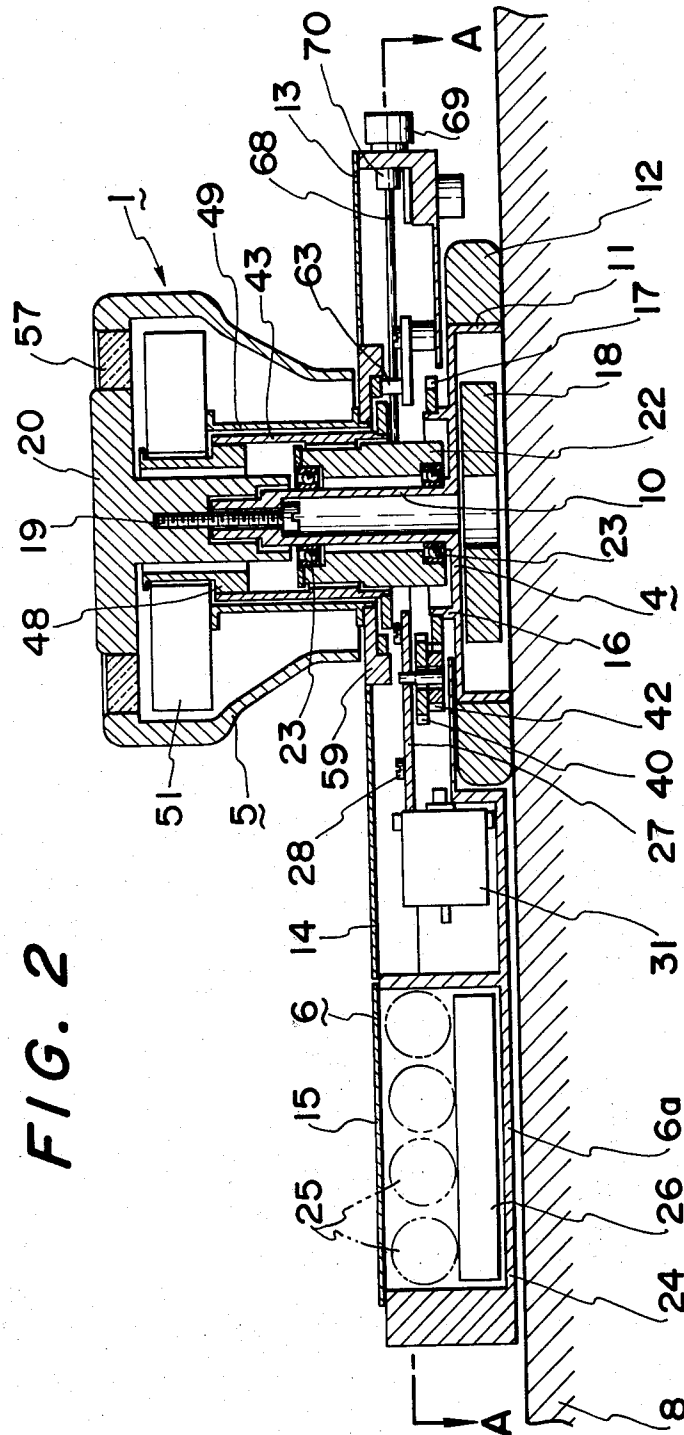


FIG. 1





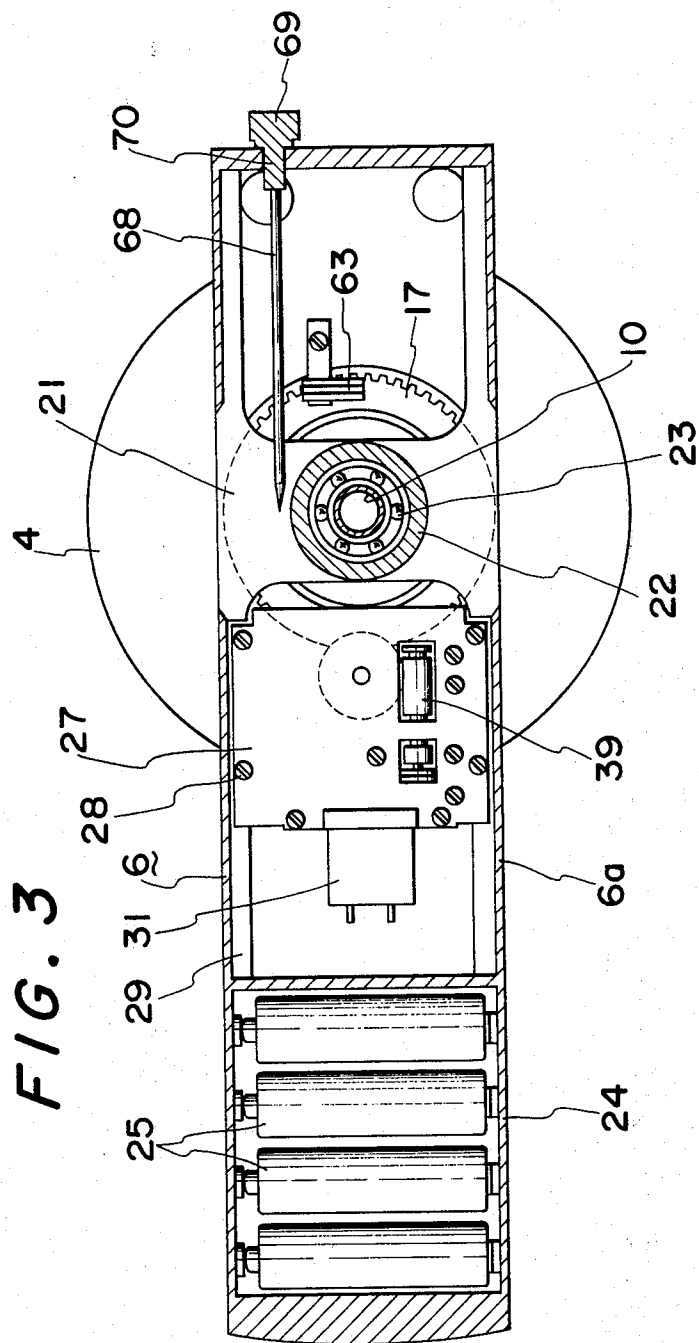


FIG. 4

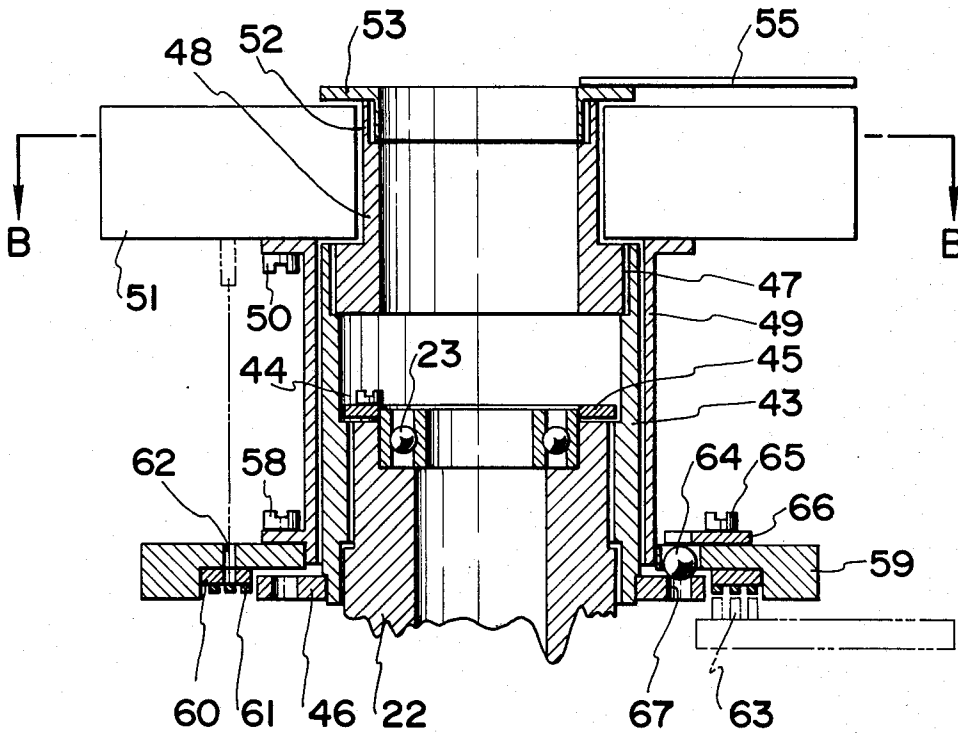


FIG. 5

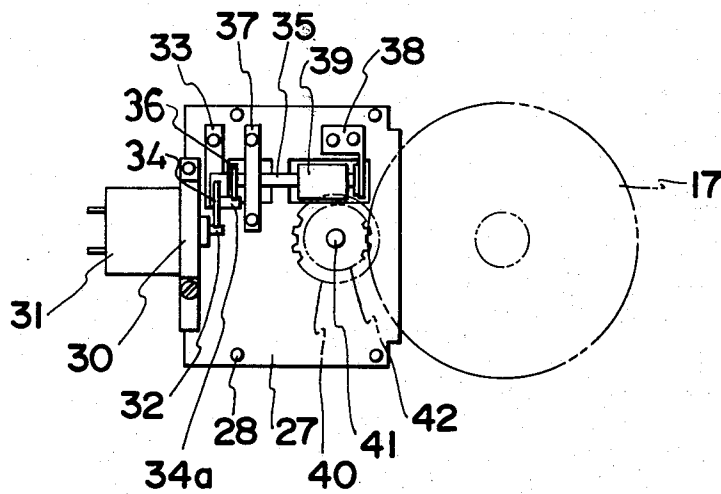


FIG. 6

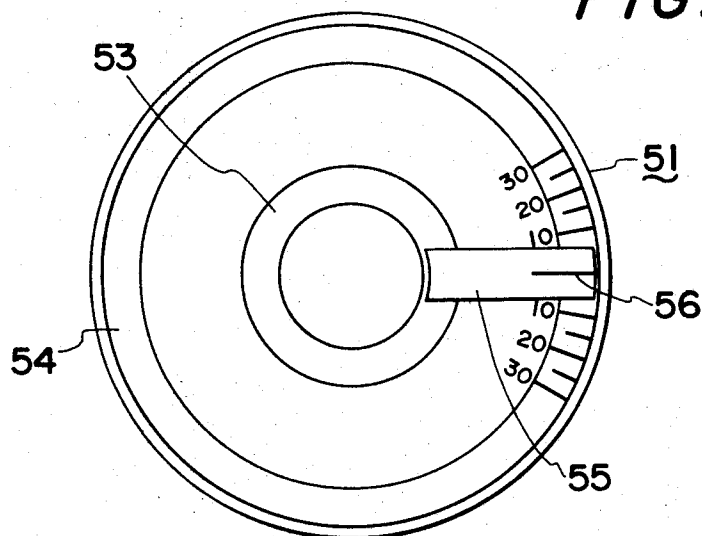


FIG. 7

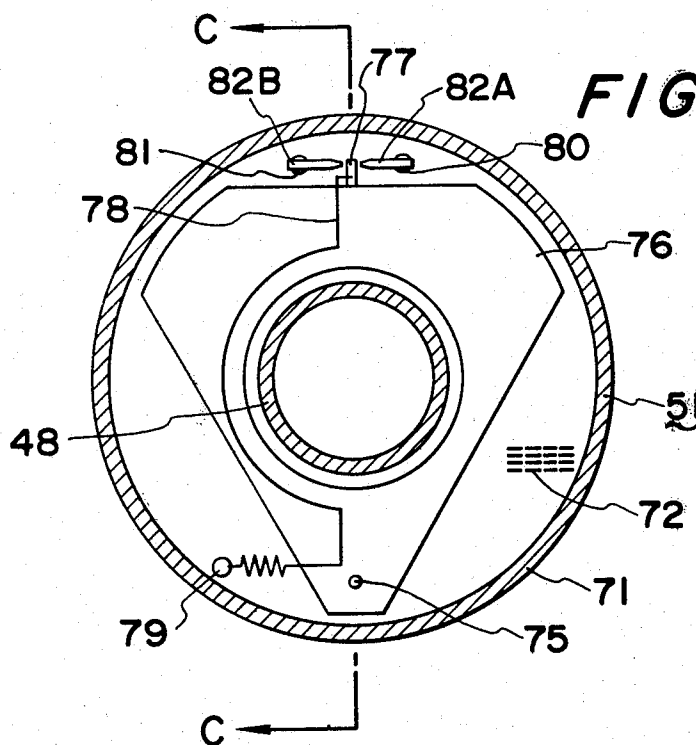


FIG. 8

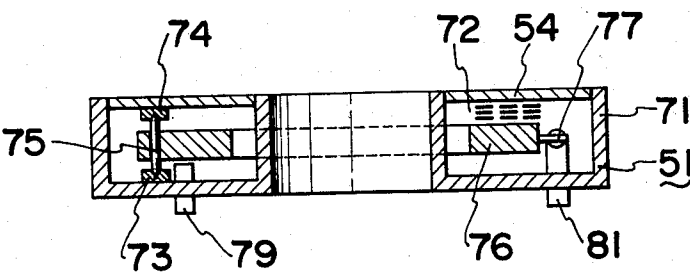


FIG. 9

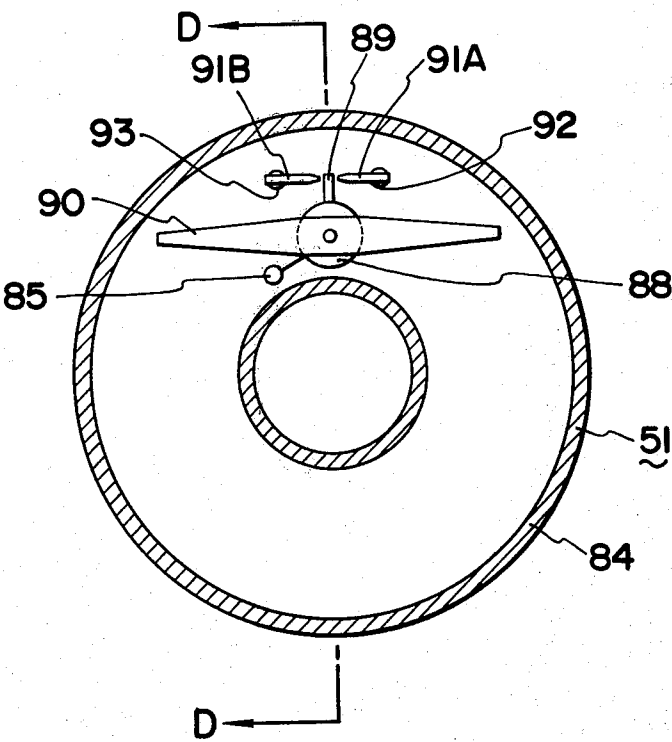


FIG. 10

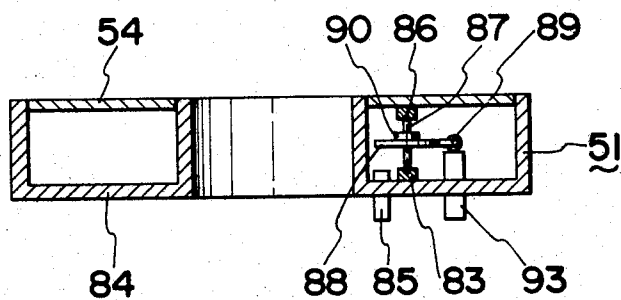


FIG. 11

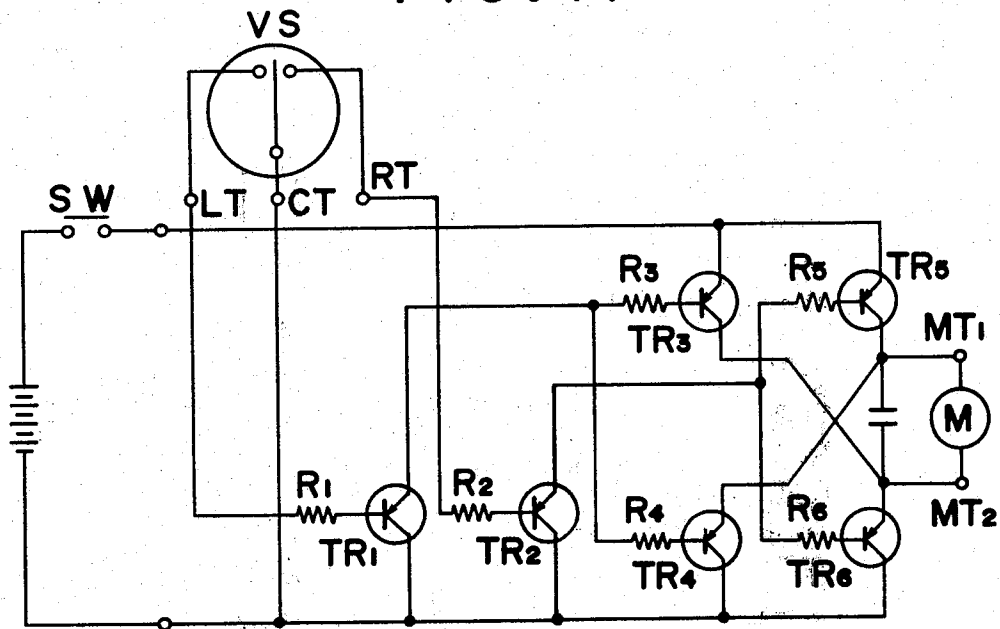


