May 16, 1950 P. GLASS 2,507,781

CATHODE-RAY RATIO INSTRUMENT MOTOR SYSTEM

Filed Sept. 10, 1945

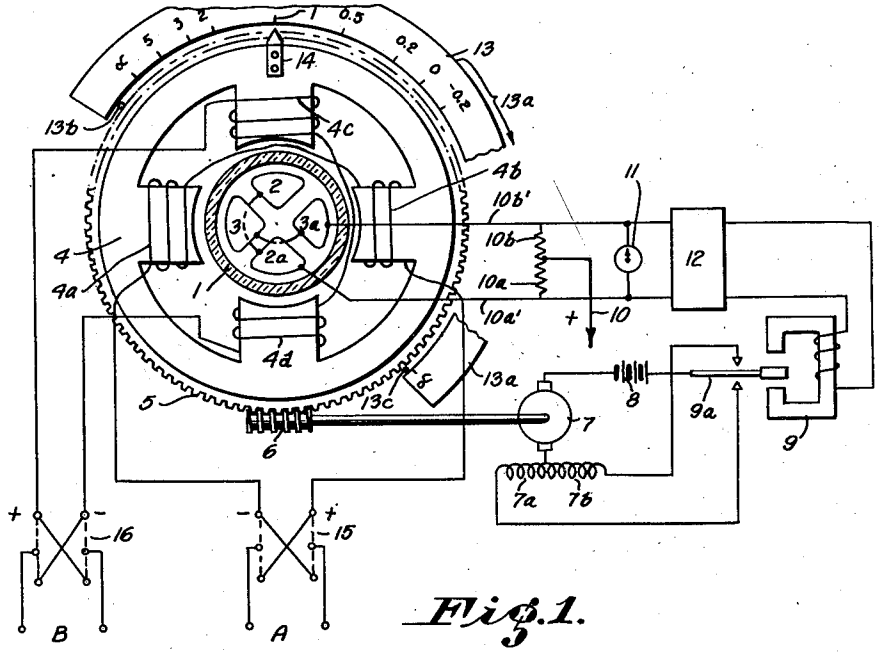


Fig. 1.

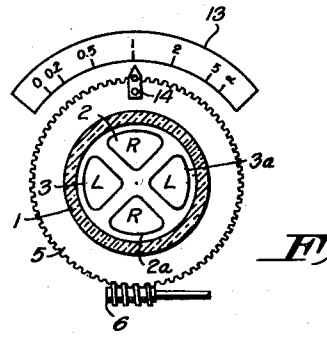


Fig. 3.

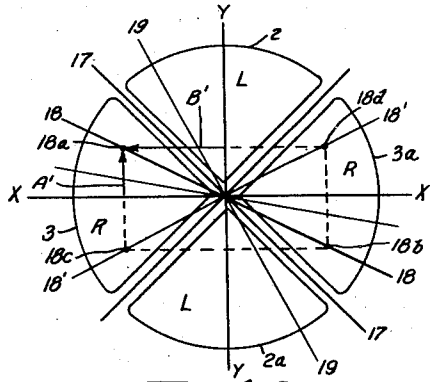


Fig. 2.

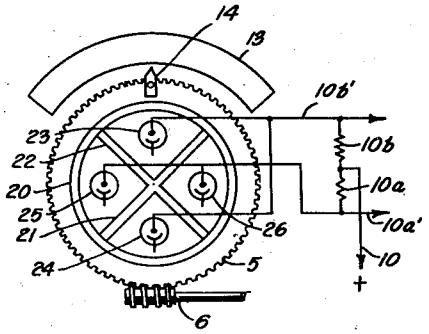


Fig. 4.

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CATHODE-RAY RATIO INSTRUMENT MOTOR SYSTEM

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10 Claims. (Cl. 318—18)

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This invention relates to instruments for the measurement and indication of the ratio between the values of two currents or voltages.

An object of the invention is to devise an instrument producing a direct indication of the ratios between two currents or voltages supplied to the instrument.

A further object of the invention is to devise a ratio instrument which is operative for either alternating current or direct current.

Still another object of the invention is to devise a ratio instrument involving a movable element which may be adjusted either manually or automatically to indicate the ratio values.

A more specific object of the invention is to devise a ratio instrument in which the currents or voltages to be compared are supplied to separate deflection elements of a cathode ray tube tending to deflect the beam in directions at right angles to each other.

