ELECTRON-OPTICAL DISCHARGE SYSTEM

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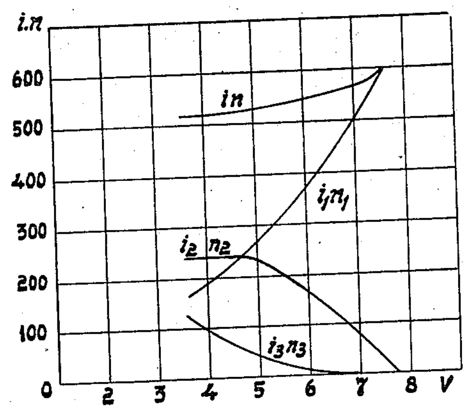

Fig. 1.

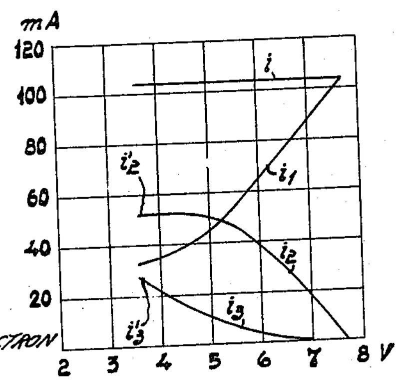

Fig. 2.

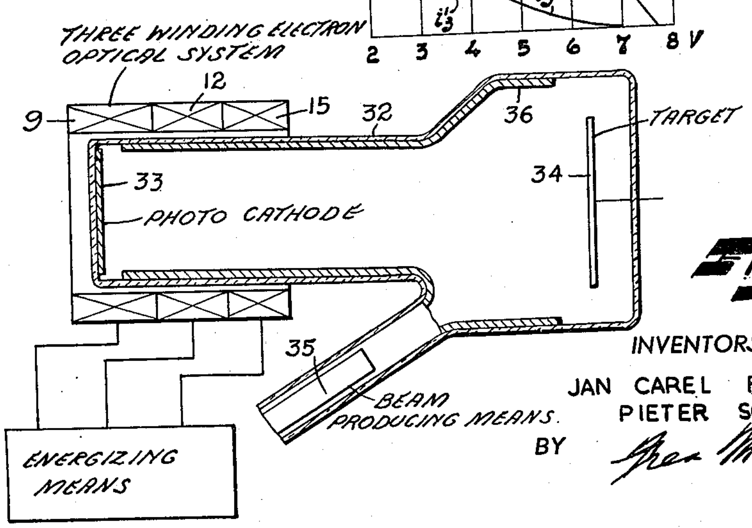

Fig. 5.

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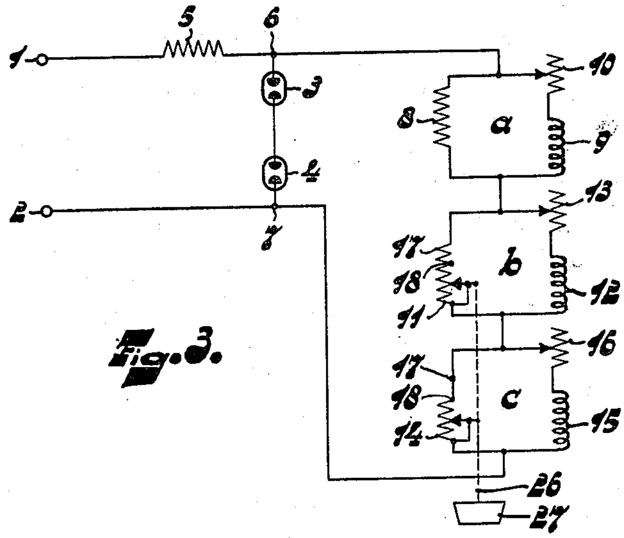

Fig. 3.

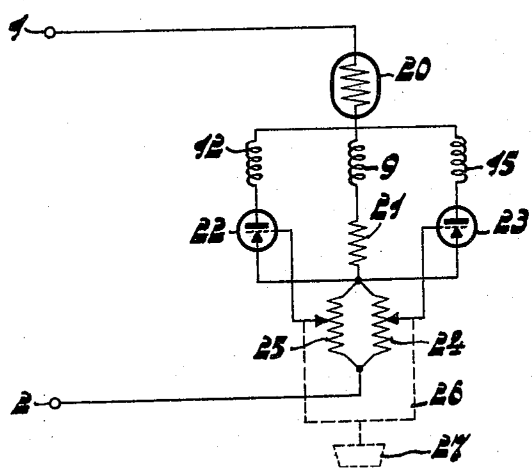

Fig. 4.