FIG. 12

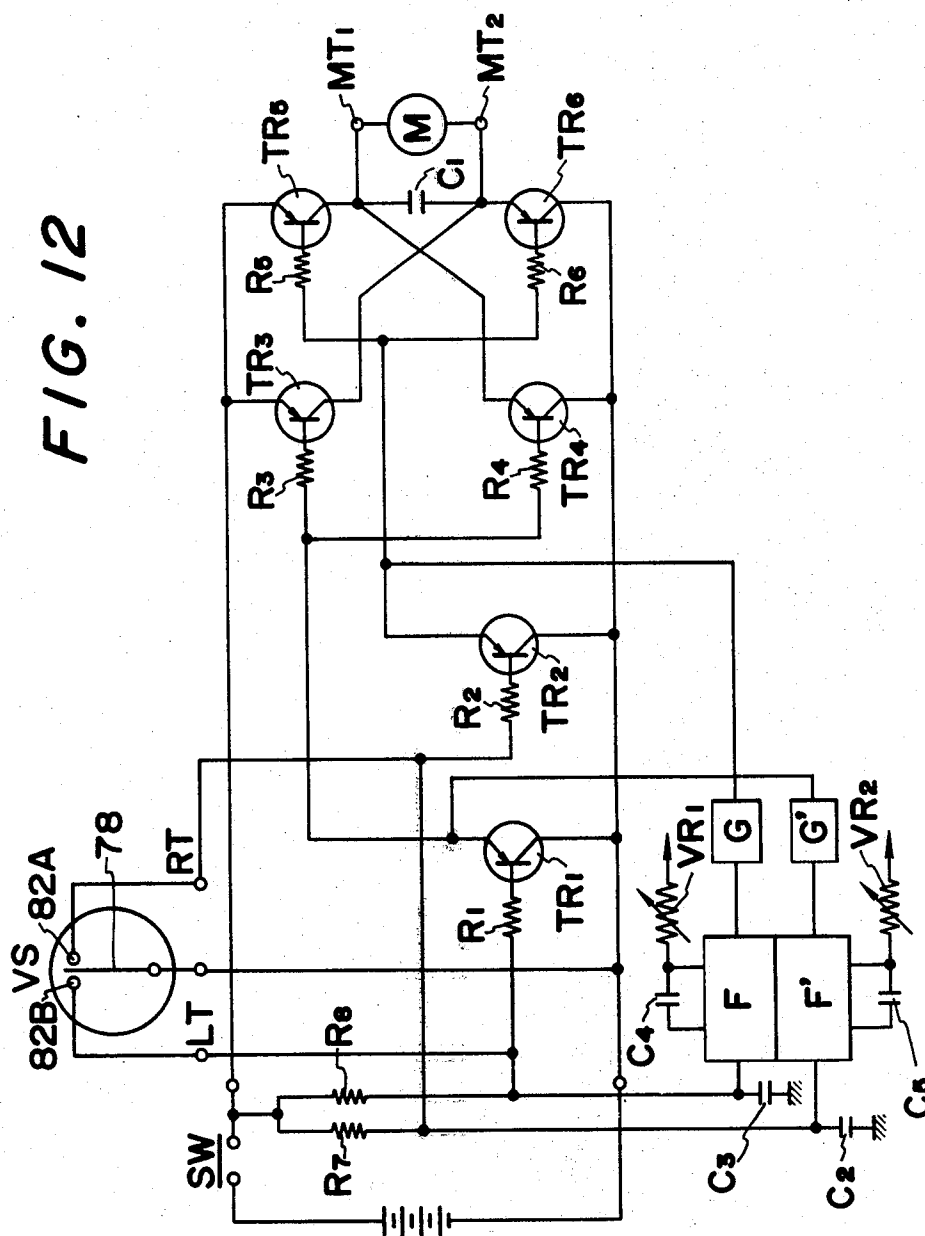
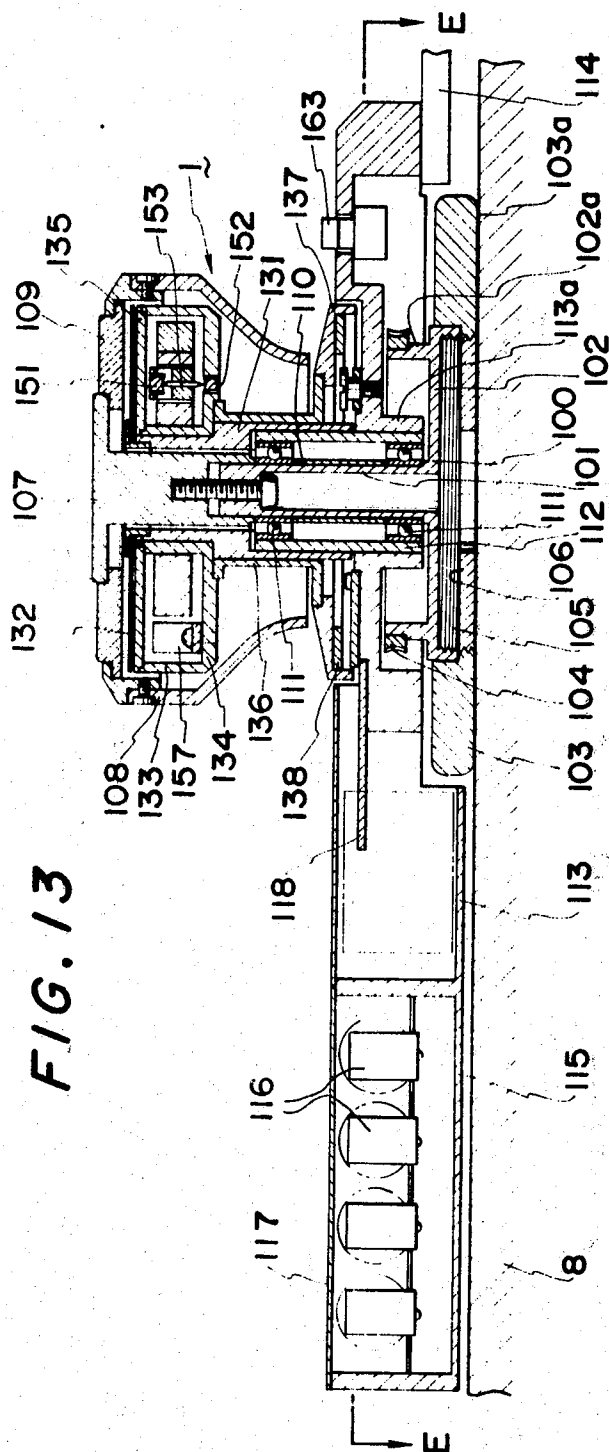


FIG. 13



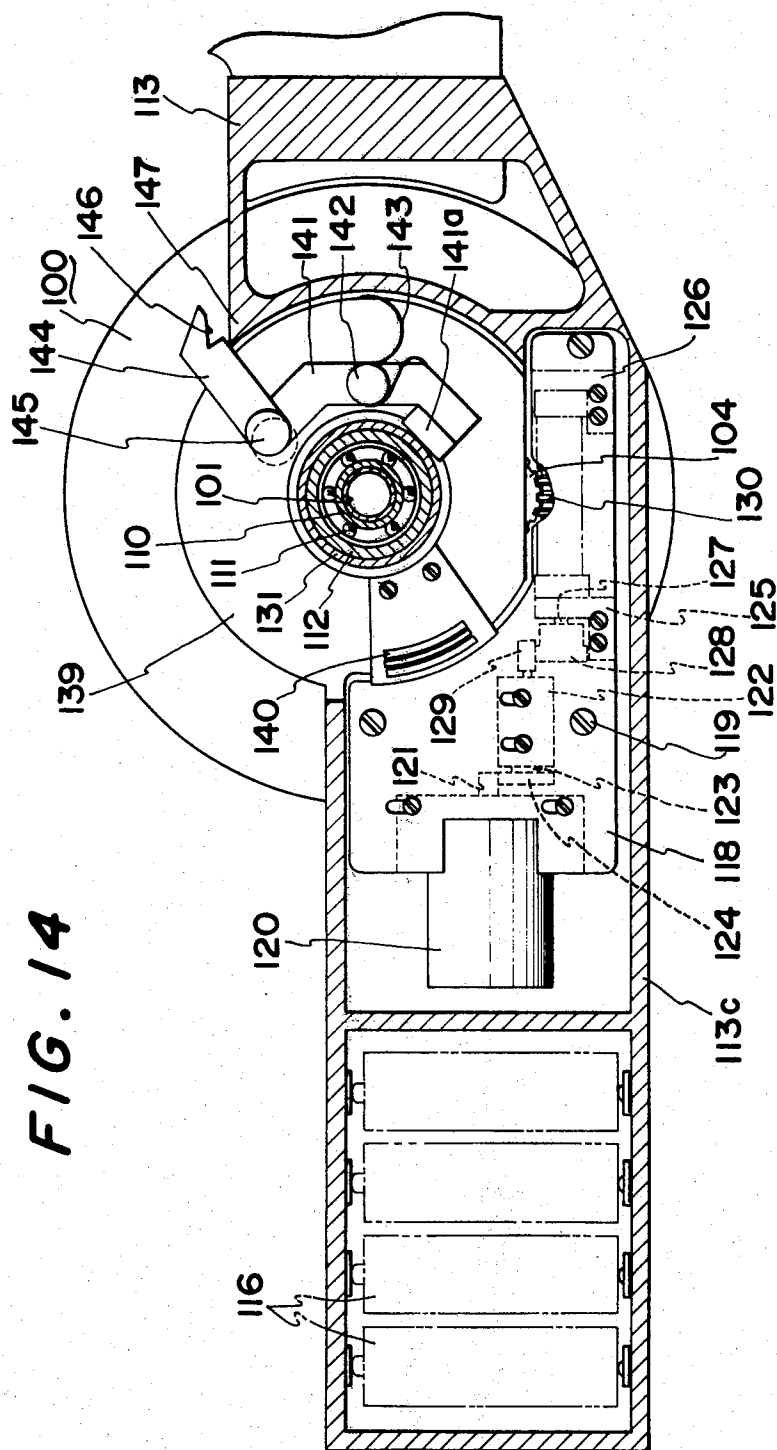


FIG. 15

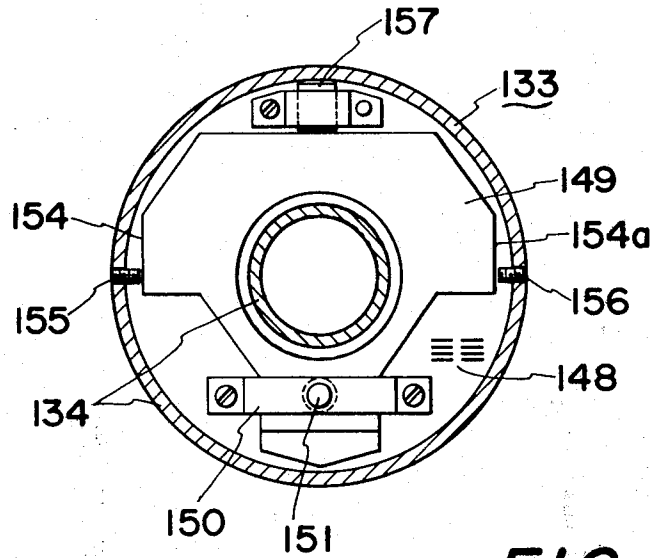


FIG. 16

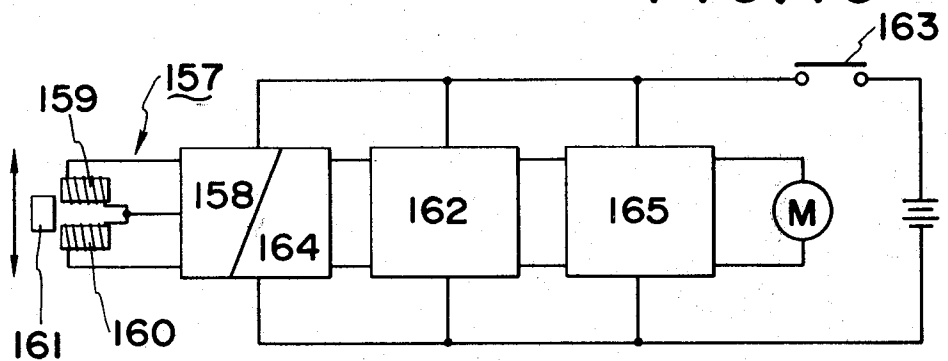


FIG. 17

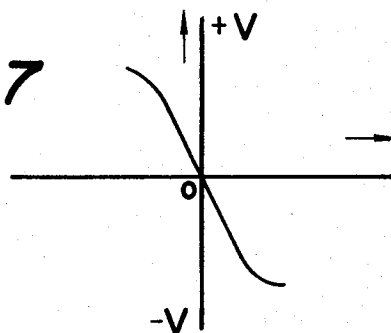


FIG. 18

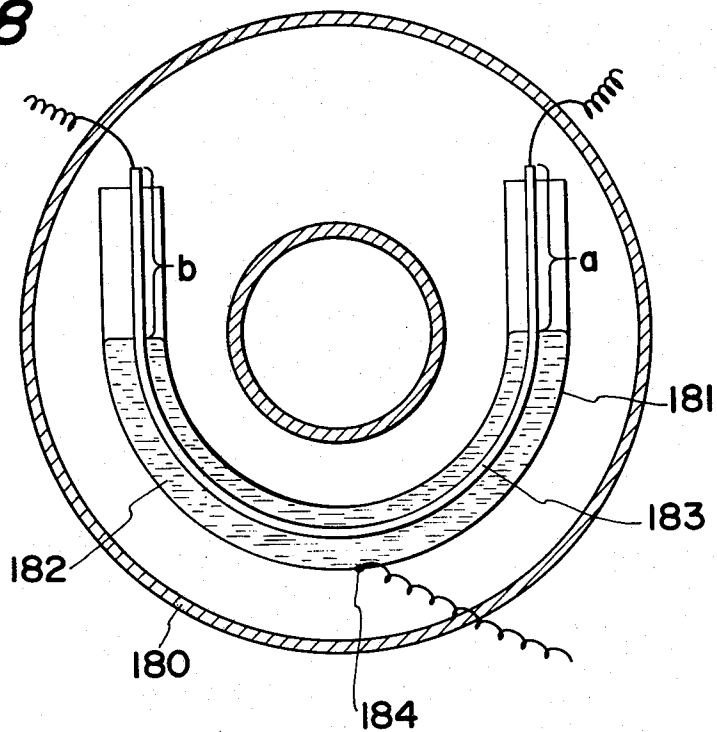


FIG. 19

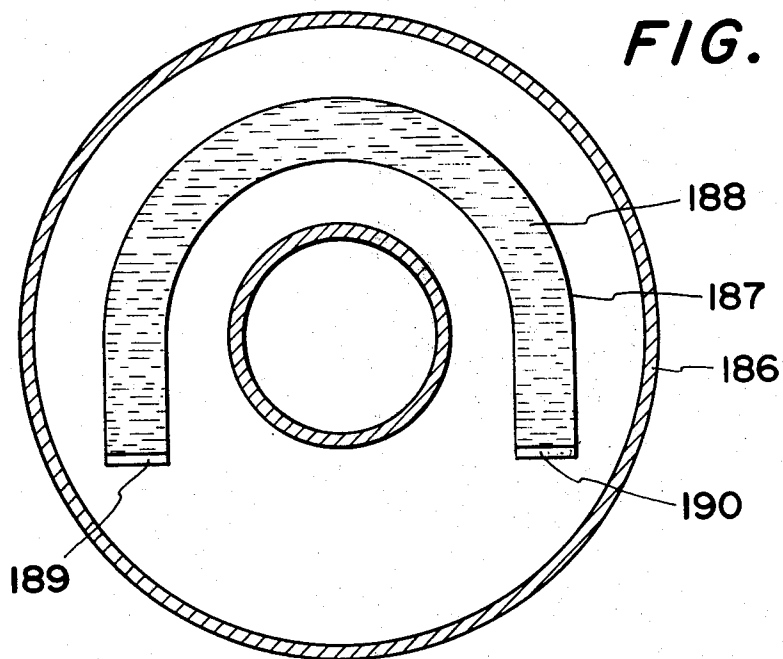


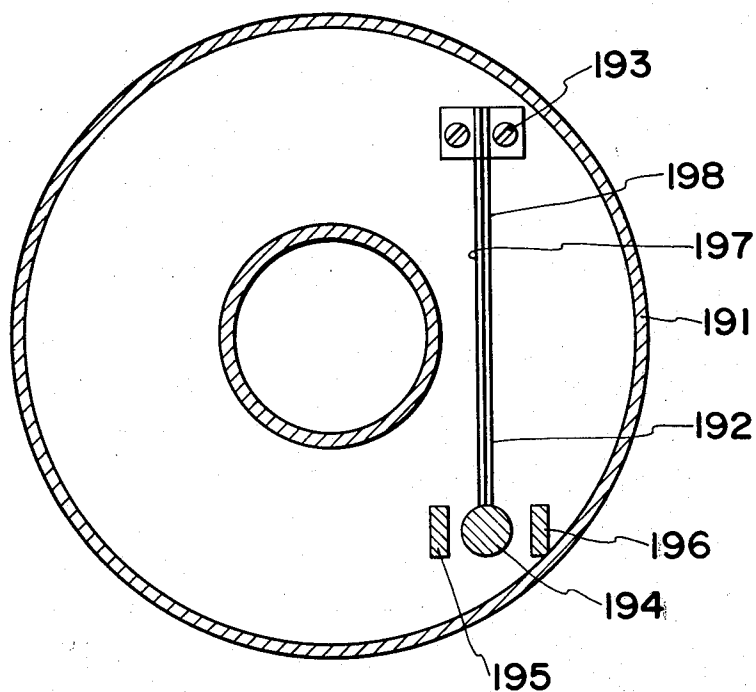
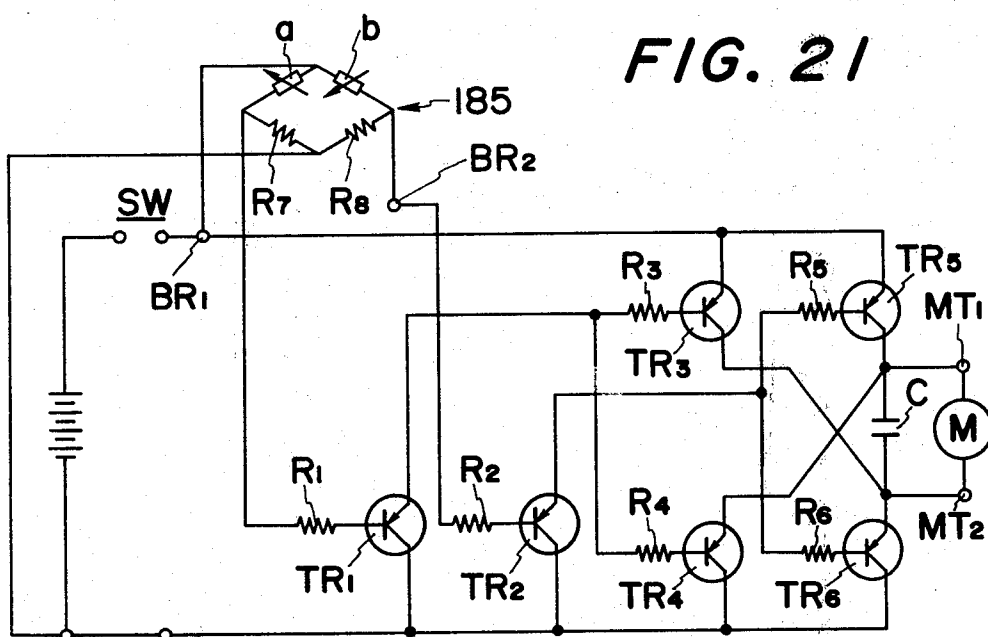
FIG. 20**FIG. 21**

