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CIRCUIT ARRANGEMENT FOR CONTROLLING VERY RAPID DEFLECTIONS
OF AN ELECTRON BEAM IN A VACUUM TUBE

Filed May 13, 1964

2 Sheets-Sheet 1

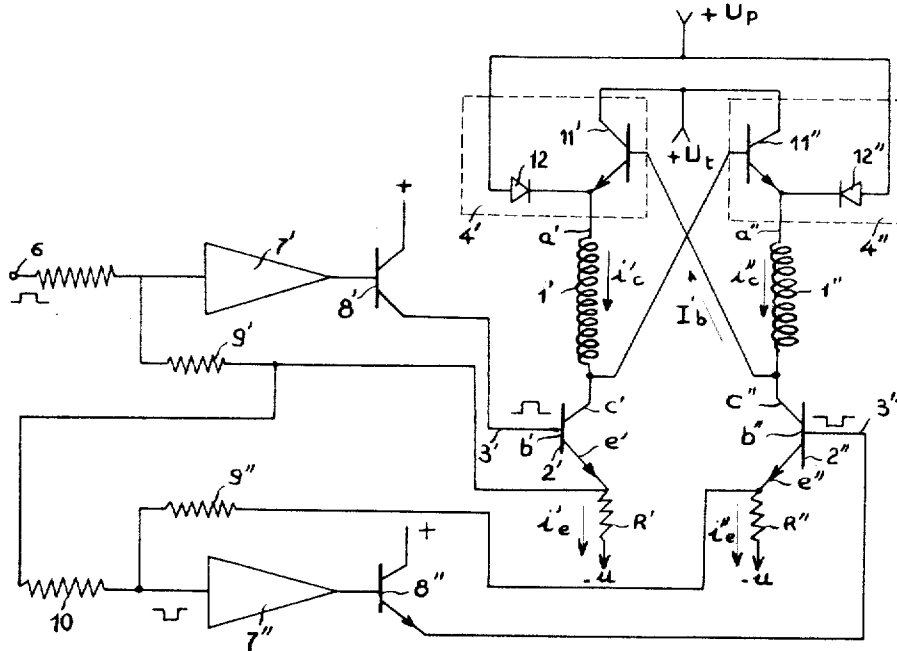


FIG. 1

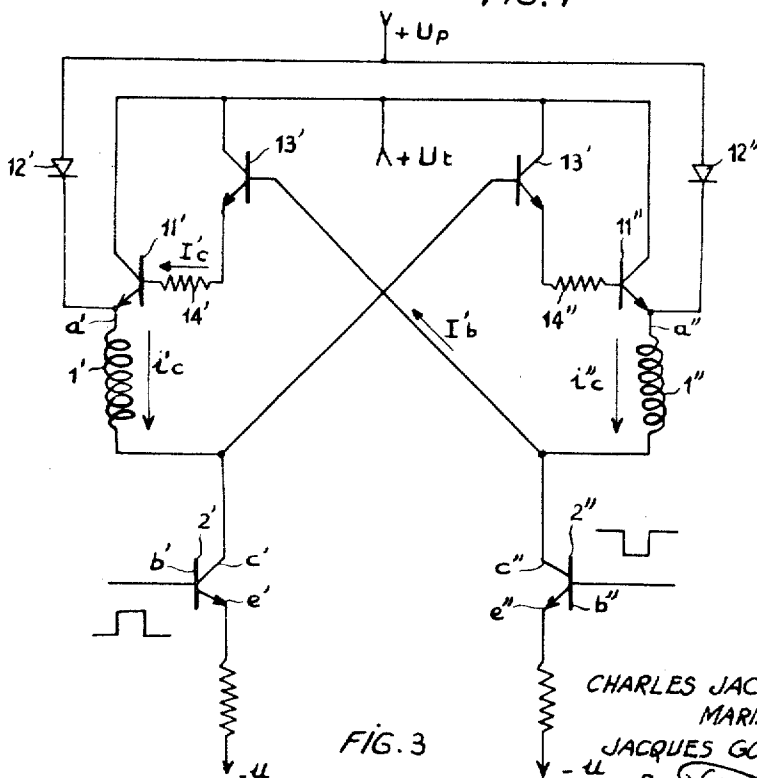


FIG. 3

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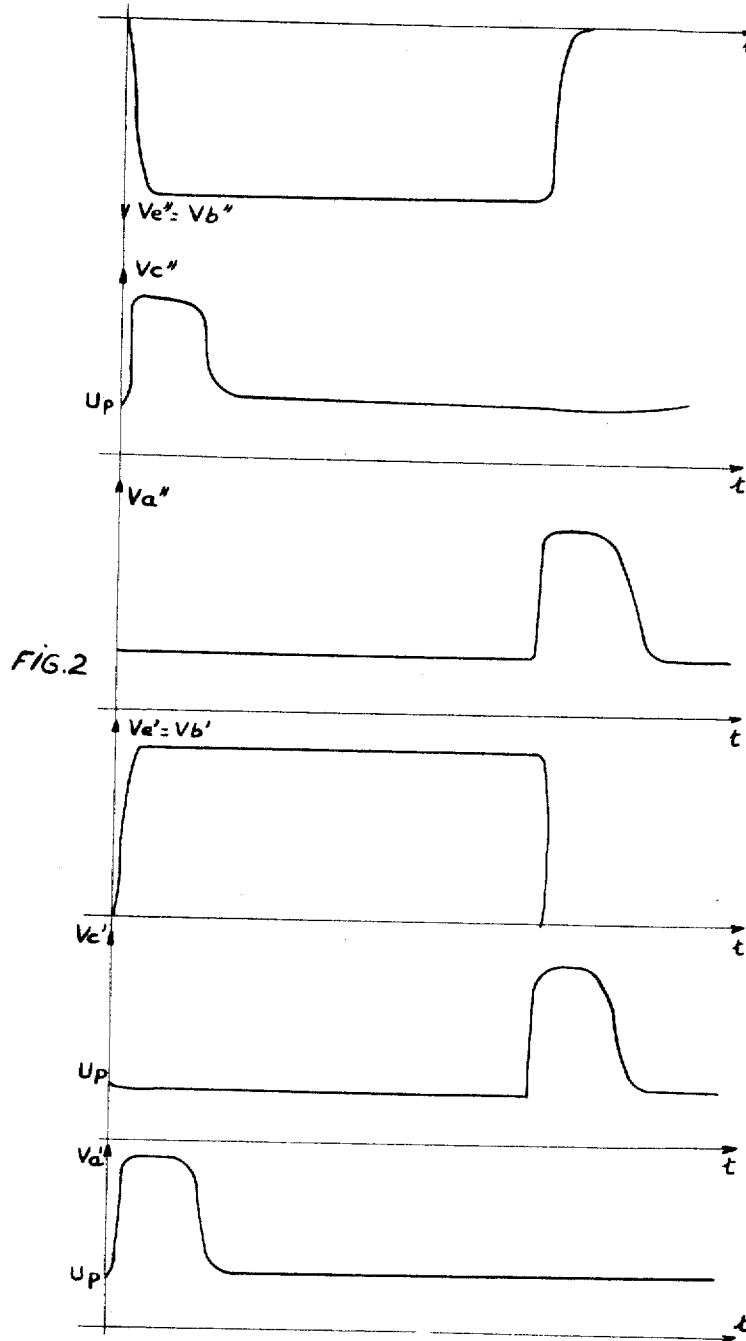
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CIRCUIT ARRANGEMENT FOR CONTROLLING VERY RAPID DEFLECTIONS OF AN ELECTRON BEAM IN A VACUUM TUBE

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ABSTRACT OF THE DISCLOSURE

This invention relates to a circuit controlling very rapid deflections of an electron beam in a vacuum tube.

The respective first ends of two push-pull field coils are connected to a main D.C. supply through two diodes and to an auxiliary D.C. supply of high voltage through two switching transistors, the control electrodes of which are cross-connected to the respective second ends of the field coils. Only the field coil having an increasing current therethrough is connected to the auxiliary supply through the corresponding transistor, the other field coil being connected to the main supply through the corresponding diode.

