Dec. 31, 1940. K. SCHLESINGER 2,227,036

ELECTROSTATIC WIDE-ANGLE DEFLECTION

Filed July 23, 1938 3 Sheets-Sheet 1

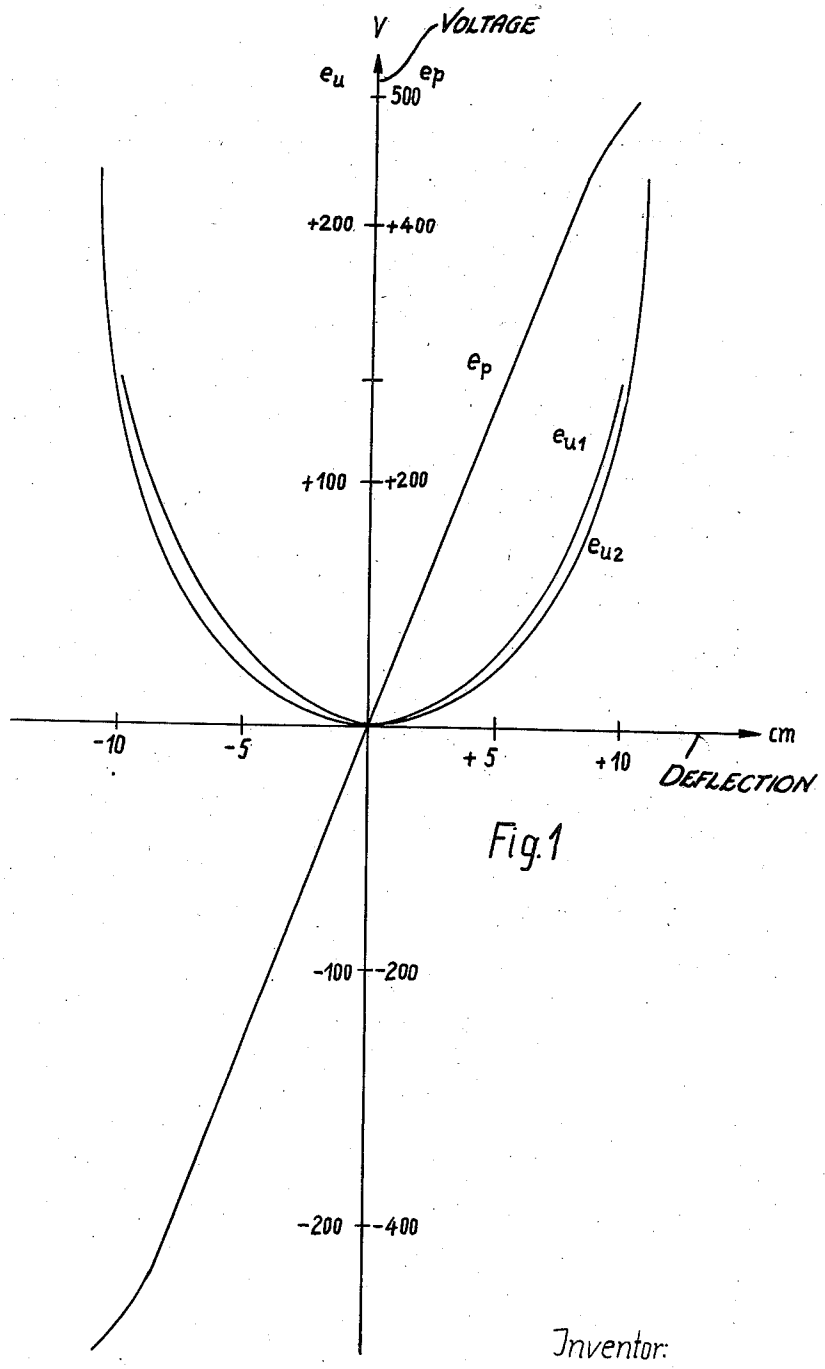


Fig.1

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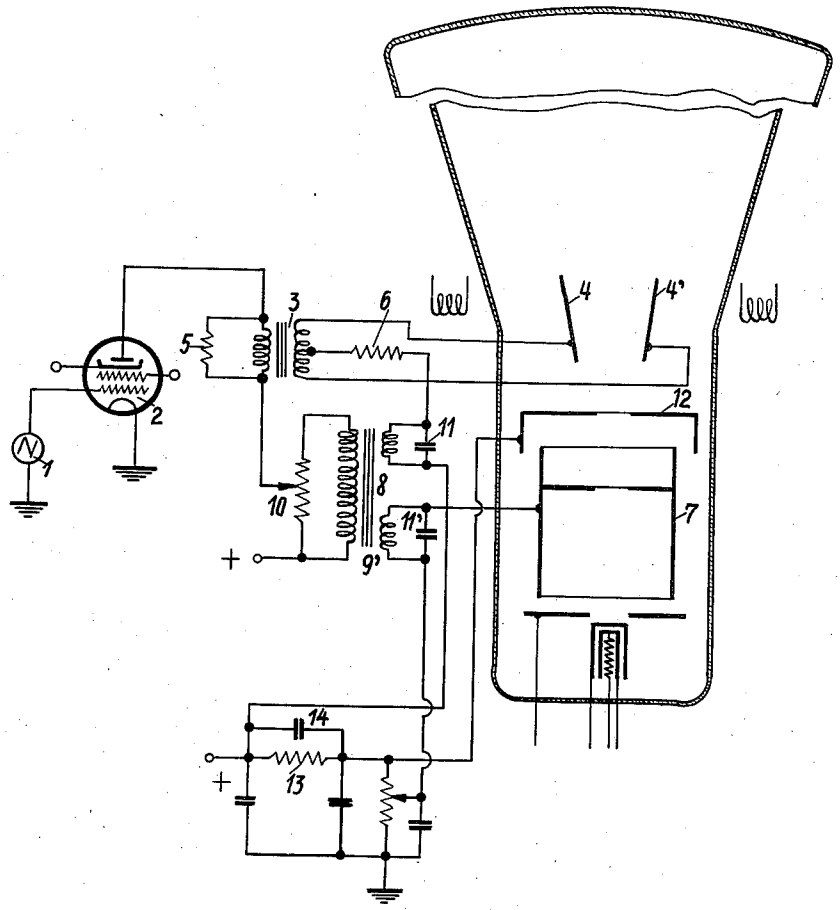