FIG. 22

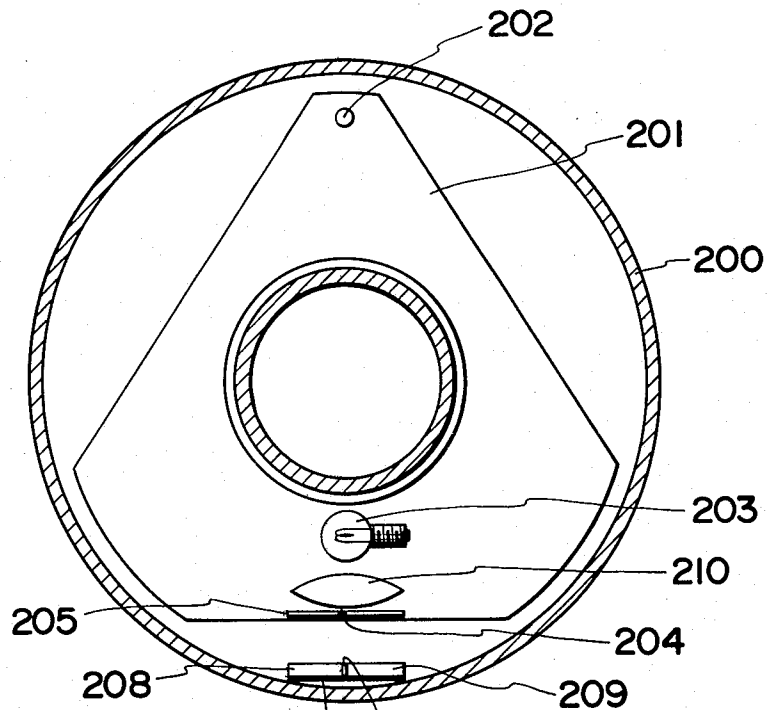
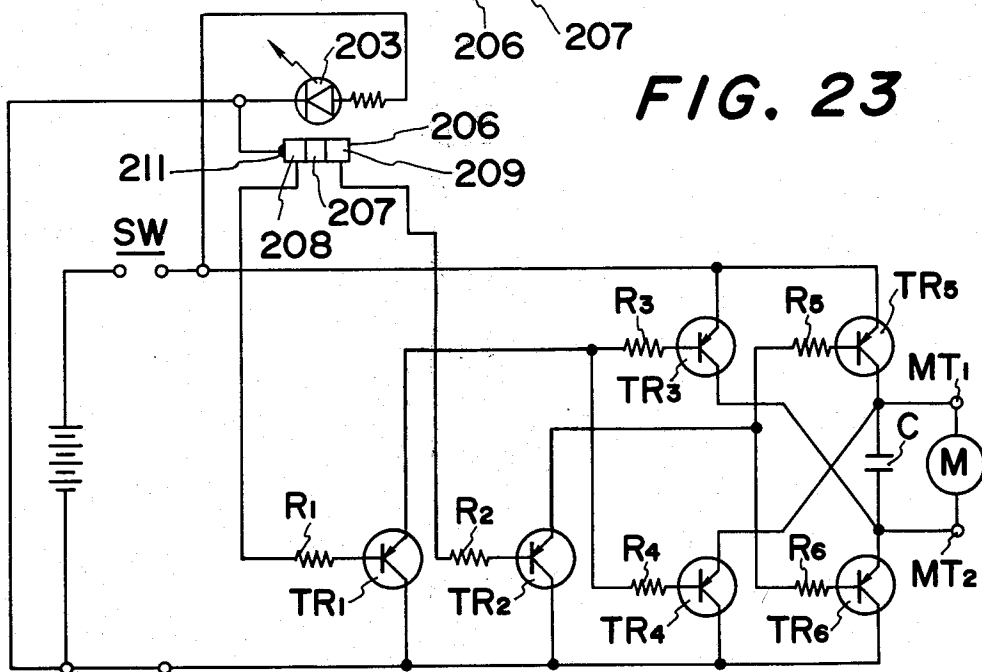


FIG. 23



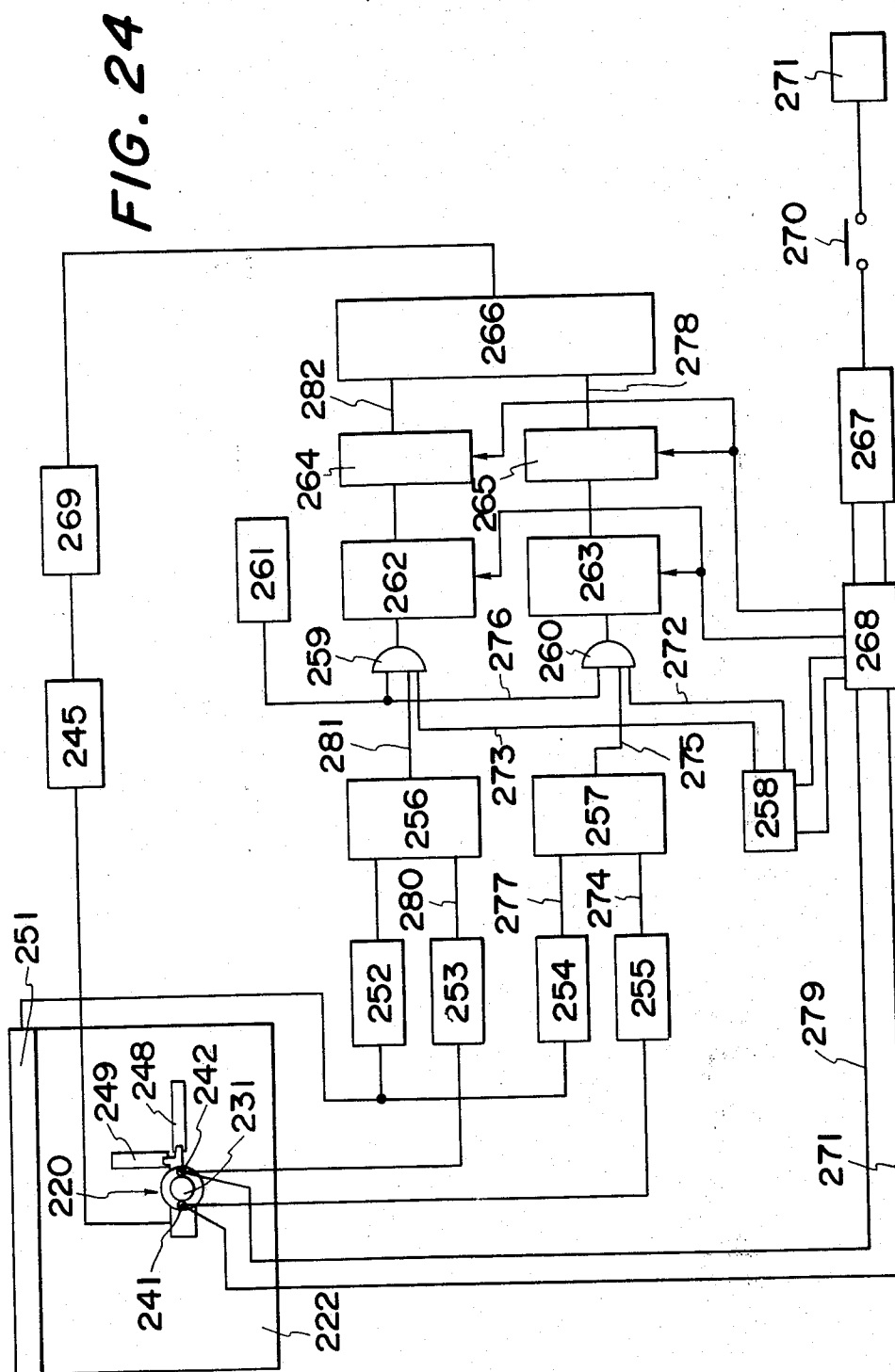


FIG. 25

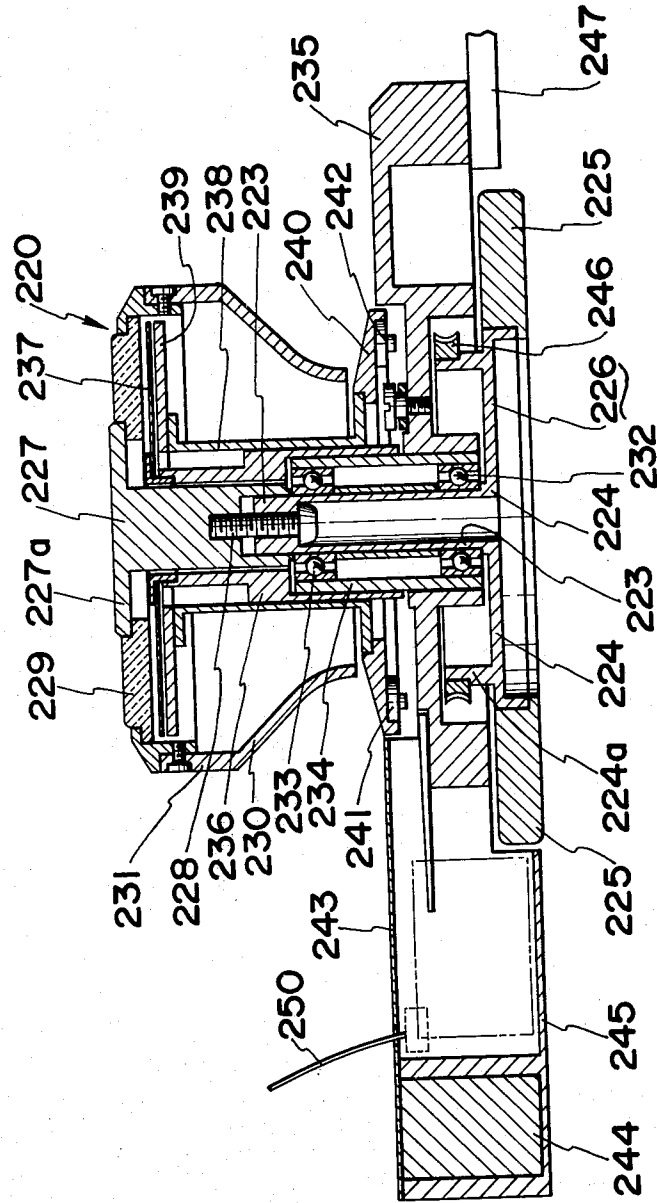


FIG. 26

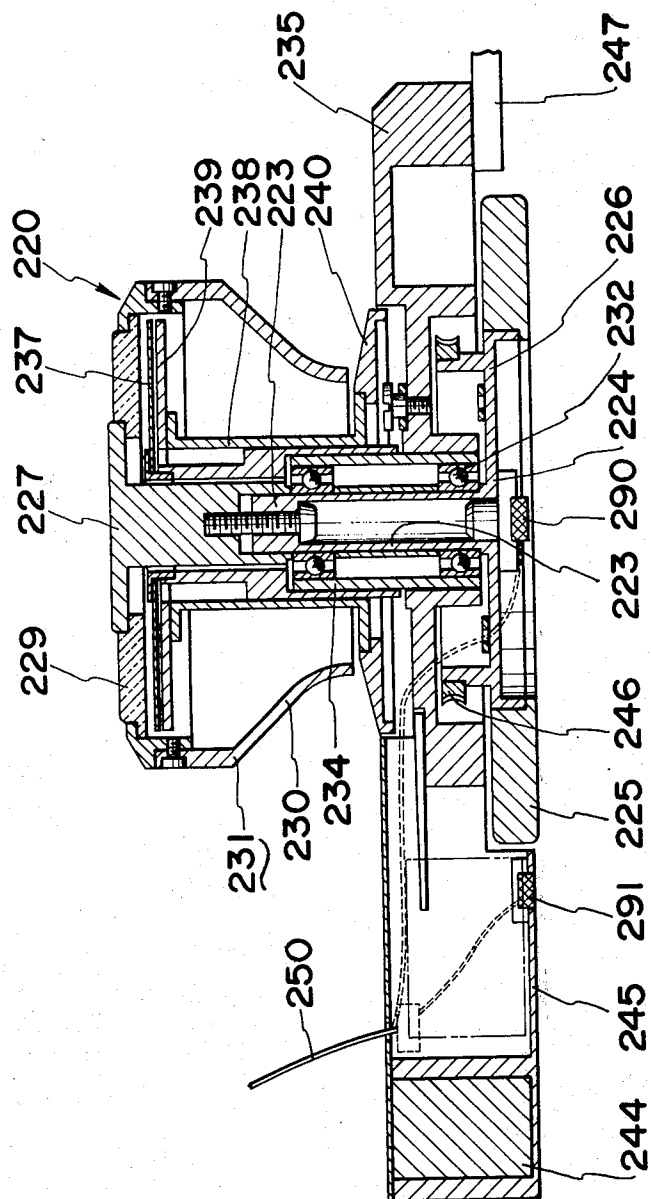
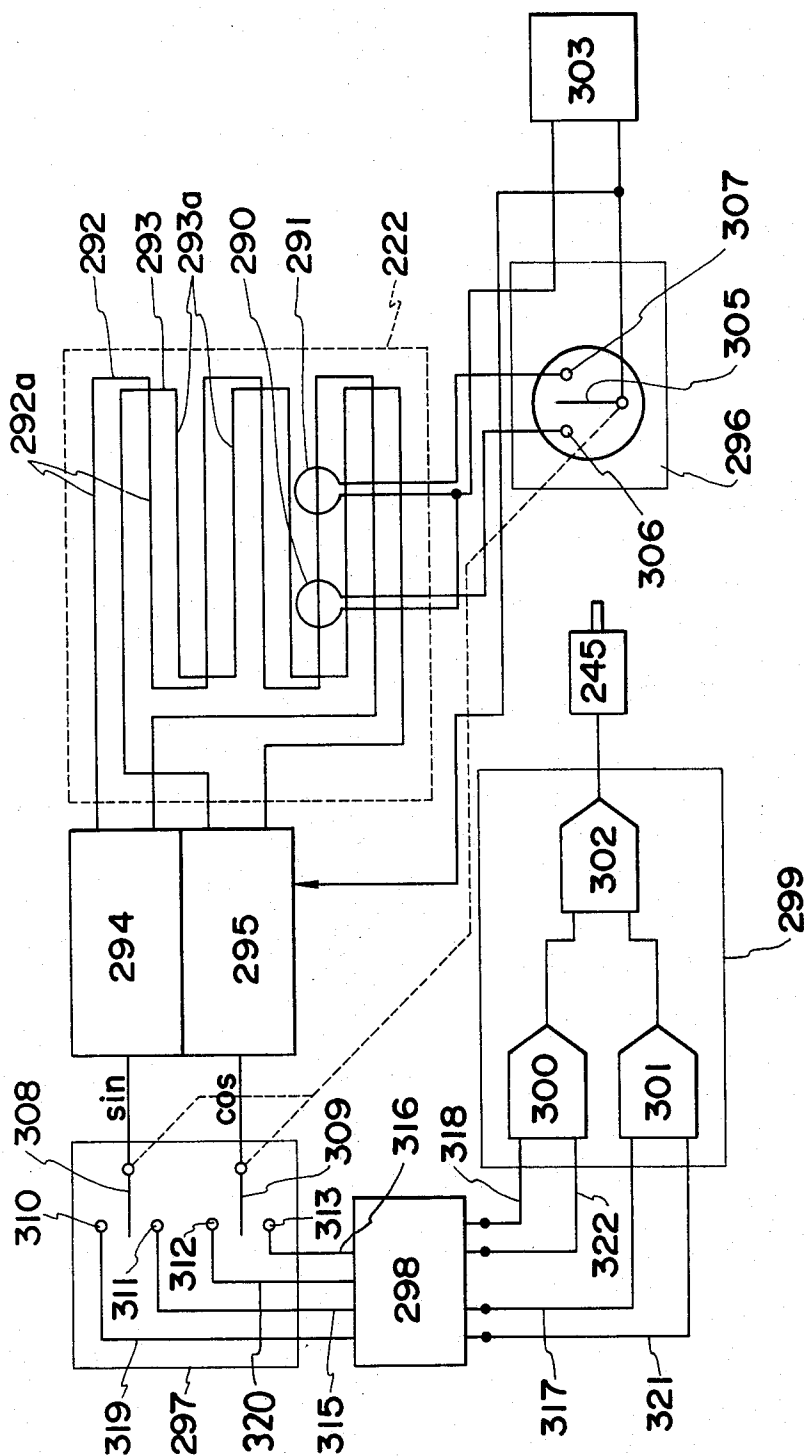


FIG. 27



DRAWING APPARATUS

BACKGROUND OF THE INVENTION

This invention relates in general to drawing apparatus constructed such that if the head is moved in any direction along the surface of a drawing board, the rulers connected to the head move in translation motion on the the drawing board. More particularly the invention relates to drawing apparatus of the type described which is characterized in that if the head is haphazardly placed through the agency of no outside supporter in any position on the drawing board without paying attention to the direction in which the head is oriented, then the direction in which the rulers are oriented is controlled such that one of the rulers automatically orients itself to form a predetermined angle with respect to a reference line. In this invention, the reference line refers to an imaginary elongated single straight line disposed in a plane parallel to the surface of the drawing board. More precisely, the reference line may be an imaginary line drawn parallel to the line of magnetic force of the earth; it may be an imaginary line formed on the surface of the drawing board disposed in an inclined position when a line perpendicular to the ground is projected onto the surface of the drawing board; it may be a line parallel to a copper wire disposed across the width of the drawing board, or it may be a line parallel to a signal receiving member disposed in a straight line on the surface of the drawing board.