The present invention relates to a circuit arrangement for electromagnetically controlling very rapid deflections of an electron beam in a vacuum tube, comprising two identical field coils mounted in push-pull and each in series with an electronic control member, preferably a transistor. Circuit arrangements of this type are already known for electromagnetically controlling the deflections of the cathode beam of an electronic tube. It is known that the speed of variation of the current passing through an inductance circuit is limited by the self-inductance of this circuit. On the other hand, in an inductance circuit of which the current is controlled by an electronic member, the electromotive forces of self-induction induced by certain rapid variations of the controlled current are capable of reversing the voltage applied to the electronic control member; if this latter is an electronic tube which is not very sensitive to the reverse voltages, this arrangement has very few disadvantages. However, the same does not apply if the current control member is a transistor and more generally a semiconductor device comprising at least one junction capable of undergoing irreversible changes when it is subjected to a reverse voltage at least equal to a certain characteristic value; known as the "Zener voltage." In these known arrangements, the reversal of the voltage applied to the electronic control members for the currents in the field coils is prevented by limiting the electromotive force of self-induction induced by the rapid variations of the said currents by means of voltage limiters connected to the terminals of the said field coils. This arrangement has the disadvantage of limiting to a certain value the overvoltages which can appear on these coils and consequently, as regards specified self-inductance coils, of limiting the speed at which the currents in the said coils can be modified; in the case of the electromagnetic control of deflections of a beam of electrons, it is understood that the arrangement referred to, if it is concerned with protecting the electronic control members against the reverse voltages, has the serious disadvantage of limiting to relatively low values the speed with which the cathode beam can be deviated.

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The arrangement according to the invention is of the type hereinbefore indicated and it permits of obtaining speeds of variation in the currents flowing through the field coils which are very much higher than those which can be obtained with the known arrangements previously referred to, while nevertheless ensuring the protection of the electronic current control members, particularly transistors, against the reverse voltages which are liable to destroy them; the arrangement according to the invention makes it possible to obtain a very high speed of deflection of a cathode beam.

The circuit arrangement according to the invention is characterised in that two diodes are each interposed between a first end of one of the two field coils and a permanent source of supply voltage, and that two switching transistors each have their emitter-collector path interposed between the said first end of one of the field coils and an auxiliary supply voltage source which is of higher value than the permanent supply voltage, while during the period of each increase in current in one of the two coils, the base of the switching transistor connected to the first end of this coil receives an unblocking current from the second end of the other coil.

Since it is then possible to select for the permanent supply voltage a value appreciably lower than that used in the prior known arrangements which have been referred to above, the result is that, except during the very short periods of rapid variations of the controlled currents when the auxiliary supply voltage is applied to one of the field coils, each current control member is almost permanently traversed by an electric power appreciably smaller than in the case of the prior known arrangements, this providing important advantages when the said control members are semiconductor devices and particularly transistors.

Since it is that, during the period of each increase in current in one of the two field coils, the base of the switching transistor connected to the first end of this coil receives an unblocking current from the second end of the other coil, this arrival of current in the said other coil obviously sets up a lack of symmetry between the currents passing through the two coils, the duration of which is that of the increasing current in one of the two coils and the concomitant decrease of current in the other coil, which exactly controls the appearance of this unblocking current. It is obvious that this lack of symmetry between the currents passing through the two coils disappears at the same time as the unblocking current which has caused it, since in continuous operation, the two field coils exert by their construction perfectly symmetrical actions on the cathode beam. On the conclusion of the increase in the current in one of the two field coils, when the unblocking current derived from the other coil is consequently cancelled out, the action exerted by this other coil on the cathode beam thus suddenly reassumes the symmetrical value of that of the action exerted by the first coil. With the start and end of each increase in the current flowing through one of the two field coils, the cathode beam is thus subjected to very rapid displacements which respectively move it away from and then bring it back to the positions which are imposed on it by the two field coils under constant operation when they are traversed by perfectly symmetrical currents, while during the period of the said increase in current, the cathode beam is subjected to a displacement which is relatively much slower and substantially rectilinear. The above arrangement thus only permits of causing a cathode beam to pass from a first to a second permanent position only along a broken line path, i.e. non-rectilinearly; this does not result in any disadvantage in the case where the application envisaged for the arrangement is such that

only the first and second permanent positions of the cathode beam are of importance, the said beam being for example extinguished while it is passing from one to the other. The same would not apply in those applications where interest is attached to all the intermediate transient positions of the cathode beam, and particularly of its luminous trace, for example on a fluorescent screen, the said beam then remaining illuminated while it is being displaced. The applications of this latter type are very numerous in the electronic art; it may for example be a question of exposing a vector on the fluorescent screen of a cathode ray tube.