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ELECTRON-OPTICAL DISCHARGE SYSTEM

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8 Claims. (Cl. 315—10)

This invention relates to electron-optical discharge systems, and more particularly, to a circuit arrangement for controlling the magnification of an image therein.

The use of an electron-optical system for a discharge tube, for example, the luminoscope, the image intensifier or the television camera tube, comprising an electromagnetic electron lens which consists of three magnetic coils surrounding the tube has been proposed, in which system each of the coils serve a different purpose. The coil closest to the cathode of the tube usually varies the magnification of the device; however, the image on the screen becomes defocussed due to variation in the field strength within the tube. Moreover, a second phenomena occurs known as image rotation, which always occurs in the case of magnified image reproduction.

By providing a second magnetic coil, the energization of the two separate coils may be controlled so that the image remains sharp, if the rate of magnification is changed. In addition, image rotation may be kept constant, in the case of a variable magnification, by adding a third coil, the field of which contributes to the formation of the lens field. The three windings together produce magnetic fields which differ in shape and strength, but which combine to produce sharp reproductions of the image on the photo-electric cathode on the image screen.

The winding nearest the photo-electric cathode preferably has a position such that the field strength at the photo-cathode is substantially at its maximum. If only this winding is energized, a short magnetic field is produced and the maximum magnification is obtained. The second winding may be arranged adjacent the first and when it is energized, the divergence of the magnetic field must decrease in order to obtain a smaller image. In order to maintain a sharp image, the current passing through the first winding must be reduced. The reduction of field strength at the area of the photo-cathode and the elongation of the field both have the effect of a smaller magnification. Consequently, the magnification may be decreased by raising the current passing through the second winding and by reducing the current passing through the first winding.

The image rotation is found to be at its minimum, if the first winding is only energized and the magnification is at its maximum. The smaller the magnification, the greater the image rotation. The variation in the image rotation may be neutralized by extending the magnetic field to a certain extent in the direction of the image screen. For this purpose a third winding may be provided between the two aforesaid windings and the image screen. The field of this winding must primarily be operative in the area free from electric fields. It compensates for the variation in the image rotation without seriously affecting the magnification and the sharpness of the image, since the winding, which is remote from the cathode, exerts little influence on the field in the proximity of the cathode.

The main object of the invention is to provide a simple

arrangement for continuously varying the magnification of the image while retaining a sharp image and minimizing any image rotation. According to the invention, it has been found that a simple arrangement for continuously varying the magnification of the image in an electron-optical image system comprising three coil windings can be provided by maintaining substantially constant the sum of the energizing currents passing through the three coil windings throughout the desired control range of the system.

The invention will now be described in greater detail with reference to the accompanying drawing in which:

Figs. 1 and 2 show, respectively, the variation of ampere-turns and current with magnification of a three winding electron-optical system;

Figs. 3 and 4 are circuit diagrams of two arrangements in accordance with the invention for maintaining a substantially constant sum of all three energizing currents;

Fig. 5 shows one form of construction in which the invention may be employed.

With a definite geometrical arrangement of the energizing windings, the number of required ampere-turns for each specific magnification is determined. The currents required, however, will be determined by the choice of the number of turns for each winding. The required ampere-turns for the various windings may be designated by $A_1(V)$, $A_2(V)$ and $A_3(V)$, respectively. Each of them is a function of the magnification V and may be plotted in a graph, as shown in Fig. 1. In addition to the required number of ampere-turns for each separate winding, the variation of the total number of ampere-turns, required for continuously controllable magnification and constant image rotation and sharpness is also indicated in Fig. 1.