Drawing apparatus of the prior art have been generally constructed such that their heads are each supported by a support arm of the pantagraph type, rails or other supporter and the head as well as the rulers are moved in translation motion along the surface of the drawing board by the guiding function of the supporter. When the head is supported by the arm or the rails, the drawing apparatus has the disadvantage of the rails or arm interfering with a drawing operation.

Other disadvantages of the prior art are that the drawing apparatus itself becomes bulky and heavy in weight when the head is connected to the rails or arm, and that the use of the arm or the rails places limitations on the range of movement of the head on the drawing board because a dead space is created on the drawing board which is beyond the reach of the rulers.

These disadvantages of the prior art can be eliminated only when the head is freed of its outside supporter and permitted to stand on its own so that its movement may not be controlled from outside.

SUMMARY OF THE INVENTION

A general object of this invention is to provide a drawing apparatus comprising a head and a pair of rulers pivotally connected thereto, wherein when the head supported by no outside supporter is haphazardly placed on the surface of a drawing board without paying any attention to the direction in which it is oriented, an angle formed by a predetermined one of the pair of rulers with respect to the aforementioned reference line is automatically detected and the rulers are controlled to orient themselves to that the angle may correspond to an angle of a predetermined value, whereby the angle formed by the predetermined one of the pair of rulers with respect to the reference line can be made to coincide with the angle of the predetermined value regardless of the direction in which the head is oriented as if the rulers moved in parallel motion.

Another object of the invention is to provide a drawing apparatus comprising angle detection means mounted in the head for detecting an angle formed by a predetermined one of the pair of rulers with respect to the reference line when the head is haphazardly place on the surface of the drawing board, and producing a signal which controls the direction in which the rulers are oriented and causes the predetermined one of the pair of rulers to form an angle of a predetermined value with respect to the reference line.

Another object of the invention is to provide a drawing apparatus comprising an angle detector mounted in the head and utilizing the directivity of a float in a fluid for detecting an angle formed by the predetermined one of the pair of rulers with respect to the reference line and producing a signal which controls the direction in which the rulers are oriented and causes the predetermined one of the rulers to form an angle of predetermined value with respect to the reference line.

Another object of the invention is to provide a drawing apparatus comprising an angle detector mounted in the head and utilizing the directivity of a pendulum member for detecting an angle formed by the predetermined one of the pair of rulers with respect to the reference line, and producing a signal which controls the direction in which the rulers are oriented and causes the predetermined one of the rulers to form an angle of a predetermined value with respect to the reference line.

Another object of the invention is to provide a drawing apparatus comprising an angle detector mounted in the head and utilizing the unidirectivity of a magnetic compass whose needle points to a direction parallel to the magnetic lines of force of the earth as means for detecting the angle formed by the predetermined one of the rulers with respect to the reference line, and producing a signal which controls the direction in which the rulers are oriented and causes the predetermined one of the rulers to form an angle of a predetermined value with respect to the reference line.

Still another object of the invention is to provide a drawing apparatus comprising an angle detector mounted in the head and utilizing a pressure responding element which responds to a change in the pressure of a liquid caused in the direction in which the rulers are oriented as means for detecting the angle formed by the predetermined one of the rulers with respect to the reference line, and producing a signal which controls the direction in which the rulers are oriented and causes the predetermined one of the rulers to form an angle of a predetermined value with respect to the reference line.

Still another object of the invention is to provide a drawing apparatus comprising an angle detector mounted in the head and utilizing a potentiometer whose resistance shows a change when there is a change in the direction in which the rulers are oriented as means for detecting the angle formed by the predetermined one of the rulers with respect to the reference line, and producing a signal which controls the direction in which the rulers are oriented and causes the predetermined one of the rulers to form an angle of a predetermined value with respect to the reference line.

Still another object of the invention is to provide a drawing apparatus comprising a suction device disposed under the head having no outside supporter for detachably attaching the head to the surface of the drawing board by the drawing force exerted by the suc-

tion device on the surface of the drawing board, whereby the head can be securedly held in any position on the drawing board.

Still another object of the invention is to provide a drawing apparatus comprising an external stress cut-off mechanism added to a power transmission and speed reducing mechanism for transmitting power to operate the rulers so that the rulers may not move in any manner and direction even if pressure is applied thereto when a line is drawn by applying a pen to one of the rulers, whereby a drawing operation can be performed positively without any error.

Still another object of the invention is to provide a drawing apparatus comprising an angle selection mechanism mounted in the head for selecting any angle as desired which the predetermined one of the rulers form with respect to the reference line.

Still another object of the invention is to provide a drawing apparatus comprising an angle guide mechanism which gives the operator a sensual guide in selecting an angle formed by one of the rulers with respect to the reference line and setting the apparatus at such angle, such guide being operative to remind the operator, through the sense of touch, of the movement of the knob through an angle of a predetermined value whereby the apparatus can be positively set at any angle with respect to the reference line.

A further object of the invention is to provide a drawing apparatus comprising a motor built in the head for moving the rulers in pivotal movement, an angle detector adapted to produce a stop signal and supply the same to the motor to interrupt the rotation of the motor when the rulers are moved by the action of the motor into a position in which the angle formed by one of them with respect to the reference line coincides with an angle of a predetermined value, and an electronic circuit adapted to impress, for a predetermined time interval, a reverse voltage signal on the motor simultaneously as the angle detector produces the stop signal. This arrangement is effective to apply the brake to the motor when the latter is inoperative so as to move the rulers quickly and positively in a predetermined direction.

A further object of the invention is to provide a drawing apparatus comprising at least two signal generators mounted in the head, signal detection means mounted on the drawing board for detecting an angle formed by a predetermined one of the rulers with respect to the reference line based on the signals produced by the signal generators, and an arithmetic unit adapted to calculate, based on signals detected by the signal detection means, the amount of any deviation of the angle formed by the predetermined one of the rulers with respect to the reference line from an angle of a predetermined value to be formed by the predetermined one of the rulers and the reference line, whereby the direction of the rulers can be controlled and varied until the deviation in angle is eliminated.

Additional and other objects and features of the invention will become evident from the description set forth hereinafter when considered in conjunction with the accompanying drawings.

While several embodiments of the invention are shown and described, it is to be understood that the invention is not limited to the specific forms of the apparatus shown and described and that many changes and modifications may be made therein within the scope of

the invention. To those skilled in the art to which this invention relates, many changes in construction and widely differing embodiments and applications of the invention will suggest themselves without departing from the spirit of the invention. The disclosures and description herein are purely illustrative and are not intended to be in any sense limiting.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of the drawing apparatus comprising one embodiment of the invention, with certain parts being cut out;

FIG. 2 is a vertical sectional view of the head of the drawing apparatus shown in FIG. 1;

FIG. 3 is a sectional view taken along the line A—A of FIG. 2;

FIG. 4 is a sectional view, on an enlarged scale, of the upper portion of the head;

FIG. 5 is a bottom plan view of the power transmission and speed reducing mechanism built in the head;

FIG. 6 is a plan view of FIG. 4;

FIG. 7 is a sectional view taken along the line B—B of FIG. 4;

FIG. 8 is a sectional view taken along the line C—C of FIG. 7;

FIG. 9 is a plan view of the inner structure of the case, showing one form of angle detector;

FIG. 10 is a sectional view taken along the line D—D of FIG. 9;

FIG. 11 is a circuit diagram of one form of electronic circuit incorporated in the drawing apparatus according to the invention;

FIG. 12 is a circuit diagram of another form of electronic circuit incorporated in the drawing apparatus according to the invention;

FIG. 13 is a vertical sectional view of another form of head of the drawing apparatus according to the invention;

FIG. 14 is a sectional view taken along the line E—E of FIG. 13;

FIG. 15 is a plan view of the inner structure of the case, showing another form of angle detector;

FIG. 16 is a circuit diagram of another form of electronic circuit incorporated in the drawing apparatus according to the invention;

FIG. 17 shows the output wave form of the power amplifier shown in the circuit diagram shown in FIG. 16;

FIG. 18 is a sectional view of another form of angle detector;

FIG. 19 is a sectional view of another form of angle detector;

FIG. 20 is a sectional view of another form of angle detector;

FIG. 21 is a circuit diagram of another form of electronic circuit incorporated in the drawing apparatus according to the invention;

FIG. 22 is a sectional view of still another form of angle detector;

FIG. 23 is a circuit diagram of still another form of electronic circuit incorporated in the drawing apparatus according to the invention;

FIG. 24 is a diagrammatic representation of another embodiment of the invention, in which the electronic circuit is not incorporated in the head and connected thereto through a cord;

FIG. 25 is a sectional view of still another form of head;

FIG. 26 is a sectional view of still another form of head; and

FIG. 27 is a diagrammatic representation of another embodiment of the invention, in which the electronic circuit is not incorporated in the head and connected thereto through a cord.

DESCRIPTION OF PREFERRED EMBODIMENTS

The construction of the drawing apparatus according to the invention will be outlined and the principle of its operation described with reference to FIG. 1. As shown, a head is generally designated 1 and has a pair of rulers 2 and 3 pivotally connected thereto. The head 1 comprises a base 4, a handle 5 affixed to the base 4, and a rotary member 6 rotatably connected to the base 4. The rotary member 6 has affixed thereto a ruler mounting plate 7 to which the rulers 2 and 3 are affixed by a screw. The rotary member 6 is angularly rotatable about the base in a plane parallel to the surface of a drawing board 8 and hence the rulers 2 and 3 are angularly rotatable with the rotary member 6. The underside of the base 4 is shaped such that the head 1 can rest in a stable manner on the surface of the drawing board 8. Normally, the drawing board 8 is inclined with respect to the horizontal when in use.

As can be clearly seen in the figure, the head 1 is not supported by an outside supporter. The underside of the head 1 or the underside of the base 4 can be placed in any position on the surface of the drawing board 8 with the head 1 being oriented in any direction as desired. When the head 1 is placed haphazardly on the surface of the drawing board 8, the underside of the rotary member 6 is disposed in parallel spaced relationship with the surface of the drawing board 8 while the underside of each of the rulers 2 and 3 is parallel to and in light engagement with the surface of the drawing board 8.

The head 1 can be moved from one position to another on the surface of the drawing board 8 by the operator gripping the handle 5 by hand. The angle formed by a predetermined one of the rulers 2 and 3 with respect to a reference line for the head 1 on the drawing board 8 must be constant at all times regardless of the position of the head 1 and the direction in which it is oriented on the drawing board 8. This is referred to as the translation motion of the rulers. In this embodiment, the reference line is an imaginary line formed on the surface of the drawing board disposed in an inclined position when a line perpendicular to the ground is projected onto the surface of the drawing board.

If the angle formed by the ruler 2 with respect to the reference line does not agree with a predetermined angle when the head 1 is haphazardly placed on the surface of the drawing board 8, then the rotary member 6 will angularly rotate about the base 4 until the angle formed by the ruler 2 with respect to the reference line agrees with the predetermined angle. The angular rotation of the rotary member 6 is effected by turning on a switch 9.

The internal structure of the head 1 will now be described with reference to FIG. 2 to FIG. 5. The base 4 comprises a vertical shaft 10, vertical shaft base 11 and circular member 12. The circular member 12, which is in the form of a disc, is connected to the handle 5 through the vertical shaft 10. The rotary member 6 is

housed in a case 6a which does not come into contact with the surface of the drawing board 8 and which is covered at its upper surface with a front cover 13, center cover 14 and cell cover 15 as shown in FIG. 2. Affixed to the right end in FIG. 1 is a mounting plate 7 to which is fixed by a screw a pair of rulers 2 and 3 disposed at right angles to each other.

The vertical shaft mechanism of the head will be described with reference to FIG. 2. The vertical shaft base 11 is formed at the lower end of the vertical shaft 10 which is in the form of tube. A gear 17 is affixed to the outer peripheral surface of an annular projection 16 formed in the vertical shaft base 11. The circular member 12 is affixed to the outer peripheral surface of the vertical shaft base 11. Mounted in the vertical shaft base 11 is a magnet 18 which is effective to preclude dislodging of the head 1 from the surface of the drawing board 8 when the latter is inclined at a large angle with respect to the horizontal. The surface of the drawing board 8 is formed of a magnetic material, and the frictional dragging of the circular member 12 on the surface of the drawing board 8 is increased by the force of attraction exerted by the magnet 18 on the surface of the drawing board 8. A vertical shaft holder 20 constituting a part of the handle 5 is attached to the upper end portion of the vertical shaft 10 through a cap screw 19. The aforementioned structure is referred to as the vertical shaft mechanism.

Referring to FIG. 3, a case frame 21 in the form of a plate disposed in the center of the right portion of the rotary member 6 and a cylindrical vertical shaft frame 22 are made integrally of the same material and attached to the rotary member 6. A bearing 23 is mounted at each end of the cylindrical vertical shaft frame 22, and the inner race of each bearing 23 is fitted over the vertical shaft 10. Thus, the rotary member case 6a or rotary member 6 can rotate lightly about the vertical shaft 10. In order that the rotary member 6 may balance, a balance weight (not shown) is mounted at an end of the rotary member 6 opposite to the end at which the rulers 2 and 3 are affixed to the rotary member 6, so as to enable the rotary member 6 to rotate smoothly.

Formed in the case 6a in which the rotary member 6 is housed is a cell chamber 24 in which four cells 25 are disposed. The cells 25 can be replaced by new ones by detaching the cell cover 15 from the rotary member case 6a. As shown in FIG. 2, an electronic circuit 26 is disposed below the cells in the cell chamber 24. Disposed in the central portion of the rotary member 6 as shown in FIG. 3 is a gear base plate 27 which is affixed by cap screws 28 to a saddle frame 29 integral with the rotary member case 6a. A power transmission and speed reducing mechanism is mounted on the gear base plate 27.

FIG. 5 shows the power transmission and speed reducing mechanism mounted on the gear base plate 27 as seen from a side opposite to the side shown in FIG. 3. In the figure, a motor 31 is affixed to the gear base plate 27 by a supporter 30 and includes a rotary shaft to which a pinion 32 is secured and maintained in meshing engagement with a spur gear 34 having secured thereto a pinion 34a which, in turn, is maintained in meshing engagement with a gear 36 affixed to the left end of a worm gear shaft 35. The worm gear shaft 35 is supported for rotation by a leftward bearing 37 and a rightward bearing 38 which are affixed to the

gear base plate 27 by screws. A worm gear 39 disposed between the two bearings 37 and 38 is fitted over and secured to the worm gear shaft 35 and at the same time maintained in meshing engagement with a worm wheel gear 40 which is rotatable about a gear shaft 41 affixed to the gear base plate 27.

A spur gear 42 disposed above the worm wheel gear 40 with respect to the plane of FIG. 5 is shown in FIG. 2 as being disposed below the worm wheel gear 40 for rotation about the gear shaft 41. Thus, the worm wheel gear 40 and spur gear 42 constitute a stepped gear. The spur gear 42 is shown as being in meshing engagement with the spur gear 17 of the vertical shaft mechanism (See FIG. 2). The aforementioned structure which is referred to as the power transmission power and speed reducing mechanism is effective to greatly reduce the rate of rotation of the motor 31 in transmitting power from the motor 31 to the spur gear 17.