One particularly advantageous embodiment of the arrangement according to the invention for electromagnetically controlling very rapid deflections of the cathode beam or ray of an electronic tube has the important advantage of being able to control rectilinear deflections of the cathode ray so as to be able to cause the appearance, for example on the fluorescent screen of a cathode ray tube, a straight luminous segment joining two successive permanent positions of the spot of the said ray or beam.

This advantageous embodiment of the arrangement according to the invention is characterised in that the emitter-base interval of at least one supplementary transistor is interposed, on the one hand, between the base of each switching transistor connected to the first end of one of the two field coils and, on the other hand, to the second end of the other coil, so as to increase the amplification of the unblocking current of the corresponding switching transistor, which is set up in the said other coil, and thus to reduce the transient dissymmetry between the currents in the two coils.

By amplifying the unblocking current set up in one of the two field coils, it is possible to maintain its strength at a relatively low value, the result of which is only a negligible transient dissymmetry between the currents traversing the two field coils; the effective path of the cathode ray spot then substantially approaches the rectilinear path which it would follow if the currents flowing through the two field coils remained perfectly symmetrical during the displacement of the said ray or beam.

By way of example, several embodiments of the circuit arrangement according to the invention are hereinafter described and illustrated diagrammatically in the accompanying drawing.

FIGURE 1 is the electric circuit of a first embodiment.

FIGURE 2 is a diagram representing the wave forms at different points of the circuits of FIGURE 1.

FIGURE 3 represents a part of the electric circuit of a second embodiment.

The embodiment of the circuit arrangement according to the invention which is illustrated in FIGURE 1 is designed to control electromagnetically the deflections of the cathode ray or beam of an electronic tube; it comprises essentially two field coils $1'$ and $1''$ and two transistors $2'$, $2''$, which are respectively adapted to control the currents passing through these coils $1'$, $1''$ and mounted in push-pull. This means that the control signals applied respectively to the control electrodes $3'$, $3''$ of the transistors $2'$, $2''$ are always in phase opposition, for example synchronous rectangular pulses, and therefore of the same duration but of opposite polarity, and the same amplitude (positive for the electrode $3'$ and negative for the electrode $3''$ in the example illustrated in FIGURE 1). These two symmetrical control signals are derived from a single asymmetrical control signal applied to the input terminal 6 of the circuit; this asymmetrical input signal acts on the input of a preamplifier $7'$, the output of which is connected to the input of an intermediate amplifier stage which is formed in the example illustrated by a transistor $8'$, of which the base is the control electrode and the collector is connected to a polarization source, while the emitter transmits the output signal to the control electrode $3'$ of the transistor $2'$; a negative feed-back is set up by means of an impedance $9'$

between the emitter of the transistor $2'$ and the input of the preamplifier $7'$; in this negative feed-back circuit, a signal in phase opposition with the asymmetrical signal applied to the input terminal 6 is extracted; this signal in phase opposition is applied by means of an impedance 10 to the input of a second preamplifier $7''$, the output of which is likewise connected to the input of an intermediate amplifier stage, likewise formed by a transistor $8''$ mounted in the same manner as the transistor $8'$, and the emitter of which acts on the control electrode $3''$ of the transistor $2''$; a negative feed-back is also assured by an impedance $9''$ between the emitter of the transistor $2''$ and the input of the preamplifier $7''$. Each of the upper ends a' , a'' of the coils $1'$, $1''$ is connected to a permanent supply voltage source U_p and to an auxiliary supply voltage source U_t , chosen in such a way as to satisfy the relation $|U_t| > |U_p|$, by the intervention of respectively independent electronic switches $4'$, $4''$; each of these electronic switches $4'$, $4''$ is formed by a transistor $11'$, $11''$, of the n-p-n type in the example illustrated, the emitter of which is connected to the upper end a' or a'' of the corresponding coil $1'$ or $1''$, and the collector is connected to the auxiliary supply voltage source U_t , while its base serves as control input for the corresponding switch; this latter comprises in addition a diode $12'$, $12''$, preferably of a semiconductor type, the anode of which is connected to the permanent supply voltage source U_p , while its cathode is connected jointly to the upper end a' or a'' of the coil $1'$ or $1''$. Finally, the control input of the switch $4'$, that is to say, the base electrode of the transistor $11'$, is directly connected to the lower end of the coil $1'$, while the control input of the switch $4''$, that is to say, the base electrode of the transistor $11''$, is directly connected to the lower end of the coil $1''$.