Fig.2

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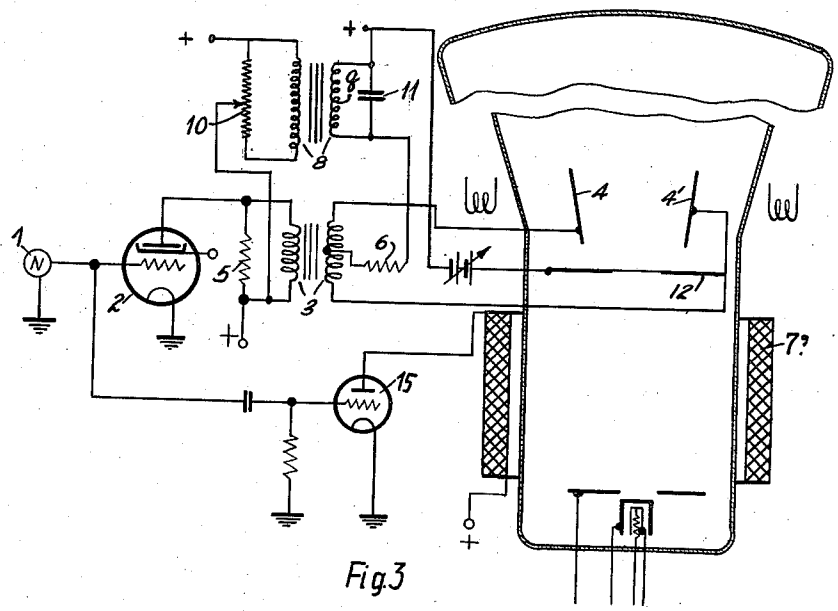


Fig.3

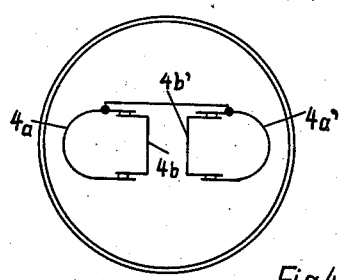
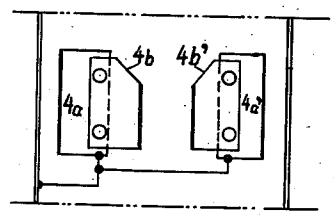