Since the spur gear 17 is connected to the circular member 12 in contact with the surface of the drawing board 8, the spur gear 17 never rotates. Accordingly, rotation of the motor 31 is transmitted to the spur gear 42 which revolves around the spur gear 17. This means that the rotary member 6 rotates at low speed about the vertical shaft 10. Since the direction of revolving movement of the spur gear 42 can be reversed by switching a current supplied to the motor 31 between different polarities, it will be appreciated that the revolution of the rotary member 6 can be switched between clockwise and counter clockwise directions by virtue of the aforementioned power transmission and speed reducing mechanism and the vertical shaft mechanism. It is to be noted that the control of the direction in which the rulers are oriented is effected by changing the positive and negative properties of a current supplied to the motor 31.

When the operator applies a pencil or a ruling pen to one of the rulers to draw a line during drawing operation, a pressure tends to be applied to the rulers 2 and 3 by the arm or an external stress tends to be applied thereto. Means must be provided to preclude misoperation of the rulers or the rotary member due to the external stress applied thereto, if the rulers are to be maintained stationary in a given position and oriented in a predetermined direction. In other words, means must be provided to keep the direction of angular rotation of the rotary member effected by automatic control from being affected by external stresses, or the rotary member itself must be locked to the vertical shaft mechanism so as to be kept from being influenced by the external stresses. This end can be attained by rendering the worm 39 inoperative when subjected to a external stress. Generally, known worm gear mechanisms of a large reduction ratio have the characteristic that the rotational force acting on the output shaft side is not transmitted to the input shaft side. This characteristic applies to the worm wheel 40 and the worm 39 used in the power transmission and speed reducing mechanism according to the invention. Thus, the worm 39 is kept from rotating when an external stress is applied to the rulers, and the external stress is transmitted through the vertical shaft mechanism to the handle 5. Accordingly, if the operator grips the handle 5 and firmly holds it so that the vertical shaft 10 may not rotate, it is possible to prevent inadvertent rotation of the worm 39 and hence displacement of the rulers 2 and 3 in the direction of rotation of the worm 39.

It is not essential to use the aforementioned power transmission and speed reducing mechanism in the apparatus according to the invention. It is possible, of course, to use a power transmission mechanism which does not have this external stress cut-off function. If this is the case, one has only to provide means whereby the rotary member 6 is locked to the base 4 to keep the former from malfunctioning during the time elapsing after the control of the direction of the rulers 2 and 3 is effected until the line drawing operation is finished. Such means can be provided independently of the power transmission mechanism.

In FIG. 4, there is shown, on an enlarged scale, an angle setting device adapted to set the ruler 2 at any angle as desired with respect to the reference line. The figure shows an upper half portion of FIG. 2 or a mechanism mounted inside the handle 5. As shown, a cylindrical inner tube 43 is fitted over the upper outer peripheral portion of the vertical shaft frame 22 for rotation relative thereto. A stop ring 45 is secured by a cap screw 44 to the top of the vertical shaft frame 22 so as to preclude dislodging of the inner tube 43 from the vertical shaft frame 22. An angle opening ring 46 is firmly fitted over the lower end of the inner tube 43 which threadably receives an external threaded portion of a minor diameter tube 48 in an internal threaded portion 47 at the upper end portion of the inner tube 43.

An outer tube 49 is fitted over the outer periphery of the inner tube 43 for rotating relative thereto, and has an angle detector 51 mounted on the upper end of the tube 49 by a cap screw 50. A ring 53 is threadably connected to an internal threaded portion 52 at the upper end portion of the small diameter tube 48 to hold the angle detector 51 in place. The ring 53 also performs the function of precluding dislodging of the outer tube 49 from the inner tube 43.

Disposed on the surface of the angle detector 51 is an angle graduation dial 54 (See FIG. 6) on which is superposed a transparent strip 55 connected at one end to the ring 53 and having marked on the other end portion an angle indication line 56 adapted to be indexed with any one of the lines for indicating angles on the graduation dial. Indexing of the angle indication line with any line as desired on the graduation dial can be ascertained by the operator by looking through a window 57 (See FIG. 2) formed in the handle 5 and covered with a transparent sheet.

Connected to the lower end of the outer tube 49 by a cap screw 58 is an angle setting knob 59 which can be rotated by hand to bring the angle indication line 56 into alignment with a line designating a desired angle on the angle graduation dial 54. By this operation, the ruler 2 can be set at a desired angle with respect to the reference line. The aforementioned mechanism is referred to as an angle setting mechanism.

Mounted below and inwardly of the angle setting knob 59 is a current collector board 60 which is made of a bad conductor and which has three conductive rotary rings 61 made of a good conductor. Connected to the conductive rotary rings 61 are three lead wires extending through an opening 62 and connected, as subsequently to be described, to three terminals of the angle detector 51. On the other hand, brushes 63 disposed on the right side of the rotary member 6 are maintained in pressing engagement with the conductive rotary rings 61 and connected to the electrical system

in the rotary member case 6a. Thus, the electrical system disposed in the rotary member case 6a is electrically connected to the angle detector 51. The provision of such mechanism is made necessary electrically to obviate, without interfering with the rotation of the angle setting knob 59, the problem of how to enable the angle setting knob 59 to rotate relative to the inner tube 43 which is coupled to the rotary member 6, in order that the ruler 2 can be set at any angle as desired with respect to the reference line. A spherical recess is formed in the angle setting knob 59 as shown in the lower right portion of FIG. 4 to receive therein a steel ball 64. A plate spring 66 is affixed at one end portion to the knob 59 by a cap screw 65 is maintained at the other end portion in resilient engagement with the steel ball 64 so as to urge the ball to move downwardly. The steel ball 64 is disposed either in one of guide openings 67 formed in the angle opening ring 46 or in any other position as the result of rotation of the angle setting knob 59, and never gets out of the spherical recess. The guide openings 67 are angularly spaced apart from another by 15° or formed in 24 positions by equidistantly dividing the circumference of the angle opening ring 46. Thus, when the operator turns the knob 59, dropping of the steel ball 64 in each guide opening 67 can be felt by the operator, so that he is guided sensually in setting the ruler 2 at a desired angle with respect to the reference line. This mechanism is referred to as an angle selection mechanism.

It is necessary that the inner tube 43 be made non-rotatable relative to the rotational member 6 or vertical shaft frame 22 except when the position of the rulers is adjusted relative to the zero line for the drawing operation as subsequently to be described. To this end, the lowermost end of the inner tube 43 is fixed to the rotary member 6 side or released therefrom by a needle 68 shown in FIG. 2 and FIG. 3. More specifically, an adjusting knob 69 is attached to the right end of the needle 68 and formed therein with a threaded portion 70 which is threadably inserted in a threaded opening formed in the rotary member case 6a, so that the needle can be moved leftwardly in the figures by turning the adjusting knob 69. Thus, the needle 68 can leave the inner tube 43 free to rotate or prevent its rotation by projecting into a space between the case frame 21 and the lowermost end of the inner tube 43. To render the inner tube 43 rotatable, the adjusting knob 69 is turned to loosen the threadable engagement of the threaded portion 70 with the threaded opening formed in the rotary member case 6a to release the needle 68 from pressing engagement with the lowermost end of the inner tube 43. The steel ball 64 is placed in one of the guide openings 67 of the angle opening ring 46 and the angle indication line 56 is indexed with the line representing the zero degree on the angle dial 54 beforehand. Then, the angle setting knob is turned by the operator. This causes the inner tube 43 to rotate together with the outer tube 49, so that the angle indication line 56 rotates with the angle detector 51 while indicating the zero degree position on the angle dial 54. The angle setting knob 59 is turned until either the ruler 2 or 3 is brought into index with the drawing zero line on the drawing. Finally, the adjusting knob 69 is turned again to bring the forward end of the needle 68 into pressing engagement with the lowermost end of the inner tube 43. At this time, the inner tube 43 is moved upwardly by the needle 68 and its offset portion is brought into

pressing engagement with the stop ring 45, whereby the inner tube 43 is fixed to the vertical shaft frame 22. Thus, either the ruler 2 or 3 is disposed parallel to the drawing zero line in any position as desired on the drawing board 8. The term "drawing zero line" refers to a center line to be drawn vertically in the central portion of the drawing sheet or drawn beforehand in the center portion of the drawing at the time a drawing operation is performed. It may be called a zero degree line for setting the rulers at a zero angle. The aforementioned mechanism is referred to as mechanism for adjusting the position of the rulers relative to the drawing zero line. If the angle setting knob 59 is turned to rotate the outer tube 49 and hence to rotate the angle detector 51 while keeping the inner tube 43 fixed to the vertical shaft frame 22, it is possible to set the rulers at any angle as desired with respect to the reference line. The mechanism responsible for this angle setting operation is the aforementioned angle selection mechanism.

The angle detector 51 may be available in many forms. One of them utilizes the buoyancy of a float. One form of angle detector 51 utilizing a float will be described with reference to FIG. 7 and FIG. 8. A case 71 is shown as being filled with a liquid 72 and having a lower pivot bearing 73 affixed to its bottom surface. An upper pivot bearing 71 is affixed to the underside of the angle dial 54 which serves as a cover for the case 71. A shaft 75 having secured to its intermediate portion one end of a float 76 is supported at opposite ends by the lower and upper pivot bearings 73 and 74 so that the shaft 75 can rotate when a force is exerted on the angle detector 51, no matter how small the force may be. The rotation of the shaft 75 causes the float 76 to pivot movement about the shaft 75.

An electric contact 77 is mounted at the other end of the float 76 and connected to a common terminal 79 (all the terminals are electrically insulated with respect to the case 71) mounted on the case 71 through a wire 78 which does not interfere with the pivotal movement of the float 76. Two terminals 80 and 81 are mounted on the underside of the bottom of the case 71, and two needle contacts 82A and 82B are mounted on the upper end of the terminals 80 and 81, respectively. The needle contacts 82A and 82B are disposed in the same horizontal plane as the contact 77 in FIG. 8 and adjusted such that a very small clearance is interposed between them and the contact 77. The case 71 is covered, as aforementioned, with the angle dial 54 to prevent leakage of the liquid contained therein.

The float 76 in the liquid of the angle detector 51 of the type which utilizes the buoyancy of the float tends to pivot about the shaft 75 to a position such that the directional line of the float connecting the shaft 75 and the contact 77 is directed to the uppermost portion of the case 71 when the angle detector 51 is tilted. In other words, the float 76 always orients itself in the direction of the gravitational pull or perpendicularly. This means that the contact 77 is brought into engagement with either of the needle contacts 82A and 82B which is disposed at a higher level when the angle detector 51 is tilted. If a voltage is impressed to all the terminals of the angle detector 51, then a current flow between the contacts brought into engagement with each other as the angle detector is tilted. This current, which is referred to as an angular deviation signal current, is supplied as an input to the electronic circuit 36 so as to actuate the motor 31 which remains operative dur-

ing the time the signal current is produced to rotate the rotary member 6 to bring the float 76 to a position in which the contact 77 at the other end thereof assumes the uppermost position. When the directional line of the rotary member 6 becomes parallel to the reference line and the angle formed by the ruler 2 with respect to the reference line coincides with an angle of a predetermined value, or reference angle, the contact 77 assumes the uppermost position as shown in FIG. 7. Thereupon, the contact 77 is released from engagement with either the needle contact 82A or 82B and the production of the angular deviation signal current is interrupted.

The directional line of the rotary member 6 is an imaginary line drawn on the surface of the rotary member 6 in any direction as desired for indicating the direction in which the rotary member 6 is oriented. The angle detector 51 is mounted on the rotary member 6 such that the former produces no signal current when the directional line of the latter is parallel to the reference line. Accordingly, when the directional line of the rotary member 6 is inclined or forms an angle with the reference line, the angle detector 51 produces an angular deviation signal current. The angle formed by the ruler 2 with respect to the reference line when the directional line of the rotary member 6 is parallel to the reference line is referred to as a set angle of the rulers.

The direction in which the float 76 of the angle detector 51 is oriented is constant at all times when the drawing apparatus according to the invention is placed on a drawing board which is inclined with respect to the horizontal. Accordingly, the direction in which the rulers connected to the detector 51 through the rotary member 6 are oriented is constant no matter in what position the drawing apparatus may be placed on the drawing board. Thus the drawing apparatus according to the invention can be moved from one position to another on the drawing board while the rulers move in translation motion by forming a predetermined angle with respect to the reference line.

Another form of angle detector 51 utilizing the directivity of a magnetic needle relative to the magnetic poles of the earth will be described with reference to FIG. 9 and FIG. 10 in which a lower pivot bearing 83 made of an electrically conducting and non-magnetic material is affixed to the bottom surface of a case 84 and connected through a wire to a common terminal 85 affixed to the underside of the case 84. An upper pivot bearing 86 made of a non-magnetic material is affixed to the underside of the angle dial 54 which serves as a cover for the case 84. Rotatably supported at opposite ends by the pivot bearings 83 and 86 in a shaft 87 made of an electrically conducting material which is rotatable when a force is exerted thereon, no matter how small the force may be. A contact supporter 88 made of an electrically conducting material in the form of a disc is mounted at the intermediate portion of the shaft 87 for pivotal movement about the shaft 87 as the latter rotates. A contact 89 is disposed at one point on the outer marginal portion of the contact supporter 88, so that a voltage can be impressed on the contact 89 through the point of contact of the lower pivot bearing 83 and the shaft 87 if the voltage is applied to the common terminal 85.

A magnetic needle 90 adapted to point to the magnetic poles of the earth is mounted on the surface of the contact supporter 88, two needle contacts 91A and

91B are disposed on opposite sides of and spaced apart a small distance from the contact, 89, and affixed to terminals 92 and 93 respectively which are mounted on the underside of the case 84. The spacing between the needle contacts 91A and 91B is adjustable.

Upon impression of a voltage on all the terminals of the angle detector, a current flows between the contacts if the contact 89 is brought into engagement with either the needle contact 91A or 91B. The current which is used as an angular deviation detection signal current as in the form of angle detector described previously is supplied to the motor 31 to angularly rotate the rotary member 6 (See FIG. 2) until the magnetic needle 90 becomes stationary. Upon the magnetic needle 90 becoming stationary, the contact 89 is released from engagement with either the needle contact 91A or 91B and the angle deviation signal current is cut off, thereby interrupting the rotation of the rotary member 6. At this time, the directional line of the rotary member 6 is disposed parallel to the reference line, so that the ruler 2 forms a predetermined or set angle with respect to the reference line. The reference line herein referred to is an imaginary line disposed on the surface of the drawing board 8 and parallel to the magnetic line of force of the earth.

Attention is drawn to the fact that the directivity of the magnetic needle 90 should not be affected by the magnetic force produced by the elements of the apparatus according to the invention. Thus, when the angle detector used is of the type utilizing the directivity of a magnetic needle relative to the magnetic poles of the earth, it is necessary that the motor 31 should be treated to avoid magnetic leakage. The magnet 18 mounted in the vertical shaft case 11 for precluding dislodging of the apparatus from the drawing board 8 disposed in an inclined position should also be treated to avoid magnetic leakage or eliminated.

When the two forms of angle detector described above are employed, some limitations are placed on the drawing apparatus in its functioning. The form of angle detector relying on the buoyancy of a float should always be used with a drawing board which is disposed in an inclined position with respect to the horizontal. Thus, if the drawing board 8 is disposed horizontally, it is impossible for the drawing apparatus according to the invention to effect automatic control of the angle formed by the ruler 4 with respect to the reference line. Also, it will be understood that the drawing apparatus using an angle detector of the type using the directivity of a magnetic needle relative to the magnetic poles of the earth cannot effect automatic control of the angle formed by the ruler 2 with respect to the reference line if the drawing board 8 is disposed at right angles to the horizontal or standing on one side. It is interesting to note that if the angle detector shown in FIG. 7 is put upside down, it can be used as an angle detector relying on the downward directivity of a pendulum. If this is the case, the case 71 may be filled with a liquid when a weight is attached to the pendulum; otherwise it is necessary to empty the case 71 of the liquid.

The cells 25 in the case 24, the electronic circuit 26, angle selection mechanism, power transmission and speed reducing mechanism and operation switch 9 are connected to one another by wire as shown in FIG. 11. These mechanisms and elements will be described with reference to an electronic circuit shown in FIG. 11. In the FIGURE, TR (1) to TR (6) are transistors, R (1)

to R (6) are resistors, C is a capacitor, SW is an operation switch (corresponding to the aforementioned operation switch 9) which is closed when depressed once and opened when depressed twice, M is a motor (corresponding to the motor 31), VS is an angle detector, RT is a right terminal of the angle detector, LT is a left terminal of the angle detector, and CT is a common terminal of the angle detector. The pressure applied between the contacts of the angle detector are so small as can be understood from the construction of the angle detector, so that the signal current flowing between the contacts is of very small value. The signal current of very small value is amplified by transistors TR (1) and TR (2). Other transistors TR (3) to TR (6) are switching transistors used for switching between the positive and negative qualities of a current supplied to the motor M.