If the three coils have n_1, n_2 and n_3 turns, respectively, the sum of the currents through the three coils is:

$$i=\frac{A_1(V)}{n_1}+\frac{A_2(V)}{n_2}+\frac{A_3(V)}{n_3} \qquad \text{(I)}$$

In general, i will also be a function of V. The values of n_1, n_2 and n_3 may now be chosen such that i is constant for all values of V in the desired control range in accordance with the invention in the following manner. By choosing n_1, the value i_1 is determined at maximum magnification, and hence also i, since in this case i_2 and i_3 are zero (see Fig. 1). The value of n_2 follows from Fig. 1 for another value of the magnification at which the third is not energized ($i_3=0$). Finally, the value of n_3 may be determined at a magnification at which all three windings are energized. In Fig. 2, i_1, i_2, i_3 and i are indicated as functions of V. It is found that between V=3.75 and V=7.75, i is constant with a tolerance of about 1% and the objects of the invention are attained.

Figs. 3 and 4 show circuit-arrangements which may be used in a device according to the invention and which carry out the foregoing method. Referring to Fig. 3, to the terminals **1** and **2** of a direct-current source (not shown) are connected two stabilizing tubes **3** and **4**, e. g. glow discharge tubes, which, in cooperation with the resistor **5**, maintain the voltage between two connecting terminals **6** and **7** constant. The voltage at these points is supplied to the series combination of three systems *a*, *b* and *c*. The system *a* comprises a resistor **8**, with which a first winding **9** connected in series with an adjusting resistor **10** is connected in parallel. The winding **9** usually surrounds the photo-electric cathode of the device.

The system *b* comprises a potentiometer **11**, with which a second winding **12** in series with an adjusting resistor **13** is connected in parallel; this winding **12** serves to control the magnification.

The system *c*, which is constructed in a similar manner to that of *b*, comprises a potentiometer **14**, with which a third winding **15** is connected in parallel; this winding serves mainly for correcting the image rotation. With this winding **15** is also connected in series an adjusting resistor **16**.

It is evident from Fig. 2 that at the maximum magnification the current passing through the second and third windings **12** and **15** is zero. The current strength in the winding **9** may then be adjusted with the aid of the adjusting resistor **10** to the correct value, which may be derived from Fig. 2. Moreover, the resistors of the winding-included branches of the systems *b* and *c* are adjusted with the aid of the resistors **13** and **16** to the same value R as that of the winding-included branch of the system *a*. Consequently, $i_1R+i_2R+i_3R=iR=v$. The voltage v is kept constant, and hence i is also constant.

In the control-range between point **17** and **18** of the potentiometer **11**, the current through the winding **15** remains adjusted to zero value. In this range no correction of the image rotation is required. The current through the winding **12** increases and the current through the winding **9** decreases to the same extent, so that their sum remains constant.

In the further control-range, provisions must be made so that the sum of the currents through the windings **12** and **15** is equal to the difference between the constant i and the current i_1 required for energizing the winding **9**. At the beginning of the control-range of the current through the winding **15**, the resistance of the potentiometer is still very low, and at the end of the control-range the resistance of the potentiometer branch must have a value at which a current i_3' (see Fig. 2) passes through the winding **15**, whereas the current through the winding **12** corresponds to a value i_2'. For the adjustment of the intermediate values of i_3, a linear resistance distribution may be used. Consequently, only the potentiometer **11** need have a special resistance variation, the value of each adjustment being found when the sum of the currents through the windings **12** and **15** have the required value, and therefore, instead of three control-resistors, only two are required, one of which may, moreover, be a linear resistor. If a slightly less accurate control than in the case of complete adaptation of the third potentiometer to the theoretically correct resistance distribution suffices, the third resistor may be composed of a number of linear parts, thereby yielding a material simplification.

Referring to Fig. 4, which shows a further modification according to the invention, the windings **9**, **12** and **15** are connected in parallel and in series with a current control-switch **20** to the terminals **1** and **2** of a current source. The current control-switch **20** is such that it keeps the current at a constant value; for this purpose use may be made, for example, of an iron wire resistor in a gaseous atmosphere.

By the choice of n_1 the current i is determined as explained beforehand. For reasons to be explained hereinafter, it is desirable to provide a value of the resistance of the current branch of the circuit including the winding **9** such that the voltage thereacross is at least 100 v. at the lowest current. For this purpose, the resistor **21** may be connected in series with the winding **9**.

A discharge tube **22** comprising a control-grid serves to control the current strength through the winding **12**, since it is not quite possible to cause the current to increase regularly from zero with the aid of a series resistor. For this purpose a discharge tube is very suitable and if, moreover, use is made of a pentode tube, the control of the current is substantially independent of the voltage, if the latter does not drop below a minimum value of, for example, 100 v.