Fig.4



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2,227,036

UNITED STATES PATENT OFFICE

2,227,036

ELECTROSTATIC WIDE-ANGLE DEFLECTION

Kurt Schlesinger, Berlin, Germany, assignor, by mesne assignments, to Loewe Radio, Inc., a corporation of New York

Application July 23, 1938, Serial No. 220,878
In Germany October 20, 1937

11 Claims. (Cl. 250—27)

In the application Ser. No. 203,487 it is pointed out that the lack of marginal sharpness occurring in the electrostatic deflection of bundles of cathode rays can be reduced by applying positive auxiliary potentials, which increase rapidly with increasing angle of deflection, between the anode and the centre point of the plate circuit and to the lens of the television tube. The two potentials will be referred to as auxiliary plate and auxiliary lens potentials. More recent investigations by the applicant has shown that a really perfect sharpness at the edge whilst maintaining in full the quality of the image point at the centre is only possible if the two auxiliary potentials are employed simultaneously. In this way a cathode ray tube is obtained having oscillatory lens and an electrostatic deflection system. The simultaneous use of two pairs of plates is also possible, but leads to considerable complications in deriving the lens-correcting potential, which then requires to be controlled in two co-ordinates simultaneously.

Static measurements of the course of the correcting potential dependent on the extent of movement have shown that both of the correcting auxiliary potentials depend on the square of deflection of the cathode ray beam. Generally speaking the extent of the correcting amplitudes varies for lens and plates. In the case of tubes with magnetic electron lenses the potential correction of the plates must in any case be converted by a tube into a current correction for the lens magnet.

The invention will be better understood with the aid of, and the essential features of the invention will be apparent from the following more detailed description and the accompanying drawings of which

Fig. 1 is a diagram showing potential curves,

Fig. 2 illustrates the connections of a television tube with electrostatic and

Fig. 3 illustrates the connections of a tube with electromagnetic ray focusing, while

Fig. 4 shows in two views a special construction of the electrostatic deflecting means.

In Fig. 1 there is shown the connection between deflection, deflection potential and auxiliary potential, as measured for a representative cathode ray tube and system. The deflection a is the abscissa, e_p the deflection potential, e_{u1} the plate aid, and e_{u2} the auxiliary lens potential.

It has already been set forth on a previous occasion that a parabolic auxiliary potential of this kind can be produced without special tubes by a single integration of the sawtooth potential of the deflection circuit. This integration can be performed by charging condensers, but it can also be obtained by exciting transformers by way of sufficiently large series resistances with a constant sawtooth current and loading the same on the secondary side by condensers.

In Fig. 2 there is shown a typical connection system, in which use is made of the invention in the case of combined plate and lens aid. The sawtooth potential 1 excites a screen grid tube 2 (pentode). In the anode circuit of the pentode there is provided in the first place a relaxation transformer 3, which operates the two plates 4, 4' of the television tube in pushpull. In order that the transformer will apply an undistorted sawtooth potential to the plates, there must be provided in parallel primary connection a resistance 5, which has a lower resistance value than the primary impedance of 3. Secondary, the secondary winding of the relaxation transformer 3 must have a shorter natural period of oscillation than the desired relaxation return. Thirdly, there must be provided in the connection between the centre of the secondary winding and ground, a resistance 6, the impedance of which is greater than that of the dispersion and building-up capacities to earth. Otherwise the secondary winding may commence to oscillate in natural oscillation. To produce the auxiliary potentials supplied simultaneously to the lens 7 and the centre of the plates in accordance with the invention there is provided a second transformer 8. Actually, in principle, two transformers 8 of this kind having independent iron cores must be connected in series, the one serving to produce the plate auxiliary potential and the other the lens. It has been found, however, that it is possible and even desirable to produce the two auxiliary potentials simultaneously by means of the one transformer and two secondary windings 9 and 9' tightly coupled with the primary winding and with each other. The operation of the auxiliary potential transformer 8 is fundamentally different to that of the relaxation transformer 3. Whereas the relaxation transformer 3 is in parallel with a low-resistance input 5, i. e. operates under no-load conditions, the auxiliary potential transformer 8 is required to operate in short-circuit. For this purpose there is provided on the primary side a potentiometer 10, the total resistance of which is always greater than the impedance of the primary winding.