Upon actuation of operation switch SW to close the circuit, one of the contacts RT and RT or contact LT, for example, of the angle detector VS which is connected to the rotary member 6 is electrically connected to the common terminal CT and an LT current signal is produced and fires transistors TR (1), TR (3) and TR (4), thereby supplying a plus current to a motor terminal MT2 and a minus current to a motor terminal MT1. This renders the motor M operative and causes the rotary member to rotate. When the directional line of the rotary member 6 becomes parallel to the reference line, the LT current signal is cut off, thereby terminating the supply of current to the motor terminals. In some cases, the rotary member 6 may overrun due to the inertia of the motor M or other mechanical elements when the directional line of the rotary member 6 has become parallel to the reference line. In such case, the contacts CT and RT of the angle detector VS are electrically connected to produce an RT signal current, thereby firing transistors TR (2), TR (5) and TR (6). This supplies a plus current to the motor terminal MT1 and a minus current to the motor terminal MT2, so that the direction of rotation of the motor M is reversed and the rotary member 6 is rotated in a direction in which its directional line becomes parallel to the reference line.

Another form of electronic circuit will be described with reference to FIG. 12 in which transistors TR (1) to TR (6), Resistors R(1) to R (6), capacitors C (1) to C (5), variable resistors VR (1) and VR (2), monostable multivibrators F and F', and driver circuits G and G' are connected together. In the FIGURE, capacitor C (4) and variable resistor VR (1) form a time constant circuit for monostable multivibrator F and capacitor C (5) and variable resistor VR (2) form a time constant circuit for monostable multivibrator F'.

Operation of the electronic circuit shown in FIG. 12 will be described with reference to the drawing apparatus shown in FIG. 1 to FIG. 8. The drawing apparatus is placed on the magnetized surface of the inclined drawing board 8, with the underside of the head 1 being brought into contact with the magnetized surface of the drawing board 8 so that the force of attraction of the magnet 18 may act on the magnetized surface. The circular member 12 is disposed on the surface of the drawing board 8 at any angle as desired. In this case, if the directional line of the rotary member 6 is inclined relative to the reference line, the float 78 in the angle detector 51 or VS will tend to move toward the top-most position of the case 71. This brings the contact 77

into engagement with whichever of the two needle contacts 82A and 82B that is disposed at a higher level. When the contact 77 is brought into engagement with the needle contact 82A, for example, a positive bias voltage is impressed on the base of transistor TR (2) through resistors R (7) and R (2) if the operation switch 9 or SW is turned on, with transistor TR (2) remaining inoperative. On the other hand, a negative bias voltage is impressed on the base of transistor TR (1) to fire the same. This renders transistors TR (3) and TR (4) operative, so that a plus current is supplied to motor terminal MT2 and a minus current is supplied to motor terminal MT1 and the motor 31 or M starts rotating.

Rotation of the motor 31 or M is transmitted through the power transmission and speed reducing mechanism to the spur gear 42 to angularly rotate the rotary member 6 counter-clockwise about the vertical shaft 10 in FIG. 3 to bring the rotary member 6 into a position in which its directional line is parallel to the reference line. Immediately before the directional line of the rotary member 6 becomes parallel to the reference line, the contact 77 is released from engagement with needle contact 82A and the base voltage of transistor TR (1) becomes positive. Simultaneously as transistor TR (1) is thus rendered inoperative, conversion of the base voltage of transistor TR (1) from negative to positive renders multivibrator F operative, so that the latter produces at its output line a negative signal whose time constant may vary depending on the values of capacitor C (4) and variable resistor VR (1). This negative signal is supplied through driver circuit G to the bases of transistors TR (5) and TR (6). This fires transistors TR (5) and TR (6) and causes voltages of opposite polarity to be supplied to motor terminals MT (1) and MT (2), so that a brake force acting in a direction opposite to the direction of rotation of the motor is applied to the motor 31 or M for an instant and interrupts the rotation thereof. When the motor becomes inoperative, the directional line of the rotary member 6 is parallel to the reference line and the ruler 2 forms a predetermined angle with respect to the reference line.

If the contact 77 is brought into engagement with needle contact 82B, the motor 31 or M will rotate in the reverse direction. Monostable multivibrator F' is rendered operative as soon as the contact 77 is released from engagement with needle contact 82B and produces a negative output signal which is supplied through driver G' to the bases of transistors TR (3) and TR (4). This fires transistors TR (3) and TR (4) and causes a brake force acting in a direction opposite to the direction of rotation of the motor to be applied to the motor 31 or M for an instant or, to be more exact, for a time interval which may vary depending on the values of capacitor C (5) and variable resistor VR (2), so as to interrupt the rotation of the motor. The time interval during which the brake is applied to the motor can be adjusted by varying the values of monostable multivibrator F and F' and variable resistors FR (1) and VR (2).

From the foregoing description, it will be appreciated that the invention provides the feature of applying, to the motor, a brake force acting in a direction opposite to the direction of rotation of the motor immediately before the motor is due to stop rotating, in effecting automatic control of the orientation of the ruler with respect to the reference line by bringing the rotary mem-

ber to a position in which its directional line is parallel to the reference line. This feature is effective to prevent overrun of the rotary member 6 and hence of the ruler 2 due to inertia at the time the motor 31 or M stops rotating, thereby permitting to bring the ruler 2 quickly and positively to a position in which it forms a predetermined or set angle with respect to the reference line. It is to be understood that the invention is not limited to the type of circuit diagram shown in FIG. 12 in applying to the motor a brake force acting in a direction opposite to the direction of rotation of the motor at the time the motor is due to stop rotating, and that many changes may be made therein according to the construction of the angle detector used.

Another form of head will now be described with reference to FIG. 13 to FIG. 16. The vertical shaft mechanism will first be described with reference to FIG. 13. A base 100 comprises a hollow vertical shaft 101, a disc 102 integral with the vertical shaft 101, and a bottom plate 103 to which the disc 102 is affixed by fitting. The disc 102 includes cylindrical portion 102a having affixed to its outer peripheral surface a worm wheel 104. A planar surface 103a is formed on the underside of the bottom plate 103 to facilitate placing of the base 100 on the surface of the drawing board. A magnet 106 in the form of a disc and formed on its outer periphery with a threaded portion threadably engaged a threaded portion formed on the inner periphery of the bottom plate 103. When the planar surface 103 on the underside of the base 103 is brought into engagement with the magnetized surface of the magnetic board which is treated with a magnetic material, the head 1 rests in a stable manner on the surface of the drawing board 8 by virtue of the force of attraction of the magnet 106 exerted on the magnetized surface of the drawing board 8. This keeps the head 1 from sliding along the drawing board 8 and dropping downwardly therefrom even if the latter is inclined with respect to the horizontal.

The magnetic force of attraction exerted by the magnet 106 on the magnetized surface of the drawing board 8 can be adjusted by rotating the magnet 106 and moving the same toward or away from the surface of the drawing board 8 at the threadable connection of its threaded portion with the threaded portion 105 of the base plate 103. By using an electromagnet in place of the magnet 106, it is also possible to effect adjustments of the magnetic force of attraction exerted on the magnetized surface of the drawing board 8 by varying the value of a voltage impressed on the electromagnet.

A vertical shaft holder 107 is fitted over the upper portion of the vertical shaft 101, and a handle 108 covered at its top with a transparent plate 109 is affixed to the vertical shaft holder 107. Ball bearings 111, mounted on the outer periphery of the vertical shaft 101 through a tubular collar 110 and disposed at upper and lower ends of the shaft 101. An inner tube 112 is fitted over the ball bearings 111 and has secured to the lower portion of its outer periphery a tubular portion 113a of a rotary member 113 which is angularly rotatable about the vertical shaft 101 in a plane parallel to the plane in which the surface of the drawing board 8 is disposed.

The rotary member 113 has secured to one end a ruler mounting plate 114 to which are affixed a vertical ruler and a horizontal ruler. Formed at the left side portion of the rotary member 113 is a case 115 housing

therein four cells 116 which can be replaced by new ones by removing a cover 117 from the case 115.

The power transmission and speed reducing mechanism of the drawing apparatus according to the invention will now be described mainly with reference to FIG. 14. The rotary member 113 includes a case portion 113c to which a gear base plate 118 is affixed by cap screws 119. Affixed to the gear base plate 118 is a DC motor 120 having an output shaft to which a pinion 121 is affixed. Rotatably supported by a bearing member 122 affixed to the gear base plate 118 is a shaft 123 having affixed to one end thereof a spur gear 124 maintained in engagement with pinion 121. Rotatably supported by support members 125 and 126 affixed to the gear base plate 118 is a worm shaft 127 having affixed to one end thereof a spur gear 128 maintained in meshing engagement with a pinion 129 affixed to one end of the shaft 123. The worm shaft 127 has formed thereon a worm 130 which is maintained in meshing engagement with a worm wheel 104 connected to the base 100. The aforementioned mechanism performs the function of reducing the rate of high speed rotation of the motor 120 and letting the worm 130 transmit high power at low speed. Since the worm wheel 104 is connected to the base 100 adapted to be placed on the surface of the drawing board 8, rotation of the output shaft of the motor 102 causes the worm 130 to move along the outer periphery of the worm wheel 104 while the worm 130 revolves about its own axis, so that the rotary member 113 angularly rotates at low speed about the vertical shaft 101 in a plane parallel to the plane in which the surface of the drawing board 8 is disposed. The direction of rotation of the rotary member 113 can be varied by switching between the positive and negative qualities of the current supplied to the motor 120, so that it is possible to switch the direction of rotation of the rotary member 113 between the clockwise and counter-clockwise directions by using in combination the aforementioned power transmission and speed reducing mechanism and the vertical shaft mechanism.

The angle setting mechanism for setting at a desired value the angle to be formed by the rulers connected to the rotary member 113 with respect to the reference line will now be described with reference to FIG. 13. A major diameter portion of an intermediate tube 131 is slidably fitted over the inner tube 112, and the upper end of the intermediate tube 131 has affixed thereto a transparent plate 132 on which is drawn an angle indicating line adapted to be indexed with any one of the lines on an angle graduation dial 135 covering a case 134 of an angle detector 133. 136 designates an outer tube fitted over the outer periphery of the intermediate tube 131 for rotation relative thereto and having affixed to its upper end the case 134 of the angle detector 133. The case 134 includes a central tubular portion which is rotatably fitted over the outer periphery of the intermediate tube 131.

Mounted on the lower end of the outer tube 136 is an angle setting knob 137 which can be turned by hand to thereby rotate the case 134 housing the angle detector 133 therein, so that the angle indication line drawn on the transparent plate 132 can be brought into index with any one of the lines which indicates an angle of desired value on the angle graduation dial 135 and the angle to be formed by the rulers with respect to the reference line can be set at a desired value. Secured to the underside of the angle setting knob 137 is a current col-

lector board 138 which is made of a bad conductor and which has conductive rotary rings connected through lead wires to the electric system of the angle detector 133.

On the other hand, the rotary member 113 includes, as shown in FIG. 14, a planar plate portion 139 which mounts on its surface brushes 140 adapted to be maintained in pressing engagement with the current collector board. The brushes 140 are connected to the electric system in the case 115 for the rotary member 113, so that the electric system housed in the case 115 for the rotary member is electrically connected to the angle detector 133.

The mechanism for adjusting the position of the rulers relative to the drawing zero line will now be described with reference to FIG. 14. A pivotal arm 141 is pivotally supported substantially at its central portion by a shaft 142 on the planar plate portion 139 of the rotary member 113, and urged by the biasing force of a spring 143 to move clockwise about the shaft 142 in the figure, so that one end portion 141a thereof is maintained in engagement with the outer periphery of the intermediate tube 131. A push lever 145 is connected at one end through a shaft 145 to the other end portion of the pivotal arm 141, and has the other end which extending out of the planar plate portion 139 of the rotary member 113. The push lever 145 is formed at the other end with a stopper cutout 146 which is adapted to receive therein a projection 147 formed in the rotary member 113, so as to maintain the push lever 144 in an operative position.

It is necessary that the intermediate tube 131 be made non-rotatable relative to the rotary member 113 except when one of the rulers is brought into index with the drawing zero line while the angle indication line drawn on the transparent plate 132 is brought into index with a line indicating the zero degree on the angle graduation dial of the angle detector 133. In the aforementioned construction, when one end of the pivotal arm 141 is maintained in engagement with the outer periphery of the intermediate tube 131, the intermediate tube 131 is prevented from rotating due to the frictional dragging of the pivotal arm 141 thereon even if the knob 137 is turned to rotate the outer tube 136 and angle detector 133. However, if the push lever 144 is pushed and moved into the head to cause the pivotal arm 141 to move counter clockwise in pivotal movement about the shaft 142 so as to thereby release one end portion 141a of the arm 141 from engagement with the outer periphery of the intermediate tube 131, the intermediate tube 131 can be rotated with the outer tube 136 as a unit by frictional engagement of the former with the latter by turning the knob 137. Accordingly, if the angle indication line drawn on the transparent plate 132 is brought beforehand into index with a line indicating the zero degree on the angle graduation dial 135, the angle detector 133 can be rotated by turning the angle setting knob 137 while the angle indication line indicates the zero degree on the angle graduation dial 135. Therefore, if the drawing apparatus is moved to any position on the drawing board 8 after turning the angle setting knob 137 to bring either one of the rulers into index with the drawing zero line on the drawing board and then moving the push lever 144 backwardly into the operative position so as to bring one end 141a of the pivotal arm into pressing engagement with the intermediate tube 131 the direction of

the selected one of the rulers will be automatically controlled and will become parallel to the drawing zero line.

The angle detector 133 shown in FIG. 13 and FIG. 15 will be described. The case 134 is filled therein with a liquid 148. Gas, mercury or any other material which imparts buoyancy to a float 149 may be used in place of the liquid 148. A support frame 150 is affixed at opposite ends to the bottom of the case 134 and has affixed thereto a pivot bearing 151. Another pivot bearing 152 disposed immediately beneath the pivot bearing 151 is affixed to the bottom of the case 134. A float 149 is pivotally supported at one end by a shaft 153 supported at opposite ends by the pivot bearings 151 and 152. Stopper surfaces 154 and 154a are formed on opposite sides of lateral protrusions of the float 149 and spaced apart a small distance from stoppers 155 and 156, respectively projecting inwardly from the inner periphery of the case 134. A differential transformer 157 is affixed to the bottom of the case 134 and has built therein a pair of coils 159 and 160 to which a high frequency current is supplied from an oscillator 158 as shown in FIG. 16. An iron core 161 attached to one end of the float 149 is disposed near the ends of coils 159 and 160. If the iron core 161 is disposed equidistantly from the coils 159 and 160, the coils 159 and 160 balance in output power and consequently the output power of a DC differential amplifier 162 becomes zero. When the output power of the DC differential amplifier 162 becomes zero, the float 149 is disposed midway between the forward ends of the stoppers 155 and 156 so that the float 149 does not come into engagement with the stoppers 155 and 156. The angle detector 133 is mounted on the rotary member 133 such that the float 149 is not brought into engagement with the stoppers 155 and 156 when the directional line of the rotary member 113 is parallel to the reference line. If the angle detector 133 is rotated through a small angle in a plan parallel to the plane in which the inclined drawing board 8 is disposed, the float will tend to move in pivotal movement about the shaft 153, so that the end of the float 149 juxtaposed against the iron core tends to move to the topmost position in the case 134. This means that the iron core 160 disposed equidistantly from the two coils 159 and 160 moves toward one of the two coils and away from the other coil. If a switch 163 is closed at this time, the coils 159 and 160 of the differential transformer 157 will become unbalanced in output powers. Output signals of the coils 159 and 160 supplied to the DC differential amplifier 162 through a rectifier circuit 164 become different in value, so that a positive or negative DC output signal is produced by the DC differential amplifier 162 (See FIG. 17). This output signal is supplied as an input to a power amplifier 165 and impressed on a motor 120 or M after being amplified by the amplifier 165, thereby initiating rotation of the output shaft of the motor 120.

In FIG. 17, the displacement of the iron core 161 is plotted as the abscissa against the output voltages of the power amplifier 165 as the ordinat. Rotation of the motor 120 results in the rotary member 113 angularly rotating about the vertical shaft 101. This causes the angle detector 133 coupled to the rotary member 113 to rotate until the end of the float juxtaposed against the iron core moves to the topmost position in the case 134. At this time, the stopper surfaces 154 and 155 are out of engagement with the stoppers 155 and 156 and

the iron core 161 is disposed equidistantly from the two coils 159 and 160 of the differential transformer 157, so that the output power of the power amplifier 165 becomes zero or substantially zero. At this time, the directional line of the rotary member 113 is parallel to the reference line, so that the ruler forms a predetermined or set angle with respect to the reference line. Thus, the rulers can move from one position on the drawing board to any other position as if it moved in translation motion.

The oscillator 158 and the rectifier circuit 164 are disposed in a case in which the differential transformer 157 is housed. The DC differential amplifier 162 and power amplifier 165 are formed into an integrated circuit and housed in the case for the rotary member 113.

FIG. 18 shows another form of angle indicator, and FIG. 21 shows an electronic circuit used for the angle indicator shown in FIG. 18 in which 180 designates a case having mounted on its underside a U-shaped tube 181 made of a non-conducting material. A liquid conductor 182 is introduced into the U-shaped tube 181 to an extent such that the liquid conductor does not reach the opposite ends of the U-shaped tube. Extending through the U-shaped tube 181 is an electric resistance wire 183 whose resistance undergoes a change when the length of each of opposite end portions *a* and *b* which are not immersed in the liquid conductor 182 varies. A common terminal 184 for the portions of the electric resistance wire 183 which is not immersed in the liquid conductor 182 or variable resistors *a* and *b* is disposed in a portion of the U-shaped tube 181 which is in contact with the liquid conductor 182 in the U-shaped tube 181.