Three embodiments of my invention are illustrated in the accompanying drawings in which

Figure 1 is a sectional view of one form of my ratio instrument taken along a transverse plane of the cathode ray tube, and showing the circuits and apparatus required for automatic operation;

Figure 2 is a diagram for explaining the operation of Figure 1; and

Figures 3 and 4 are fragmentary diagrams showing modified forms of the invention.

Referring to Figure 1 of the drawing, 1 indicates the envelope of a cathode ray tube containing four segmental anodes 2, 2a, 3 and 3a arranged in one end of the tube. The end of the tube containing the electron emitting cathode and the other elements necessary to establish an electron beam within the tube is cut away and is not shown in Figure 1, the view in this figure being along the axis of the beam and towards the end of the tube containing the four anode elements. A beam deflecting system is formed of a magnetic ring 4 having four pole pieces carrying magnetizing windings 4a, 4b, 4c and 4d. Windings 4a and 4b are connected in series to a source of current or voltage A and establish a magnetic field transversely of the path of the electron beam in tube 1, while windings 4c and 4d are connected in series to a second source of current or voltage B and establish a second magnetic field transversely of the path of the electron beam and at right angles to the axis of the field established by windings 4a—4b.

Magnetic ring 4 is mounted for rotation about the axis of the tube 1 while the tube remains

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stationary. Rotation may be accomplished by manual movement of the ring about its axis or it may be driven from a suitable source of power by means of a ring gear 5 attached to the magnetic ring and being driven by a worm gear 6 from a motor 7. The motor is energized from a suitable source of current 8 and is driven in one direction by energizing the motor through a field winding 7a, and in the opposite direction by energizing the motor through field winding 7b. The connections for driving the motor in opposite directions are completed by a normally centered movable armature 9a of a polarized relay 9. It will be understood that the arrangement shown and described for controlling the motor 7 is given simply by way of example, since other arrangements may be employed.

The operation of the motor 7 is controlled in accordance with the direction of deflection of the electron beam in tube 1 by the following arrangement. Two diametrically opposite anodes 2 and 2a are connected together and are connected through a suitable resistance 10a to a lead 10 connected to the positive terminal of the anode supply source, while the remaining two anodes 3 and 3a are connected together and are connected to the positive anode lead 10 through a resistance 10b. A suitable indicating meter 11, preferably a center-zero voltmeter, is connected across the two anode leads 10a' and 10b' to indicate any potential difference between the two sets of anodes. The winding of polarized relay 9 is energized from anode leads 10a' and 10b' either by a direct connection or through a suitable amplifier 12.

A stationary scale 13 of arcuate form is arranged adjacent the periphery of the magnetic ring 4 and is calibrated in terms to indicate the ratio between the values of the current or voltage A and the current or voltage B. A pointer or indicator 14 is attached to the ring 4 and is arranged to cooperate with the scale 13.

A reversing switch 15 is included between the source A and the magnetizing windings 4a—4b while a similar switch 16 is inserted between the source B and the magnetizing windings 4c and 4d.

The operation of the arrangement shown in Figure 1 will be explained by reference to the diagram shown in Figure 2 which shows an enlarged view of the four segmental anodes of Figure 1. The windings 4a—4b establish a magnetic field along the axis X—X in Figure 2, and the axis of the field established by windings 4c—4d is indicated at Y—Y. It will be assumed that with no current flowing in the magnetizing

windings on ring 4, the electron beam is directed at the center of the anodes and either does not strike any anode or else strikes all four anodes equally. If currents A and B are of equal magnitude and have the polarities as shown in Figure 1, then windings 4a—4b will deflect the beam upwardly by a given amount and windings 4c and 4d will deflect the beam to the left by the same amount so that the beam will be deflected along the 45° axis indicated by the line 17. When the beam is positioned at any point on the line 17, it lies wholly within the space between anodes 2 and 3 or else energizes these two anodes equally and no potential difference develops across anode leads 10a' and 10b'. This condition indicates a 1:1 ratio of the currents as shown by the position of the pointer 14 in Figure 1.