The theoretical explanation for this condition is as follows:

There is to be produced a curve having the form of kt^2 (parabola) from one having the form of kt (sawtooth). Obviously, therefore, the desired curve is the integral of the sawtooth curve. According to the invention there can be employed for this purpose two transformers, which in the first place are capacitatively shunted on the secondary side, and secondly, are excited with constant current on the primary side (short-circuit condition). The short-circuiting of an inductive secondary circuit by a condenser, the impedance of which is smaller than the impedance of the secondary winding, i. e. the series connection of condenser and self-induction, results, with respect to the potential at the condenser, in the integral of the secondary current. The latter, however, is the integral of the secondary transformer potential. The terminal potential at the loading condenser is accordingly the double-integral of the transformer secondary potential. As well known, however, secondary and primary terminal potentials of a transformer under no-load conditions are proportional to one another (transformation ratio). In consequence the potential at the load condensers 11 and 11' is the double-integral of the primary terminal potential. It must accordingly be sought to make the primary terminal potential equal to the differential curve of a sawtooth. This is obviously accomplished when an undistorted sawtooth current is passed through a winding acting as inductance, as in this case there is produced as primary terminal potential the potential

$$L\frac{di}{dt}$$

and this is obviously the differential curve of a sawtooth. The double integration on the secondary side is then accordingly equivalent to the single integration of a sawtooth $i\ (t)$, such as present in the anode circuit of the pentode 2 in Fig. 2. Under these conditions there accordingly appears at the secondary condensers 11 and 11' a parabolic auxiliary potential, so long as the primary circuit is traversed by an undistorted current sawtooth and so long as the resistance of 10 is greater than the resistance of 8 on the primary side.

Owing to the not infinitely short return period of the relaxation oscillations being finite and not zero, departures occur from this simple theory. It has found that the phase shift of the peak of the parabola in Fig. 1 made necessary on account of the finite return period can best be produced by not making the two circuits 9, 9' exactly equal, such as would appear necessary in itself, but by selecting the loading condensers 11 and 11' to be different. In themselves two windings tightly coupled together and with a common primary winding are equivalent to one single winding, the loads of the two part-windings being connected in parallel with each other. This, however, applies only when the conditions of operation of the two windings, including also the loads, i. e. the currents therein, have the same form and the same phase. For example a winding 9 having 1,800 turns with a condenser 11 of 1,000 micro-microfarads supplies exactly the same potential as a winding 9 having 900 turns with a condenser of 500 micro-microfarads together with a second similar winding 9', 11', which then also supplies the same potential. It is accordingly possible in the first place to connect these two part-windings in the two part-current circuits of an electrostatic lens 7 and between the anode 12 and the centre 6 of the plates, and the auxiliary potential amplitude can be brought to the proper value on the primary side with the potentiometer 10 by the particular connection as shown (constant primary impedance), or better still on the secondary side by an equal and simultaneous variation of the two integration condensers 11 and 11'. There is then obtained a considerable improvement in the sharpness of the edge, in which connection, by means of a positive auxiliary potential preferably produced by the power supply apparatus at the resistance 13, filtered by the condenser 14, the direct potential value carried by the anode parabola—equal to a third of the maximum amplitude of the auxiliary potential—requires to be replaced in inversely equivalent fashion.

Owing, however, to the stated influence of the relaxation return time it is necessary in accordance with the invention to adjust a de-tuning between the two circuits 11 and 11'. It is immaterial whether 11' or 11 is made to be greater. The adjustment of the de-tuning preferably occurs during an image transmission or during a test period supplied with signals by a synchronised point-impulse generator. It has been found, for example, that a doubling of the condenser 11 in relation to 11' brings about an optimum of marginal correction (11=1,000 micro-micro-farads, 11'=500 micro-microfarads). These values are naturally of a relative kind; they depend on the number of lines per frame of the picture and on the no-load potential of the transformer, i. e. on the extent to which the transformer can be choked with respect to potential by the condenser until it provides the proper correcting potential. It provides the parabolic form immediately, as stated, when the conductive value of the condenser with respect to the basic relaxation oscillation is greater than the conductive value of its secondary winding.