The operation of the circuit shown in FIGURE 1 will now be described by means of wave form diagrams shown in FIGURE 2; when constant voltages are applied to the bases b' , b'' of the two transistors $2'$, $2''$, the two transistors $11'$, $11''$ are blocked for the reasons which will hereinafter be indicated, while the two diodes $12'$, $12''$ are conductive, so that if they are neglected the voltage drops at their terminals, and also the ohmic resistances of the coils $1'$, $1''$, the collectors c' , c'' of the transistors $2'$, $2''$ receive voltages which are practically equal to $+U_p$; it is thus seen that the two transistors $11'$, $11''$ have substantially the same voltage at their bases and at their emitters, this explaining that they are blocked. When the respectively ascending and descending pulse flanks are applied to the bases b' and b'' of the transistors $2'$, $2''$, a brief positive pulse appears on the collector c'' of $2''$ (see $v_{c''}$ in the diagram) which, being applied to the control electrode of the transistor $11'$, unblocks the latter; the result is that the emitter of the transistor $11'$ transmits this positive voltage pulse to the upper end a' of the coil $1'$, which is also temporarily brought to a potential which is between $+U_p$ and $+U_t$, so that the diode $12'$ stops being conductive. During this time, the transistor $11''$ does not cease to be blocked and the diode $12''$ to be conductive, so that the upper end a'' of the coil $1''$ is kept at the voltage $+U_p$. When the voltages applied to the two control inputs $3'$ and $3''$ have reached their new level, the current $i'_{c'}$ ceasing to vary, no further pulse is applied to the base of the transistor $11'$, so that the latter is again blocked, and the diode $12'$, the cathode of which is no longer brought to a voltage higher than the voltage U_p applied to its anode, again becomes conductive; as a consequence, the voltage U_p is again applied to the upper end a' of the coil $1'$, and also in first approximation to the collector c' of the transistor $2'$. When the rear flanks of the two pulses in phase opposition are applied respectively to the control inputs $3'$ and $3''$, the operation of the circuit is symmetrical with that previously described: it is the transistor $11''$ which is unblocked by the positive pulse which is transmitted to it by the collector c' of the transistor $2'$, and its emitter consequently applies

to the upper end a'' of the coil $1''$, a potential which is between the auxiliary supply voltage U_t and the permanent supply voltage U_p , the diode $12''$ being blocked. With the ending of the control pulses, the permanent running is re-established. It will be observed that, in this embodiment, the control pulse applied to each of the electronic switches $4'$, $4''$ is formed by the shunt circuit formed by the transistor $2''$ or $2'$, in series with the self-inductance of the coil $1''$ or $1'$, respectively.

With respect to the known arrangement in which the supply voltage of the field coil maintains a constant value U_p , even at the time of rapid variations of their currents i_c , the arrangement according to the invention permits of obtaining appreciably higher variation speeds

$$\frac{di_c}{dt}$$

of the current i_c ; in actual fact, according to formula:

$$(1) \quad \left| \frac{di_c}{dt} \right| = \frac{1}{L} |v_a - v_c|$$

in which v_a represents the voltage applied to the upper end a of the coil $1'$ or $1''$ and v_c is the potential of the collector c of the transistor $2'$ or $2''$, or given self-inductance coils L . The amplitude of the speed of increase of i'_c has for example the value