The current across the winding **15** must be controllable from zero; for this purpose use is also made of a discharge tube **23** comprising a control-grid. The control-voltages for the tubes **22**, **23** are derived from a pair of potentiometers **24** and **25**, which are included in series with the windings in the current supply leads on the cathode side of the discharge tubes **22**, **23**.

After the choice of the number of turns for each winding is made as described above, the current strength associated with a number of values of the magnification are determined, as well as the adjustments of the potentiometers at which these current strengths are obtained. As in the device shown in Fig. 3, one of the potentiometers may be a linear resistor and the other may be of particular construction such that each adjustment is associated with a resistance value which controls the current through the associated winding to the difference between the total current and the sum of the currents through the two other windings, in accordance with the prescribed value and the invention.

The broken connecting line **26** in Figs. 3 and 4 indicates that the sliding contacts of the resistors **11** and **14** and **24** and **25**, respectively, are displaced simultaneously with the aid of a common control-knob **27**.

Fig. 5 shows a cross-sectional view of an image iconoscope type of television camera tube to illustrate the general combination of the invention. The camera tube comprises an envelope **32** containing a photocathode **33** at one end and a target electrode **34** at the other end. Electron beam producing means **35** are located in a side branch of the envelope **32** for scanning the target electrode **34**. The image to be televised is optically projected onto the photcathode **33** producing a corresponding electron image, which is then electron-optically projected onto the target **34**. The latter is accomplished by a three winding system employing a first winding **9** surrounding the photocathode and a second winding **12**, which latter windings serve to control the magnification. A third winding **15** serves mainly to control the image rotation. A conductive layer **36** is also present in the tube to establish an electric field at the photocathode **33**. The energizing means shown schematically represents the circuits illustrated in Figs. 3 and 4.

While we have described our invention in connection with specific embodiments and applications, other modifications thereof will be readily apparent to those skilled in this art without departing from the spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. In combination, a discharge device, an electron-optical system associated with said discharge device including three coil windings, and means for energizing said windings; said energizing means comprising a source of current, and means to vary the current passing through at least one of said windings and to simultaneously maintain substantially constant the sum of the currents passing through said three windings throughout a given range of adjustment.

2. In combination, a discharge device including a photo-cathode, an electron-optical system associated with said discharge device and comprising three successively-arranged coil windings surrounding said device, and means for energizing said windings; said energizing means comprising a source of current, means for concurrently varying the current passing through at least two of said windings to change the magnification of the electron-optical system over a predetermined range, and means for maintaining substantially constant the total current passing through all three windings throughout said predetermined range to maintain a focussed image and minimize any image rotation.

3. The combination set forth in claim 2, wherein said last-named means includes constant current control means arranged in series with the three windings.

4. The combination set forth in claim 2, wherein a fixed resistor is associated with one of the windings, and mechanically-coupled variable resistors are associated each with one of the other two windings.

5. A circuit-arrangement for energizing an electro-magnetic-lens system comprising three coil windings for

an electron-optical discharge system, comprising a source of current having a substantially constant voltage, said three windings being connected in series with said source, a resistor connected in parallel with one of said windings, a pair of potentiometers each connected in parallel with one of the other two windings, and means to concurrently vary the resistance of said potentiometers and to simultaneously maintain the sum of the currents passing through said three windings substantially constant throughout a given range of adjustment.

6. A circuit arrangement as claimed in claim 5, in which at least one of the potentiometers is a linear resistor.

7. A circuit-arrangement for energizing an electromagnetic-lens system comprising three coil windings for an electron-optical discharge system, comprising a source of substantially constant current, said three windings being connected in parallel with said source, a pair of variable resistive elements each connected in series with one of said windings, and means to concurrently vary the resistance of said variable resistive elements and to simultaneously maintain the sum of the currents passing

through said three windings substantially constant throughout a given range of adjustment.

8. A circuit-arrangement as claimed in claim 7, in which the variable resistive elements are constituted by electric discharge tubes comprising a control grid, and a pair of potentiometers are provided in series with the parallel-interconnected windings, the control voltages for said control grids of said electric discharge tubes being derived from said potentiometers.

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