The effect of the de-tuning of the two circuits, as can be recognized from the double-ray oscillograph, is equivalent to a timed displacement of the initiation phase of the secondary potential, taken in relation to the initiation of the primary potential or of the synchronisation signal. This is exactly the requirement resulting from the return effect.

Naturally the principle of combining oscillatory lens and oscillatory plate can also be applied to television tubes having magnetic lenses. The correcting circuits are, upon the excitation of the coil lens, different to Fig. 2 for the excitation of the electric field lens. In a tube having a magnetic lens, the sawtooth can be applied in undistorted fashion to a correcting tube 15, so long as the impedance of the field lens in the anode circuit of this tube is greater than the inner resistance of the correcting tube, as in this connection system the current in the field lens is already the integral of the grid potential.

Fig. 3 shows a cathode ray tube together with an alternative means of supplying the correcting potentials. In Fig. 3 the plate current flowing to the tube 2 through the potentiometer 10 sets up a potential which is transferred from the primary winding of the transformer 8 to the secondary winding 9; the secondary winding is shunted by a condenser 11. Induced voltage, therefore, is supplied in series with the potentials supplied by the terminals marked plus and connected to the condenser 11 and to the elec-

trode 12. The pushpull deflection is supplied through the transformer 8. The lens coil is 7'. The adaptation tube 15, so long as the lens coil 7' represents a very large external resistance in respect thereof, can be directly coupled with the undistorted relaxation potential circuit 1. In this connection the tube 15 should preferably be a triode. If on the other hand a pentode is used, a special integration requires to be performed by means of parallel condensers or series coils, as described in the above.

The numerical constants of the circuits can quite readily be calculated by those skilled in the art, bearing in mind the necessary condition that the lens field should have a focal distance increasing in quadratic proportion to the deflection to the right and left of the centre of the image, i. e. a decreasing refractive power, and that at the same time there is to be imparted to the plates with increasing deflection a similar positive aid. In this connection it is immaterial from the point of view of the invention whether the lens field is produced by a magnet coil or by an electric field lens.

The practical tests of the invention had shown that a plate deflection made sharp at the edges by the method described can be combined without interference with a magnetic deflection effectively vertical thereto. It is accordingly possible to place an outer deflecting magnet over a condenser deflection system corrected in the manner described, in such a manner that the magnetic field traverses the tube parallel to and coinciding with the electric field. The vertical deflection of the cathode ray thereby brought about does not interfere with the deflection qualities of the electric component produced. The combination is particularly useful when the electric system assumes the rapid line deflection and the magnetic system the slow image deflection. In this way the advantages of both systems are combined, and the disadvantages, which consist in the case of a rapid magnetic deflection in a considerable consumption of power, are avoided. A further advantage resides in the simultaneous deflection of both co-ordinates at the same location, and the consequent remarkable shortness of the combined deflecting element in the direction of the ray. It is advisable in this case to produce more particularly the deflecting plates from iron. A plate constructed in accordance with Fig. 4 has been found particularly suitable. It consists of two parts 4a, 4b riveted one to the other in insulated fashion, wherein the poles 4a, 4a' are connected together and with the anode and do not produce deflection of the beam. On the other hand the plate portions 4b, 4b' are connected with the deflecting potentials. The two parts are riveted together in insulated fashion. If they are both produced from iron and if the backs of the parts 4a are in close proximity to the glass wall of the tube, the magnetic field has a lower effective air-path external to the ray space, because of the iron of the plates, and the sensitivity of the magnetic deflection is three times greater. The sharpness of the edge of the magnetic deflection is also considerably improved in a deflection of this nature, as the density of the field is very homogeneous and the air gap is relatively short.

I claim:

1. In a television apparatus comprising a cathode ray tube, containing means for producing a cathode ray, combined with an electron lens for focusing said cathode ray, at least one pair of electrostatic deflecting plates, and a screen, and means for supplying said deflecting plates with symmetrical deflecting voltages: in combination means for automatically altering the refractive force of said electron lens in rhythm with the deflection of said cathode ray beam, and means for superposing on the voltages of said deflecting plates a correcting potential varying in rhythm with the deflection of said cathode ray beam.