$$\frac{1}{L} |v_{a'} - U_p|$$

since $v_{a'}$ is close to $v_{c'}$ and $v_{c'}$ is close to U_p , while the amplitude of the speed of decrease of i'' then has the value

$$\frac{1}{L} |U_p - v_{c''}|$$

equal to the foregoing, since $v_{a'}$ is close to U_p ; now $U_p - v_{c''}$ may be only slightly smaller than $|U_p - U_t|$, thus of arbitrary value. This is made possible by the fact that the permanent values of the current i_c flowing through the coil $1'$ or $1''$ do not depend on the value v_a of its supply voltage, but only on the value of the control voltage applied to the input terminal $3'$ or $3''$, that is to say, to the control electrode of the transistor $2'$ or $2''$; it is in fact easily shown that:

$$(2) \quad i_c = \frac{i_e}{1 + 1/\beta} \approx i_e$$

i_e designating the emitter current of the transistor $2'$ or $2''$ and its current gain, which is generally very much higher than 1; on the other hand, by representing by R , v_e and $-u$ the resistance, the potential and the polarisation voltage, respectively, of the emitter of the transistor $2'$ or $2''$, it is obvious that:

$$(3) \quad i_e = \frac{v_b + u}{R} = \frac{(v_b - \epsilon) + u}{R}$$

v_b designating the potential of the base of the transistor $2'$ or $2''$ and $v_b - v_e = \epsilon$, the contact potential at the level of the junction between its base and its emitter, which is relatively very small. The comparison of the above Formulae 2 and 3 shows that it is possible to write:

$$(4) \quad i_c = A v_b + B$$

this Formula 4, in which A and B are two constants independent of the control voltage v_b certainly show that in constant operation the value of the current i_c flowing through the coil $1'$ or $1''$ only depends exclusively on the said control voltage v_b , and not at all on the value of the supply voltage v_a of the said coil; it is thus possible for the latter to be arbitrarily modified, particularly in such a way as to increase the speed of variation of i_c , without resulting in any modification of the permanent value finally taken by i_c . The operation of the circuit according to the invention is particularly advantageous when continuously operating, from the point of view of the power consumed; actually, in the case where the coil

$1'$ or $1''$ is traversed by a permanent current $i_c = 2$ amperes, for example, in order to produce a constant deflection of the electron beam, when disregarding the ohmic resistance of the said coil $1'$ or $1''$, the collector c of the transistor $2'$ or $2''$ is brought substantially to the voltage $U_p = 18$ volts; as its base must be brought to a voltage in the region of $v_b = 5$ volts in order that its collector current is to have the value indicated above, and its emitter is then substantially at the same potential as its base, its emitter-collector path is subjected to a voltage in the region of 13 volts, so that the transistor $2'$ or $2''$ dissipates a power in the region of $13 \times 2 = 26$ watts; under the same conditions, the previously mentioned known arrangement applies to the emitter-collector path of the transistor a voltage in the region of 45 volts—5 volts = 40 volts, so that the transistor thereof dissipates a power of 80 watts, that is to say, a very much higher power; the arrangement according to the invention is thus of interest in causing the operation under constant conditions of the control transistor at a clearly lower rate of power, this increasing the effective life of the transistor and also its resistance to over-voltages and to reverse voltages.

It has been shown above (see Formula 4) that the strength of the currents i'_c , i''_c in the two field coils $1'$ and $1''$ only depend under continuous running conditions on the potentials v_b , and $v_{b''}$ applied respectively to the bases b' and b'' of the two control transistors $2'$ and $2''$, in accordance with the linear formulae:

$$(4') \quad i_{c'} = A v_{b'} + B$$

$$(4'') \quad i_{c''} = A v_{b''} + B$$

Since, by hypothesis,

$$(5) \quad v_{b'} = -v_{b''}$$

the symmetry of the currents flowing through the two field coils is translated by the relation

$$(6) \quad \frac{i_{c'} + i_{c''}}{2} = B$$

in which B is a constant.