In FIG. 21, transistors TR (1) to TR (6), electric resistors R (1) to R (8), capacitor C and switch SW are electrically connected together as shown. The variable resistors *a* and *b* form with electric resistors R (7) and R (8) a bridge circuit 185 whose output terminals BR (1) and BR (2) are connected to the bases of transistors TR (1) and TR (2) respectively. When the directional line of the rotary member 6 (See FIG. 1) is parallel to the reference line, the levels of the liquid conductor 182 at the opposite ends of the U-shaped tube 181 are equal to each other. At this time, the variable resistors *a* and *b* are equal to each other in length and the values of their electric resistance are also equal to each other, so that the bridge circuit 185 balances. Voltages of the same potential are impressed on the bases of transistors TR (1) and TR (2), so that the bases of TR (1) and TR (2) are equal in potential to the emitters of TR (1) and TR (2). Thus, transistors TR (1) and TR (2) remain inoperative so long as the bridge circuit 185 balances. Transistors TR (1) and TR (2) each constitute an amplifier circuit while transistors TR (3) to TR (6) each constitute a switching circuit for switching between the positive and negative qualities of the current supplied to the motor M. It is to be understood that the tube 181 is not limited to the U-shape as shown and described herein and that it may be of any other suitable shape.

When the head 1 (See FIG. 1 and FIG. 2) is placed on the magnetized surface of the drawing board 8 and the base 4 of the head 1 is brought into contact with the surface of the drawing board 8 at any desired angle by utilizing the magnetic force of attraction of the magnet 18 (See FIG. 2), the U-shaped tube 181 will be inclined and the variable resistors *a* and *b* of the electric resis-

tance wire 183 differ from each other in length if the directional line of the rotary member 6 is not parallel to the reference line. The difference in length between the two variable resistors *a* and *b* results in a difference in their resistance, so that the bridge circuit 185 becomes unbalanced. For example, if variable resistor *a* becomes greater in length than variable resistor *b*, then the resistance of the latter increases and the base resistance of transistor TR (1) also increases. Thus, the base potential of transistor TR (1) becomes lower than the emitter potential of transistor TR (1) because of the potential lowering action of the base resistance, thereby firing transistor TR (1).

At this time, transistors TR (3) and TR (4) are rendered operative, and a plus current and a minus current are supplied to motor terminals MT2 and MT1 respectively, thereby initiating the rotation of the motor M. The rotation of the motor M is transmitted through the power transmission and speed reducing mechanism to the rotary member 6 which angularly rotates about the base 4 clockwise in FIG. 3, for example. When the directional line of the rotary member 6 becomes parallel to the reference line, the U-shaped tube 181 is restored to its original position and the variable resistors *a* and *b* become equal in length. This restores balance to the bridge circuit 185, so that the base potential of transistor TR (1) is increased and transistor TR (1) is rendered inoperative, thereby interrupting the rotation of the motor M.

In case the directional line of the rotary member 6 is inclined in a direction opposite to the direction in which it is inclined as aforementioned, the value of resistance of variable resistor *b* becomes greater than that of variable resistor *a* and the base potential of transistor TR (2) becomes lower than the emitter potential of transistor TR (2), so that transistor TR (2) is fired. This renders transistors TR (5) and (6) operative so as to supply a plus current and a minus current to motor terminals MT (1) and MT (2) respectively, thereby rotating the motor M in the reverse direction. When the directional line of the rotary member 6 become parallel to the reference line, the U-shaped tube 181 is restored to its original position and transistor TR (2) is rendered inoperative, thereby interrupting the rotation of the motor M.

Another form of angle detector will be described with reference to FIG. 19 in which 186 designates a case mounting on its underside a U-shaped tube 187 made of a non-conducting material and filled with a non-conducting liquid 188. It is to be understood that the tube 187 is not limited to a U-shape and that it may be of any suitable shape. The U-shaped tube 187 has mounted at opposite ends thereof pressure sensing elements 189 and 190 which exhibit a difference in electric resistance when the pressure of liquid at opposite ends of the tube 187 changes. If the variable resistors *a* and *b* in the electronic circuit shown in FIG. 21 are replaced by the pressure sensing elements 189 and 190, it will be possible to convert the change in resistance exhibited by pressure sensing element 189 and 190 into a signal for controlling the operation of the motor M.

FIG. 20 shows another form of angle detector used with the drawing apparatus according to the invention in which 191 designates a case. A flexible plate member 192 made of an insulating synthetic resinous material is affixed at its upper end to the underside of the case 191 by screws 193 and has a weight 194 affixed to

its free end. Stoppers 195 and 196 are disposed on opposite sides of the weight 194 and spaced apart therefrom a suitable distance. The plate member 192 has mounted on opposites thereof resistor elements 197 and 198 made of metal foil and adapted to exhibit a change in electric resistance when a stress is applied thereto to produce a strain. Thus the plate member 192 and the resistor elements 197, 198 constitute a strain gauge. When no stress is applied to the plate member 192, the resistor elements 197 and 198 are equal to each other in electric resistance.

If the case 191 is rotated in a plane parallel to the plane in which the inclined drawing board 8 is disposed, the plate member 192 will be deformed perpendicularly by the weight of the weight 194. Deformation of the plate member 192 results in the electric resistance of resistor element 197 differing from the electric resistance of resistor element 198 in value, thereby enabling to determination of the deviation of the directional line of the rotary member 6 from the reference line. Thus, by replacing the variable resistors *a* and *b* in the electronic circuit shown in FIG. 21 by the strain gauge described above, it is possible to bring the rotary member 6 into a position in which its directional line is parallel to the reference line.

FIG. 22 shows another form of angle detector and FIG. 23 shows an electronic circuit adapted for use with the angle detector shown in FIG. 22. 200 designates a case for the angle detector in which is housed a pendulum 201 having a weight attached to its free end and pivotally supported at its upper end by a shaft 202 so as to extend from the upper end to the lower end of the case 200. 203 designates a light source which may be a light emitting diode mounted on the pendulum 201. A light intercepting plate 205 formed therein with a slit 204 is mounted on the pendulum 201 in a position in which the light intercepting plate 205 is juxtaposed against the light source 203. 206 designates a detector disposed in the case 200 and consisting of light receiving elements 208 and 209 connected to each other with a very small insulating space 207 being formed therebetween.

A lens 210 is interposed between the light intercepting plate 205 and the light source 203 so as to cause the light emanating from the light source 203 to be incident on one point on the detector 206. The detector 206 and the light receiving elements 208, 209 are mounted on a common conducting base (not shown). When the directional line of the rotary member 6 is parallel to the reference line on the inclined drawing board 8, the light emanating from the light source 203 is incident on the insulating space between the light receiving elements 208 and 209.

In FIG. 23, light source 203, detector 206, transistors TR (1) to TR (6), resistors R (1) to R (6), capacitor C and switch Sw are electrically connected together as shown. In the figure, 211 is a terminal of the conducting base common to the light receiving elements 208 and 209. When no light is incident on the light receiving elements 208 and 209, bias voltage supply circuits for the bases of transistors TR (1) and TR (2) are rendered substantially inoperative by the light receiving elements 208 and 209 so as to maintain transistors TR (1) and TR (2) inoperative. Transistors TR (1) and TR (2) each constitute an amplifier circuit, and transistors TR (3) to TR (6) each constitute a switching circuit to switch the polarities of an input signal to the motor M.

In operation, the head 1 is placed on the magnetized surface of the inclined drawing board 8 and the base 4 is brought into contact with the surface of the drawing board at any angle as desired by utilizing the magnetic force of attraction exerted by the magnet 18. In case the directional line of the rotary member is inclined with respect to the reference, the lower end of the pendulum 201 tends to move to the lowermost position in the case 200. Because of this, the light emanating from the light source 203 is incident on either light receiving element 208 or light receiving element 209, whichever is in a lower position. When the light is incident on light receiving element 208, for example, the latter shows a reduction in electric resistance and the bias voltage supply circuit for the base of transistor TR (1) is rendered operative. This impresses a negative bias voltage on the base of transistor TR (1), so that transistor TR (1) is fired and renders transistors TR (3) and TR (4) operative. This supplies a plus current to motor terminal MT (2) and a minus current to motor terminal MT (1), thereby rotating the motor M. The rotation of the motor M is transmitted to the rotary member 6 which angularly rotates clockwise in FIG. 3, for example, until its directional line becomes parallel to the reference line. When the directional line of the rotary member 6 becomes parallel to the reference line, the light emanating from the light source 203 is incident on the insulating space 207 and transistor TR (1) is rendered inoperative. As a result, the motor M stops rotating.

If the light emanating from the light source 203 is incident on light receiving element 209, then transistor TR (2) is fired and transistors TR (5) and TR (6) are rendered operative, so that a plus current and a minus current are supplied to motor terminals MT (1) and MT (2) respectively. This causes the motor M to rotate in the reverse direction, so that the rotary member 6 angularly rotates counter clockwise in FIG. 3 until its directional line becomes parallel to the reference line. Upon the directional line of the rotary member 6 becoming parallel to the reference line, the light emanating from the light source 203 is incident on the insulating space 207 and transistor TR (2) is rendered inoperative, thereby interrupting the rotation of the motor M.

Another embodiment of the invention will be described with reference to FIG. 24 and FIG. 25. 220 designates a head and 223 designates a vertical shaft having affixed to its lower end a base plate 224 which in turn is affixed to a bottom plate 225. The vertical shaft 223, base plate 224 and bottom plate 225 constitute a base member 226. The vertical shaft 223 has affixed to its upper end by a bolt 228 a vertical shaft holder 227 of the T-shape which is formed with a flange 227a for supporting a transparent plate 229. A cover 230 is secured to the transparent plate 229. The vertical shaft holder 227, transparent plate 229 and cover 230 constitute a handle 231.

An inner tube 234 is rotatably fitted over the vertical shaft 223 through ball bearings 232 and 233, and has secured thereto a tubular portion of a rotary member 235. 236 designates an intermediate tube slidably fitted over the outer periphery of the inner tube 234 and having affixed to its upper end a transparent disc 237 on which an angle indication line (not shown) is drawn. 238 designates an outer tube fitted over the outer periphery of the intermediate tube 236 for rotation relative thereto and having an angle graduation dial 239 affixed to its upper end. The surface of the dial 239 is

provided with a graduation in angles (not shown). 240 is a knob affixed to a flange formed at the lower end of the outer tube 238 and having mounted on its underside supersonic wave generators 241 and 242 spaced apart from each other a suitable distance. The supersonic wave generators 241 and 242 are mounted on the knob 240 such that the line connecting them together parallels the directional line of the rotary member 235. The supersonic wave generators 241 and 42 generate supersonic waves in a direction in which there are no obstacles.

243 designates a case affixed to the rotary member 235 and having a balance weight 244 and a servomotor mounted therein. The servomotor 245 includes an output shaft which is maintained, through a worm, in meshing engagement with a worm wheel 246 affixed to the outer periphery of protuberance 224a formed in the base plate 224. When the servomotor 245 is rendered operative, the rotary member 235 angularly rotates about the vertical shaft 223 in a plane parallel to the plane in which the surface of a drawing board 22 is disposed. Affixed to one end of the rotary member 235 is a ruler mounting plate 247 to which rulers 248 and 249 are secured. 250 designates a cord through which the a current is supplied to the servomotor 245 and supersonic wave generators 241 and 242 from a current collector mechanism or other suitable means.

A servomotor control mechanism will be described with reference to FIG. 24. 251 designates a known condenser microphone disposed in a straight line at one side of the drawing board 222. The condenser microphone 251 is constructed such that a thin copper sheet is secured to a glass epoxy material and the surface of the thin copper sheet is roughened to increase its surface area. A thin silver sheet is applied to the roughened surface. When a supersonic wave is supplied to the thin silver sheet, the latter vibrates and a capacity change occurs in the thin silver sheet. This change is indicated by a preamplifier as a pulse signal.

In FIG. 24, 252, 253, 254 and 255 designate wave form shaping circuits, 256, 257 and 258 designate flip-flop circuits, 259 and 260 designate AND gate circuits, 261 designates a clock pulse generator, 262 and 263 designate counters, 264 and 265 designate registers, 266 designates a comparator circuit, 267 designates a high voltage producing device, 268 designates a controller, 269 designates a servo-amplifier, 245 designates a servomotor built in the head 220, 270 designates a switch, and 271 designates a power source. The servomotor 245 which is built in the head 220 is connected to the aforementioned elements as shown.

Operation of the embodiment described above will now be described. The handle 231 of the head 220 is gripped by hand and the head 220 is placed on the surface of the drawing board 222 such that its underside is disposed in any position at any horizontal angle. Then, the switch 270 is turned on. This supplies a high voltage from the high voltage producing device 267 to the controller 268 from which the high voltage is supplied alternately to the supersonic wave generators 241 and 242. Simultaneously as the high voltage appears on an output line 271 of the controller 268, a set signal is supplied from the controller 268 to flip-flop circuit 258 to set the same. This results in a signal of high level appearing on an input line 272 of AND gate circuit 260.

On the other hand, if a high voltage is supplied to supersonic wave generator 241, then a supersonic wave

is generated by generator 241 and supplied in the direction of the condenser microphone 251. Simultaneously, as the supersonic wave is generated by the generator 241, a signal generator (not shown) built in the supersonic wave generator 241 is rendered operative and produces a positive pulse signal which is supplied, through wave form shaping circuit 255, to a set input line 274 of flip-flop circuit 257 which is rendered operative to produce a signal of high level at its output line 275. Thus, signals of high level appear on input lines 272 and 275 of AND gate circuit 260, so that clock pulses continuously supplied from the pulse generator 261 to AND gate circuit 260 through an input line 276 pass through AND gate circuit 260 and supplied continuously to counter 263.

Upon the supersonic wave generated by the generator 241 reaching the condenser microphone 251, the latter undergoes a capacity change which is indicated by a preamplifier (not shown) as a pulse signal and supplied, through wave form shaping circuit 254, to an input line 277 of flip-flop circuit 257 to reset the same. This results in a signal of low level appearing on the input line 275 of AND gate circuit 260. This blocks AND gate circuit 260, so that the clock pulses are kept from reaching counter 263.

Then a set signal is supplied from the controller 268 to register 265, so that the information contained in counter 263 is stored in register 265. At the same time, the number counted by counter 263 appears on an input line 278 of the comparator circuit 266. Thereafter, a reset signal is transmitted from the controller to counter 263 which is reset and made ready for the next following operation.

Simultaneously as a high voltage appears on an input line 279 by the action of the controller 268, a reset signal is transmitted from the controller 268 to flip-flop circuit 258 to reset the same. This results in a signal of high level appearing in an input line 273 of AND gate circuit 259 and signal of low level appearing on the input line 272 of AND gate circuit 260.

On the other hand, if a high voltage is supplied to supersonic wave generator 242, then a supersonic wave is generated by generator 242. Simultaneously as the supersonic wave is generated, a signal generator (not shown) built in the supersonic wave generator is rendered operative and produces a positive pulse signal which is supplied, through wave form shaping circuit 253, to a set input line 280 of flip-flop circuit 256 which is rendered operative to produce a signal of high level at its output line. Thus, signals of high level appear on input lines 281 and 273 of AND gate circuit 259, so that clock pulses continuously supplied from the pulse generator 261 are supplied to counter 262. When the supersonic wave generated by supersonic wave generator 242 reaches the condenser microphone 251, flip-flop circuit 256 is reset and AND gate circuit 259 is shut off.

Then, the information contained in counter 262 is transferred in register 264 to store the same therein. At the same time, the number counted by counter 262 appears at an input terminal 282 of the comparator circuit 266. Thereafter, counter 262 is reset by a reset signal from the controller 268.

On the other hand, the information contained in counter 262 is compared with the information contained in counter 263 by the comparator circuit 266. If the distance between supersonic wave generator 241

and condenser microphone 251 is called A and the distance between supersonic wave generator 242 and condenser microphone 251 is called B, then the directional line of the rotary member 235 is parallel to the reference line when $A=B$. The reference line herein referred to is an imaginary line drawn on the surface of the drawing board such that it is parallel to the longitudinal extension of condenser microphone 251. When the directional line of the rotary member 235 is inclined with respect to the reference line, $A < B$, for example, and a deviation signal corresponding to $A-B$ appears in the comparator circuit 266. The deviation signal is supplied through the servo-amplifier 269 to the servomotor 245 to drive the same. Operation of the servomotor 245 causes the rotary member 235 to angularly rotate counterclockwise about the vertical shaft 233 in FIG. 24. Angular rotation of the rotary member 235 causes the outer tube 238 and knob 235 to rotate through frictional engagement with the inner tube 234 and the outer tube 238, so that supersonic wave generators 241 and 242 move counter clockwise about the vertical shaft 223 and the difference between the distances A and B gradually decreases.

The aforementioned operation is repeated several times while the switch 270 remains in the ON position. When the distance A becomes equal to the distance B, the deviation signal produced by the comparator circuit 266 becomes zero and the directional line of the rotary member 235 becomes parallel to the reference line. Thus, the servomotor 245 is rendered inoperative. When $A > B$, the servomotor 245 operates in the reverse direction and is rendered inoperative when the distance A becomes equal to the distance B. It will be appreciated that, no matter at what angle the head 220 may be disposed with respect to the reference line when it is placed haphazardly on the surface of the drawing board, the ruler 248 connected to the rotary member 235 as shown in FIG. 24 automatically forms a predetermined or set angle with respect to the reference line. When it is desired to change the angle formed by ruler 248 with respect to the reference line, one has only to turn the knob 240 relative to the inner tube 234 so as to thereby vary the positions of supersonic wave generators 241 and 242 with respect to the rotary member 235.