Assume now that current A decreases to a value equal to one-half of current B. If the vector A' indicates the strength of the current A and the vector B' indicates the strength of the current B, then the electron beam will be deflected to the point 18a and will impinge upon the anode 3. This will cause a potential difference to develop tween anode leads 10a' and 10b' thereby causing an indication on meter 11 and also operating polarized relay 9 in a direction to rotate the ring 4 to the right or in a clockwise direction. This is indicated by the letter R applied to the anode 3 in Figure 2. The motor 7 drives the ring 4 to the right through an angle corresponding to the angle between the lines 17 and 18 in Figure 2, and this causes the electron beam to move through the same angle and to move into the space between the anodes 2 and 3 on the line 17 at which time the relay 9 will be de-energized to stop the motor 7. At this point, the pointer 14 will have moved over opposite the point on the scale 13 marked 0.5. It will be observed that whenever the electron beam is deflected to fall upon the line 18—18 in Figure 2, the ring 4 will be moved through a constant angle and will stop at the same point on the scale 13, regardless of how far the beam is positioned from the axis of the tube.

If the polarities of both sources A and B should be reversed from that shown in Figure 1, then the electron beam would be deflected to the point 18b for the current value shown in Figure 2, and the operation would be the same as described above, since anode 3a produces the same direction of rotation as anode 3.

If source A should have a polarity opposite from that indicated in Figure 1 while the polarity of B remains as shown, then the electron beam would be deflected to the point 18c instead of to the point 18a and the ring 4 would be rotated to the right, but instead of being rotated through an angle represented by the angle between the lines 17 and 18, it would be rotated through a larger angle shown by the angle between the lines 17 and 18'. This would cause the pointer 14 to move beyond the right end of scale 13, and in order to prevent this operation it is only necessary to operate the reversing switch 15 to the opposite position, and this will cause the beam to strike the point 18a.

If the polarity of source B should be opposite from that shown in Figure 1 while the source A remains as shown, then the beam would strike the point 18d on the line 18'—18', and the pointer 14 would be driven off of scale 13 in the same manner as described above for the point 18c. The pointer is brought back onto the scale simply by operating the reversing switch 16 to the opposite position, and the beam will then strike the point 18a.

If current A should have a value twice that of current B, then the electron beam will be deflected to some point on the line 19—19 in Figure 2 and would impinge upon either anode 2 or 2a. This will cause operation of the motor 7 to drive ring 4 so that the pointer 14 moves to the left, as shown by the marking "L" on the anodes 2 and 2a in Figure 2. This produces movement of the beam through an angle corresponding to the angle between lines 17 and 19 in Figure 2, and the movement of the ring 4 will stop as soon as the pointer 14 reaches the mark "2" on the scale 13, at which time the electron beam will be directed into the space between the anodes 2 and 3, assuming the polarities shown in Figure 1.

In the foregoing description it has been assumed that the sources A and B are direct current sources, but the instrument will operate to indicate the ratios of alternating current sources. This is possible by reason of the connections of the anodes so that deflection of the beam along any given line on opposite sides of the axis will produce the same direction of movement of the ring 4. It is necessary that the sources A and B should have the same phase relation.

In the case of operation by alternating current, the trace of the electron beam on the anodes will be a straight line passing through the axis of the tube and the difference of potential developed across the anode leads will be formed of a series of pulses of the same polarity, one for each alternation of the alternating current. It will be understood that the meter 11 and the polarized relay 9 will not respond to the individual pulses but will respond to the integrated effect of these pulses. When the beam oscillates along a line which traverses anodes 2 and 2a, relay 9 will be operated in one direction, and when the beam oscillates along a line which traverses anodes 3 and 3a the relay will be operated in the opposite direction.

It will be clear that the ring 4 may be adjusted manually to indicate the ratio values, and the correct position of the ring is indicated by a zero reading on the instrument 11.

The reversing switches 15 and 16 may be omitted by extending the scale 13 on the opposite side of the zero position to duplicate the ratio scale as shown at 13a in Figure 1. With this arrangement, the scale to the left of the zero position would indicate positive ratios, while the scale to the right would indicate negative ratios. A pair of stops 13b and 13c may be provided to prevent the pointer 14 from moving out of the range of the double scale.

In Figure 3 I have shown a modified arrangement in which the magnetic deflection system, which is not shown in Figure 3, remains stationary, while the cathode ray tube is rotated. In this arrangement elements corresponding to like elements in Figure 1 are indicated by the same reference numerals. In this arrangement, however, the cathode ray tube 1 is mounted for rotation about its axis, and the ring gear 5 is attached to the tube and is employed to rotate the tube by means of the worm gear 6. The arrangement for controlling the operation of the worm gear 6 is the same as that shown in Figure 1, except that the connections for controlling the motor 7 are arranged so that anodes 2 and 2a produce clockwise rotation of the tube while anodes 3 and 3a produce anti-clockwise rotation of the tube. Also, it will be observed that the graduation on scale 13 in Figure 3 is reversed from that of the scale in Figure 1.