2. In a television apparatus comprising a cathode ray tube, containing means for producing a cathode ray, combined with an electrostatic electron lens for focusing said cathode ray, at least one pair of electrostatic deflecting plates, and a screen, and means for supplying said deflecting plates with symmetrical deflecting voltages: in combination means for superposing on the potential of one of the electrodes of said electron lens a correcting potential varying in rhythm with the deflection of said cathode ray beam, and means for superposing on the voltages of said deflecting plates a correcting potential varying in rhythm with the deflection of said cathode ray beam.

3. In a television apparatus comprising a cathode ray tube, containing means for producing a cathode ray, combined with an electrostatic electron lens having a plurality of electrodes for focusing said cathode ray, at least one pair of electrostatic deflecting plates, and a screen, means for supplying the electrodes of said electron lens with constant potentials, said potentials being so adjusted that said cathode ray beam is sharply focused upon the centre of said screen, and means for supplying said deflecting plates with symmetrical deflecting voltages of saw-tooth wave form: in combination means for superposing on the constant potential of one of the electrodes of said electron lens a correcting potential substantially proportional to the integral of said deflecting voltages, and means for superposing to the voltages of said deflecting plates a correcting potential substantially proportional to the integral of said deflecting voltages.

4. In a television apparatus comprising a cathode ray tube, containing means for producing a cathode ray, combined with an electromagnetic electron lens for focusing said cathode ray, at least one pair of electrostatic deflecting plates, and a screen, and means for supplying said deflecting plates with symmetrical deflecting voltages: in combination means for superposing on the current through the magnet coil of said electron lens a correcting current varying in rhythm with the deflection of said cathode ray beam, and means for superposing on the voltages of said deflecting plates a correcting potential varying in rhythm with the deflection of said cathode ray beam.

5. In a television apparatus comprising a cathode ray tube, containing means for producing a cathode ray, combined with an electromagnetic electron lens for focusing said cathode ray, at least one pair of electrostatic deflecting plates, and a screen, means for feeding the magnet coil of said electron lens with a constant current, said constant current being so adjusted that said cathode ray beam is sharply focused upon the centre of said screen, and means for supplying said deflecting plates with symmetrical deflecting voltages of saw-tooth wave form: in combination means for superposing on the constant current of said magnet coil a correcting current substantially proportional to the integral of said deflecting voltages, and means for superposing on

the voltages of said deflecting plates a correcting potential substantially proportional to the integral of said deflecting voltages.

6. In a television apparatus comprising a cathode ray tube, containing means for producing a cathode ray including an anode, combined with an electron lens for focusing said cathode ray, at least one pair of electrostatic deflecting plates, and a screen, and means for supplying said deflecting plates with symmetrical deflecting voltages of saw-tooth wave form: in combination means for automatically altering the refractive force of said electron lens in rhythm with the deflecting of said cathode ray beam, and further means for superposing on the voltages of said deflecting plates a correcting potential varying in rhythm with the deflection of said cathode ray beam, said further means comprising a transformer, the primary winding of which is connected in parallel with a resistance greater than the impedance of said primary winding and is fed with a current of saw-tooth wave form by a variable tapping of said resistance, the secondary winding of which is connected in parallel with a condenser and connected between the anode of said tube and the middle of the secondary winding of a relaxation transformer.

7. In a television apparatus comprising a cathode ray tube, containing means for producing a cathode ray including an anode, combined with an electrostatic electron lens comprising a plurality of electrodes for focusing said cathode ray, at least one pair of electrostatic deflecting plates, and a screen, means for supplying the electrodes of said electron lens with constant potentials, said potentials being so adjusted that said cathode ray beam is sharply focused upon the centre of said screen, and means for supplying said deflecting plates with symmetrical deflecting voltages of saw-tooth wave form: in combination means for superposing on the constant potential of one of the electrodes of said electron lens a correcting potential substantially proportional to the integral of said deflecting voltages, and means for superposing on the voltages of said deflecting plates a correcting potential substantially proportional to the integral of said deflecting voltages, said means for superposing correcting potentials comprising a transformer the primary winding of which is connected in parallel with a resistance greater than the impedance of said primary winding and is fed with a current of saw-tooth wave form by a variable tapping of said resistance, said transformer having two secondary windings each connected in parallel with a condenser, the one of said secondary windings being connected between the middle of the secondary winding of a relaxation transformer and the anode of said tube, the other winding being connected between one of the electrodes of said electron lens and a source of constant potential.