Another embodiment of the invention will be described with reference to FIG. 26 and FIG. 27. In FIG. 26, 290 designates a magnetic signal generating element comprising high frequency coils and disposed at the lower end portion of the vertical shaft 223. A magnetic signal generating element 291 identical in construction to magnetic signal generating element 290 is disposed on the rotary member 235 side. The two elements 290 and 291 are disposed such that the line connecting their central portions together coincides with the directional line of the rotary member 235. The head 220 is similar in construction to the head shown in FIG. 25 in other respects, so that detailed description thereof shall be omitted.

In FIG. 27, 292 designates sine wave producing induction coils arranged in a number of rows and embedded in the drawing board 222 and disposed below the surface thereof. Their parallel portions 292a are large in number and arranged parallel to and equidistantly spaced apart from one another. 293 designates cosine wave producing induction coils arranged in a number

of rows and embedded in the drawing board 222 and disposed below the surface thereof.

Their parallel line portions 293a are large in number and arranged parallel to and equidistantly spaced apart from one another. Parallel portions 292a are disposed relative to the parallel portions 293a such that there is a phase difference of 90° between them. Since the coils 292 and 293 are embedded in the drawing board 222, the surface of the latter is flat and smooth.

In FIG. 27, 294 and 295 are synchronous rectifier circuits, 296 and 297 are coupling change-over circuits, 298 is a holding circuit, and 299 is a phase difference detector circuit comprising multiplying circuits 300 and 301 and a differential amplifier 302. 245 is a servomotor, and 303 is a high frequency alternating current generator. The aforementioned circuit blocks and various parts are electrically connected as shown. In this embodiment, the reference line is an imaginary line drawn on the surface of the drawing board 222 and disposed parallel to the parallel portions 292a and 293a of the rows of coils.

In operation, the head 220 is placed in any position on the surface of the drawing board 222 and at any angle with respect to the reference line, and a power source switch (not shown) mounted on the head 220 in a suitable position is turned on. This actuates the high frequency alternating current generator 303. On the other hand, a movable contact 305 of change-over circuit 296 is moved by a suitable electronic or mechanical mechanism in reciprocating motion between fixed contacts 306 and 307 in a predetermined timing. When movable contact 305 is brought into engagement with fixed contact 306, an output of the high frequency alternating current generator 303 is supplied a signal producing element 290. An induced electromotive force is produced in rows of coils 292 and 293 when a high frequency signal is supplied to signal producing element 290. The movable contact 305 of change-over circuit 296 is coupled to movable contacts 308 and 309 of change-over circuit 297, so that movable contacts 308 and 309 are brought into engagement with fixed contacts 311 and 313 respectively when movable contact 306 is brought into engagement with fixed contact 306.

When movable contact 305 is brought into engagement with fixed contact 307, a high frequency signal is supplied to signal producing element 291. At this time, movable contacts 308 and 309 are brought into engagement with fixed contacts 310 and 312 respectively. The switching of movable contact 305 between fixed contacts 306 and 307, movable contact 308 between fixed contacts 310 and 312 and movable contact 309 between fixed contacts 311 and 313 takes place continuously. When the head 222 is moved in any direction along the surface of the drawing board 222, synchronizing rectifier circuit 294 detects a sine wave while synchronizing rectifier circuit 295 detects a cosine wave. Upon engagement of movable contact 305 with fixed contact 306 during the movement of the head 220, a signal included in the rows of coils 292 is supplied as an input to synchronous rectifier circuit 294 where it is subjected to synchronous rectification by a synchronizing signal from the high frequency alternating current generator 303. Thus, a signal of $\sin \alpha$ appears on an output line of synchronizing rectifier circuit 294. On the other hand, a signal of $\cos \alpha$ is detected in synchronous rectifier circuit 295. The signals

of $\sin \alpha$ and $\cos \alpha$ are supplied through lines 315 and 316 respectively to the holding circuit 298 where they are held and appear on output lines 318 and 319 of the holding circuit 298 respectively.

If switching of the movable contacts of change-over circuits 296 and 297 between the respective fixed contacts is effected and a high frequency signal is transmitted to synchronous rectifier circuit 291, then a signal of $\sin \beta$ is detected in synchronous rectifier circuit 294 while a signal of $\cos \beta$ is detected in synchronous rectifier circuit 295. The α represents the phase of a sine wave output and a cosine wave output induced in the rows of coils 292 and 293 respectively when signal producing element 290 is moved in a direction which is at right angles to the parallel portions 292a and 293a of the rows of coils 292 and 293 respectively. The β represents the phase of a sine wave output and a cosine wave output induced in the rows of coils 292 and 293 when signal producing element 291 is moved in a direction which is at right angles to the parallel portions 292a and 293a of the rows of coils 292 and 293, respectively.

The signals of $\sin \alpha$ and $\cos \beta$ are supplied through lines 319 and 320 respectively to the holding circuit 298 where they are held and appear on output lines 321 and 322. The signals of $\sin \alpha$ and $\cos \beta$ appearing on the output lines 320 and 321 of the holding circuit 298, respectively, are introduced into multiplying circuit 300 where $\sin \alpha$ is multiplied by $\cos \beta$ and the result of multiplication of circuit 301 is supplied to the differential amplifier 302.

On the other hand, outputs of $\sin \beta$ and $\cos \alpha$ appearing on output lines 321 and 317 of the holding circuit 298 are introduced into multiplying circuit 301 where $\sin \beta$ is multiplied by $\cos \alpha$ and the result of multiplication is also supplied to the differential amplifier 302. In the differential amplifier, the calculation $\sin \alpha \cdot \cos \beta - \sin \beta \cdot \cos \alpha = \sin (\alpha - \beta)$ is performed, and the output $\sin (\alpha - \beta)$ of the differential amplifier 302 is supplied to the servomotor 245 which is driven to rotate angularly the rotary member 235 in a direction in which $\alpha - \beta$ becomes zero or $\alpha = \beta$.

The aforementioned operation is repeatedly performed, and α becomes equal to β when the line connecting the center of element 290 to the center of element 291 is parallel to the parallel portions 292a and 293a of the rows of coils 292 and 293, respectively. At this time, the phase difference detector circuit 299 produces no output, thereby interrupting the rotation of the servomotor 245. Thus, the directional line of the rotary member 235 is parallel to the reference line, and ruler 248 forms a predetermined angle with respect to the reference line. By placing the head 220 first in one position on the surface of the drawing board 222 and then moving the same in any direction as desired, it is possible to automatically control ruler 248 and make the same form a predetermined angle with respect to the reference line at all times, no matter in what position the head may be disposed on the surface of the drawing board 222. While several types of angle detector have been shown and described, it is to be understood that the invention is not limited to the specific forms of angle detector and that many changes and modification can be made therein without departing from the scope of the invention.

From the foregoing description, it will be appreciated that according to the invention the angle formed by the

directional line of the ruler carrying rotary member with respect to the reference line is detected, and a signal is produced for controlling the angular rotation of the rotary member to thereby render the directional line thereof parallel to the reference line, so that the rulers can be made to be oriented in a predetermined direction no matter where they may be moved on the surface of the drawing board. As a result, the head can be moved in translation motion on the surface of the drawing board without requiring any outside supporter to support the same. This feature offers many advantages. The absence of outside supporter for the head permits the operator's eye to reach every nook and corner of the drawing board, and at the same time eliminates all the dead space on the drawing board. The operation of removing the head from the drawing board or moving the same thereon can be preformed with ease. In short, the handling of the drawing apparatus is facilitated. Since a compact overall size is obtained in a drawing apparatus, it can be stored and transported with less trouble and care than drawing apparatus of the prior art.

I claim:

1. A drawing apparatus comprising a head adapted to be placed on the surface of a drawing board without requiring any outside supporter, said head comprised of a base of a shape adapted for positioning the head on the surface of the drawing board and a rotary member rotatably connected to said base, at least one ruler connected to said rotary member, angle deviation detection means disposed on the rotary member for detecting an angular deviation of a directional line defined by said rotary member from a predetermined imaginary reference line and producing an angular deviation signal responsive to detection of angular deviation between said lines, drive means built in said head for angularly rotating said rotary member, and control means coupled to said angle deviation detection means and said drive means for automatically controlling the direction and amount of angular rotation of said rotary member based on the angular deviation signal produced by said angular deviation detection means, whereby the directional line of the rotary member can be made parallel to the reference line.

2. A drawing apparatus according to claim 1 wherein said angle deviation detection means comprises an angle detector including a magnetic needle pivotally supported in a case so that the magnetic needle may be oriented in the direction of magnetic poles of the earth and adapted to detect an angular deviation of the directional line of said rotary member from the direction in which the magnetic needle is oriented.

3. A drawing apparatus according to claim 1 further comprising suction means disposed on the underside of said base and adapted to be brought into engagement with the surface of the drawing board, whereby the head can be brought into and out of intimate engagement with the surface of the drawing board by the drawing action of said suction means.

4. A drawing apparatus according to claim 1 further comprising means for firmly fixing said rotary member to said base for preventing rotation of said latter relative to the former when an external force is exerted, as by the pressure of a pen, on said at least one ruler connected to the rotary member.

5. A drawing apparatus according to claim 1 further comprising a power transmission and speed reducing

mechanism operatively connecting said rotary member to said base, said power transmission and speed reducing apparatus performing the function of preventing inadvertent rotation of the rotary member due to pressure applied to said at least one ruler, as by a pen.

6. A drawing apparatus according to claim 5 further comprising a mechanism for adjusting the position of said at least one ruler relative to the imaginary reference line which is capable of moving, conjointly with the angle deviation detection means, an angle indication line indicating the angular position of the angle deviation detection means with respect to the rotary member when an angle is selected at which the angle deviation detection means is disposed with respect to the rotary member.

7. A drawing apparatus according to claim 1 wherein said angle deviation detection means comprises a potentiometer including a curved tube having sealed therein a suitable amount of a liquid conductor and an electric resistance wire arranged in said curved tube, said angle deviation detection means being capable of detecting an angular deviation of the directional line defined by said rotary member from the reference line based on a change in the value of resistance of said potentiometer when the surface of the drawing board is inclined with respect to the horizontal.

8. A drawing apparatus according to claim 1 wherein said angle deviation detection means comprises a plurality of pressure sensitive elements each mounted at one of opposite ends of a curved tube having a fluid sealed therein, said angle deviation detection means being capable of detecting an angular deviation of the directional line defined by said rotary member from the reference line based on a change in the values of resistance of said pressure sensitive elements.

9. A drawing apparatus comprising a head adapted to be placed on the surface of a drawing board without requiring any outside supporter, said head comprised of a base of a shape adapted for positioning the head on the surface of the drawing board, a rotary member rotatably connected to said base, angle deviation detection means for detecting an angular deviation directional line defined by said rotary member from a predetermined imaginary reference line and producing an angular deviation signal responsive thereto, drive means built in said head for angularly rotating said rotary member, and control means built in said head and coupled to said drive means and said angle deviation detection means, and adapted automatically to control the direction and amount of angular rotation of said rotary member based on the angular deviation signal produced by said angle deviation detection means so as to render said angular deviation signal zero, and at least one ruler connected to said rotary member.

10. A drawing apparatus according to claim 9 wherein said angle deviation detection means comprises a strain gauge including a flexible plate member supported at one end by said rotary member and oriented in a predetermined direction at its free end at all times, and a plurality of resistors made of metallic foil and mounted on opposite sides of the plate member, said angle deviation detection means being capable of detecting an angular deviation of the directional line defined by said rotary member from the reference line based on a change in the value of resistance of said strain gauge.

11. A drawing apparatus according to claim 9 wherein said angle deviation detection means comprises a unidirectional member mounted on said rotary member, a plurality of light receiving elements mounted on one of said rotary member and said unidirectional member and a light source mounted on the other of said unidirectional member and said rotary member, said light source being spaced apart from said light receiving elements an equal distance, said angle deviation detection means being capable of detecting an angular deviation of the directional line defined by said rotary member from the reference line based on a position in which the light emanating from said light source is incident on one of said light receiving elements.

12. A drawing apparatus comprising a head adapted to be placed without requiring any outside supporter on the surface of a drawing board inclined with respect to the horizontal, said head comprised of a base of a shape adapted for positioning said head on the surface of the drawing board, a rotary member rotatably connected to said base, an angle deviation detector means connected to said rotary member and comprised of a float pivotally supported in a case containing a liquid therein, said angle deviation detector means being capable of detecting an angular deviation of a directional line defined by said rotary member from a direction in which the float is oriented and producing an angular deviation signal responsive thereto, drive means built in said head for angularly rotating said rotary member, and control means built in said head and coupled to said angle deviation detector means and said drive means and adapted automatically to control the direction and angular amount of rotation of said rotary member based on the angular deviation signal produced by said angle deviation detector means so as to render said angular deviation signal zero, and at least one ruler connected to said rotary member.

13. A drawing apparatus comprising a head adapted to be placed without requiring any outside supporter on the surface of a drawing board inclined with respect to the horizontal, said head comprised of a base of a shape adapted for positioning said head on the surface of the drawing board, a rotary member rotatably connected to said base, an angle deviation detector means connected to said rotary member and comprised of a pendulum pivotally supported at the eccentric portion of said pendulum in a case, said angle deviation detector means being capable of detecting an angular deviation of a directional line defined by said rotary member from a predetermined direction in which the pendulum is oriented and producing an angular deviation signal responsive thereto, drive means built in said head for angularly rotating said rotary member, and control means built in said head and coupled to said drive means and said angle deviation detector means and adapted automatically to control the direction and amount of angular rotation of said rotary member based on the angular deviation signal produced by said angle deviation detector means so as to render said angular deviation signal zero, and at least one ruler connected to said rotary member.

14. A drawing apparatus comprising a head adapted to be placed on the surface of a drawing board without requiring any outside supporter, said head comprised of a base of a shape adapted for placing said head on the surface of the drawing board, a rotary member ro-

tatably connected to said base, angle deviation detection means connected to said rotary member for detecting an angular deviation of a directional line defined by said rotary member from a predetermined imaginary reference line and producing an angular deviation signal responsive thereto, an angle selection mechanism for freely selecting and setting the rotary member at any angle as desired at which said angle detection means is disposed with respect to said rotary member no matter in what position the head may be disposed on the surface of the drawing board, drive means built in said head for angularly rotating said rotary member, and control means coupled to said angle deviation detection means and adapted automatically to control the direction and amount of angular rotation of said rotary member based on the angular deviation signal produced by said angle deviation detection means so as to render said angular deviation signal zero, and at least one ruler connected to said rotary member.

15. A drawing apparatus according to claim 14 further comprising an angle guide mechanism for guiding an operator by the sense of touch when said angle selection mechanism is actuated to select and set the apparatus at any angle as desired at which said angle deviation detection means is disposed with respect to the rotary member, no matter in what position the head may be disposed on the surface of the drawing board.

16. A drawing apparatus comprising a head adapted to be placed in the surface of a drawing board without requiring any outside supporter, said head comprised of a base of a shape adapted for positioning the head on the surface of the drawing board and a rotary member rotatably connected to said base, a motor built in said head for angularly rotating said rotary member relative to said base, angle deviation detection means for detecting an angle formed by the directional line defined by said rotary member with respect to a predetermined imaginary reference line and producing an angular deviation signal, an electronic circuit for controlling the motor and coupled thereto, said circuit adapted to produce a starting signal and a stop signal for said motor based on an angular deviation signal produced by said angle deviation detection means to control the rotation of the motor so that the directional line of said rotary member can be made parallel to the predetermined imaginary reference line, said electronic circuit being further adapted to impress for an instant a re-

verse voltage signal on said motor simultaneously as said stop signal is produced and applied to the motor to interrupt its rotation, and at least one ruler connected to said rotary member.

17. A drawing apparatus comprising a head adapted to be placed on the surface of a drawing board without requiring any outside supporter, said head comprised of a base of a shape adapted for placing the head on the surface of the drawing board, a rotary member rotatably connected to said base, angle deviation detection means comprised of a unidirectional member mounted on said rotary member, an iron core mounted on one of said unidirectional member and said rotary member and a differential transformer mounted on the other of said rotary member and said unidirectional member, said differential transformer and said iron core being disposed in spaced juxtaposed relationship, said angle deviation detection means detecting an angular deviation of a directional line defined by said rotary member from the direction in which said unidirectional member is oriented and producing an angular deviation signal by detecting the amount of displacement of said iron core from said differential transformer, and drive means built in said head for rotating said member in a direction and for an amount to render said angular deviation signal zero, and at least one ruler connected to said rotary member.

18. A drawing apparatus comprising a head adapted to be placed on the surface of a drawing board without requiring any outside supporter, said head comprised of a base of a shape adapted for placing said head on the surface of the drawing board, a rotary member rotatably connected to said base and drive means built in said head for rotating said rotary member in any direction as desired, at least one ruler connected to said rotary member, at least two signal generators, at least one of which is mounted on said rotary member, signal detection means mounted on the drawing board for detecting signals produced by said signal generators, an arithmetic means for calculating an angular deviation of a directional line defined by said rotary member from a predetermined imaginary reference line based on the signals detected by said signal detection means and automatic control means for controlling the direction and amount of angular rotation of said rotary member so as to render zero an angular deviation signal produced by said arithmetic means.

* * * * *

50

55

60

65