The operation of Figure 3 may be readily under-

stood by reference to Figure 2, it being remembered that the anode elements rotate while the deflecting fields remain stationary. Assume that current A has a value half that of current B, and the beam is deflected to the point 18a in Figure 2, the tube 1 will be rotated in a counter-clockwise direction, and the pointer 14 will move to the left, until the space between anodes 2 and 3 moves into the path of the beam, and at this point the motor 7 will be stopped. The pointer 14 will stop opposite the graduation 0.5 on scale 13.

If the electron beam should be deflected to any point which strikes anodes 2 or 2a, the tube 1 will be rotated in a clockwise direction, and the pointer 14 will move to the right of the position shown in Figure 3 to indicate a ratio greater than unity.

If care is taken to apply the currents to the instrument with the proper polarity so that the beam is always deflected in the upper lefthand quadrant, only anodes 2 and 3 will be required and anodes 2a and 3a may be omitted or disconnected. Likewise, if the polarities are such as to produce a deflection of the beam into the lower righthand quadrant, then only anodes 2a and 3a need be employed. This applies to both Figures 1 and 3. Also, the electrostatic deflecting plates may be employed instead of the magnetic deflecting coils.

In Figure 4 I have shown a form of my invention using a cathode ray oscilloscope of usual construction. In this arrangement the cathode ray oscilloscope is not shown but is of usual construction and is provided with a fluorescent screen on the end of the tube envelope, it being understood that the oscilloscope is provided with two sets of deflecting means energized by the two sources of current to be compared and serving to deflect the beam in two directions at right angles to each other. The beam is normally directed along an axis passing through the center of the fluorescent screen. Instead of employing four segmental target anodes as in Figures 1 and 3, I use a different type of output element in the form of photocells which are positioned in front of the fluorescent screen and are energized by the light spot on the screen. These cells are mounted in separate compartments of a light-tight housing positioned in front of the fluorescent screen. As shown in Figure 4, the housing 20 is of cylindrical form and is provided with crossed partition walls 21 and 22 which divide the interior of the housing into four equal compartments containing four photoelectric cells 23, 24, 25 and 26, respectively. Figure 4 shows a view of the casing from the end which faces the fluorescent screen. This end is open, but the rear end is closed. Partitions 21 and 22 are provided to prevent more than one cell being energized at a time by the light spot on the screen.

The casing 20 is mounted for rotation about its axis which is positioned in line with the normal axis of the electron beam, and the casing is rotated in either direction by means of the worm gear 5 attached to the casing and is driven by the worm 6 from the motor 7. The gear 5 carries the pointer 14 which cooperates with the scale 13 as in Figures 1 and 3.

All of the cathode elements of the photocells of Figure 4 are grounded or connected together and connected to the negative terminal of a suitable source of current. The anodes of cells 23 and 24 are connected to the lead 10b' which supplies the meter 11 and the amplifier 12 as in Figure 1, while the anodes of cells 25 and 26 are connected to the lead 10a'. Operating current for

the photocells is supplied from lead 10 connected to the positive terminal of the source of current and through resistance elements 10a and 10b connected to leads 10a' and 10b', respectively. The motor which drives the worm 6 is controlled in the same manner as in Figure 1.

The operation of Figure 4 will be understood from the foregoing description of the operation of Figure 3. If the beam is deflected so that it forms a spot on the fluorescent screen in the quadrant covered by the compartment for cell 23, then this cell will be energized and will operate relay 9 to drive the gear 5 to the right until the partition 22 covers the spot on the screen and stops the motor. If the spot should occur in the quadrant covered by the compartment of cell 25, the motor will be energized in a direction to drive the gear 5 in a counterclockwise direction until the spot is covered by the partition 22 and stops the motor. It will thus be seen that the four areas of the screen which are covered by the four compartments of the casing 20, together with the four photoelectric cells, constitute four output elements which are energized by the electron beam and serve the same function as the four target anodes in Figure 3 to rotate the pointer 14 to the proper position. In Figure 4 all parts of the cathode ray tube or oscilloscope remain stationary, and only the cell housing is rotated by the motor. If desired, the cell housing may be mounted in a stationary position in front of the screen of the oscilloscope, and the oscilloscope may be mounted for rotation about the normal axis of the electron beam as in Figure 3.