8. In a television apparatus comprising a cathode ray tube, containing means for producing a cathode ray, combined with an electromagnetic electron lens for focusing said cathode ray, at least one pair of electrostatic deflecting plates, and a screen, means for feeding the magnet coil of said electron lens with a constant current, said constant current being so adjusted that said cathode ray beam is sharply focused upon the centre of said screen, and means for supplying said deflecting plates with symmetrical deflecting voltages of saw-tooth wave form: in combination means for superposing on the constant current of said magnet coil a correcting current substantially proportional to the integral of said deflecting voltages, and means for superposing on the voltages of said deflecting plates a correcting potential substantially proportional to the integral of said deflecting voltages, said means for superposing a correcting current comprising a triode, the grid of which is supplied with relaxation potentials of saw-tooth wave form, said magnet coil being connected between the anode of said triode and a source of potential and having an impedance greater than the resistance of said triode.

9. In a cathode ray tube system, a cathode ray tube comprising an envelope having within the envelope means for forming a focused beam of electrons and beam deflecting electrodes, a source of sawtooth wave energy, means to produce from said wave energy energy representative of the time integral of said energy, a source of substantially constant voltage for actuating said beam forming means, means to supply said deflecting electrodes with sawtooth wave energy and a predetermined portion of said produced energy, and means to supply said beam forming means with said constant voltage and a second predetermined portion of said produced energy.

10. A cathode ray tube system comprising a cathode ray tube having an envelope wherein is contained a source of electrons, a control electrode, a first and a second focusing electrode positioned in register with said electron source and said control electrode, means to supply said first electrode with a predetermined positive voltage, means to supply said second electrode with a positive voltage having a different value than the predetermined value of said first named voltage to develop an electron beam, a target means upon which the developed beam is adapted to impinge, a pair of deflecting plates positioned intermediate said second electrode and the target, a source of sawtooth wave energy, an electron discharge amplifier having an input circuit and an output circuit, means to supply sawtooth wave energy from said source to the input circuit of said amplifier, a first and a second transformer, each of said transformers having at least one primary winding and one secondary winding, a connection from the output circuit of said amplifier to the primary windings of said first and second transformers, connections from the secondary of said first transformer to said deflecting electrodes, a serially connected condenser and resistance element connected to the midpoint of the secondary of said first transformer and to said first named source of voltage, connections from the secondary of said second transformer to said condenser, means to superimpose a voltage proportional to the time integral of the sawtooth wave energy upon said voltage supplied to said first electrode, and magnetic deflecting means for producing deflection of electrons at right angles to deflection of the electrons produced by said deflecting electrodes.

11. A cathode ray tube system comprising a cathode ray tube having an envelope wherein is contained a source of electrons, a control electrode, an anode positioned in register with said electron source and said control electrode, means to supply said anode with a predetermined positive voltage to produce an electron beam, a target element to receive the said beam, a pair of deflecting plates positioned intermediate said anode and target, a magnetic focusing coil positioned intermediate said control electrode and

said anode, a source of sawtooth wave energy, an electron discharge amplifier having an input circuit and an output circuit, means to supply sawtooth wave energy from said source to the input circuit of said amplifier, a first and a second transformer, said transformers each having at least one primary winding and one secondary winding, a connection from the primary winding of said first and second transformers to the output circuit of said amplifier, connections from the secondary of said first transformer to said deflecting electrodes, a serially connected condenser and a resistance element connected to the midpoint of the secondary of said first transformer and to said first named source of voltage, connections from the secondary of said second transformer to said condenser, means to superimpose a voltage proportional to the time integral of the sawtooth wave energy upon said voltage supplied to said first electrode, means to supply energy from said source of sawtooth energy to a second electron discharge amplifier, means to supply the amplified energy to said magnetic focusing coil, and magnetic deflecting means for producing deflection of electrons from the source of electrons at right angles to the deflection of the electrons produced by the deflecting electrodes.

KURT SCHLESINGER.