In the appended claims whenever reference is made to "current" or "currents" it will be understood that such terms are to be given a generic meaning to include voltage or voltages.

I claim:

1. Apparatus for indicating the ratio of the magnitudes of two currents comprising, a cathode ray tube including means for producing an electron beam normally directed along a predetermined axis, a pair of co-planar target anodes separated by a gap centered on the normal axis of said beam, beam deflecting means including a pair of deflecting elements energized by one of said currents for deflecting said beam in one direction and a second pair of elements energized by the second current for deflecting said beam at right angles to said one direction a rotary member for producing relative rotation between said beam deflecting means and said target anodes about the normal axis of said beam, a reversible motor for rotating said rotary member, and means including circuit connections for energizing said motor for operation in one direction in response to deflection of said beam onto one of said anodes and for energizing the motor for operation in the opposite direction in response to deflection of the beam onto the other anode.

2. Apparatus according to claim 1 wherein said beam deflecting means is stationary and said beam deflecting means is mounted for rotation about the normal axis of said electron beam.

3. Apparatus according to claim 1 wherein said beam deflecting means is stationary and said cathode ray tube including the target anodes therein is mounted for rotation about the normal axis of said electron beam.

4. Apparatus for indicating the ratio of the magnitudes of two currents comprising, a cathode ray tube including means for producing an electron beam normally directed along a predetermined axis, beam deflecting means including a

pair of deflecting elements energized by one of said currents for deflecting said beam in one direction and a second pair of elements energized by the second current for deflecting said beam at right angles to said one direction, an output element arranged to be energized by deflection of said beam from its normal axis in one direction, a second output element arranged to be energized by deflection of said beam from its normal axis in direction at right angles to said one direction, a rotary member for producing relative rotation between said beam deflecting means and said output elements about the normal axis of said beam, a reversible motor for rotating said rotary member, and means including circuit connections for energizing said motor for operation in one direction in response to energization of one of said output elements and for operation of said motor in the opposite direction in response to energization of the other output element.

5. Apparatus according to claim 4 wherein said electrical elements comprise two co-planar target anodes positioned within said cathode ray tube.

6. Apparatus according to claim 4 wherein said cathode ray tube is provided with a fluorescent screen at the end thereof, and said output elements comprise a pair of photoelectric cells positioned in front of said screen to be energized by light from different parts of said screen and being mounted for rotation about the normal axis of said beam, and a light shield interposed between said cells.

7. In combination, a cathode ray tube including means for producing an electron beam normally directed along a predetermined axis and having a fluorescent screen at the end thereof, a housing positioned in front of said screen and containing a pair of photoelectric cells energized by light from different portions of said screen, a light shield interposed between said cells, a rotary member for producing relative rotation between said cathode ray tube and said housing about the normal axis of said beam, a reversible motor for driving said rotary member, and means including circuit connections for energizing said motor for one direction of operation in response to energization of one of said cells and for energizing the motor for the opposite direction of operation in response to energization of the other cell.

8. A combination according to claim 7 wherein said cathode ray tube is stationary and said housing is mounted for rotation about the normal axis of said electron beam.

9. In combination, a cathode ray tube including means for producing an electron beam normally directed along a predetermined axis, four co-planar anodes mounted within said tube in a common plane normal to the normal axis of said beam and being separated by two relatively narrow gaps crossing each other at the normal axis of said beam, an electric motor having two energizing circuits for driving said motor in opposite directions, means for energizing one of said circuits in response to deflection of said beam upon either anode of a pair of diametrically disposed anodes and means for energizing the other motor circuit in response to deflection of said beam upon either anode of the other pair of diametrically disposed anodes.

10. In combination, a cathode ray tube including means for producing an electron beam normally directed along a predetermined axis, four beam responsive elements positioned in a common plane normal to the normal axis of said beam and being arranged about the normal axis of said beam in pairs of diametrically disposed elements, an electric motor having two energizing circuits for operating said motor in opposite directions, means for energizing one of said circuits in response to energization of either element of one pair of diametrically disposed beam responsive elements, and means for energizing the second motor circuit in response to energization of either element of the second pair of diametrically disposed beam responsive elements.

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Certificate of Correction

Patent No. 2,507,781 May 16, 1950

PAUL GLASS

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows:

Column 6, line 51, after the word "direction" insert a comma; line 63, strike out "beam deflecting means is" and insert instead *cathode ray tube and the target anodes are*; column 7, line 22, for "electrical" read *output*;

and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 1st day of August, A. D. 1950.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.

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