When for example the potential applied to the base b' of the control transistor $2'$ increases (front flank of the rectangular pulse), the current i'_c increases, while the current i''_c decreases; as a consequence, a positive voltage pulse appears on the collector c'' of the control transistor $2''$, which is transmitted through the direct connection to the base of the transistor $11''$, which is consequently unblocked, as previously explained. The situation exists as long as the voltage pulse transmitted through the lower end of the field coil $1''$ to the base of the transistor $11'$ lasts, that is to say, as long as the increase in current in the field coil $1'$ lasts. Throughout the period of this transient condition, the field coil $1''$ sends, by way of its lower end, an unblocking current I'_b into the base-emitter path of the transistor $11'$; as the value of this base current I'_b of the transistor $11'$ is connected to that of its emitter current i'_c by the relation

$$(7) \quad I'_b = \frac{i'_c}{\beta}$$

in which β designates the current amplification of the transistor $11'$ which, under transient conditions, corresponding to a spectrum extending towards the high frequencies, has a value appreciably smaller than under constant running conditions, and the value i'_c is on the other hand determined by that of $v_{b'}$ (Formula 4') the fraction of the current i''_c flowing through the field coil $1''$, which is shunted in the direction of the base of the said transistor $11'$, is relatively large; as the voltage pulse which then appears at the lower end of the field coil $1'$ is negative, and as a consequence it does not unblock the transistor $11'$, the value of the current i'_c flowing through the

said field coil 1' is always given by the above Formula 4', while the Formula 4'' is replaced by:

$$(8) \quad i_{c''} = I'_{b0} + A v_{b0} + B$$

From the above Formulae 4', 8, 5 and 7, there is easily deduced the formula:

$$(6') \quad \frac{i_{c'} + i_{c''}}{2} = \frac{i'_{c0}}{2\beta} + B = \frac{A}{2\beta} v_{b0} + \left(1 + \frac{1}{2\beta}\right) B$$

which shows that, to the extent that their arithmetic mean is no longer constant, the currents i'_{c0} and i''_{c0} flowing through two field coils 1' and 1'' are no longer symmetrical during the transient running period under consideration, in which v_b varies. If there are particularly designated by v_{b0} and v_{b1} the values of the potential of the base b' of the control transistor 2', respectively in the initial permanent state and in the final permanent state, the above Formula 6' shows that with the commencement of the increase v_b , from the value v_{b0} , the spot of the cathode ray on the fluorescent screen of the vacuum tube undergoes a sudden displacement which is proportional to the discontinuity to which the current intensity i'_{c0} in the field coil 1' is then subjected and the value of which is:

$$(9) \quad I'_{b0} = \frac{A v_{b0} + B}{\beta}$$

while at the end of said increase in v_b , which has then reached the value v_{b1} , the said spot undergoes a fresh sudden displacement, the value of which is proportional to:

$$(10) \quad -I'_{b1} = -\frac{A v_{b1} + B}{\beta}$$

the result of this is that the spot of the cathode ray is not subjected to a uniform displacement throughout the period of the increase in current in the field coil 1'; in the usual case, where two pairs of field coils such as 1' or 1'' are provided, arranged in such a way as to exert actions perpendicular to one another on the cathode ray of the vacuum tube, for example, along the directions of two orthogonal coordinate axes, it is along the directions of these two axes that the spot of the cathode ray is subject to very rapid displacements at the start and end of each increase in the current i'_{c0} ; since there is no linear relationship between these very rapid displacements along the two axes under consideration, it is understood that the resultant very rapid displacements of the spot on the screen do not take place in the direction of the straight line passing through the two permanent positions, respectively the initial and final positions, of the said spot; the latter traces, on the contrary, on the fluorescent screen, a broken line which joins the initial point to the final point.

The improvement of the arrangement according to the present invention as illustrated in FIGURE 3 consists in introducing the emitter-base path of a supplementary transistor 13' or 13'' between, on the one hand, the base of each transistor 11', 11'' connected to the upper end of one of the two field coils 1' or 1'' and, on the other hand, the lower end of the other coil 1'' or 1'. The collector of each supplementary transistor 13' or 13'' is in addition directly connected, like those of the transistors 11', 11'', to the auxiliary supply voltage source U_c . On the other hand, a current-limiting resistance 14' or 14'' is interposed between the emitter of each of the supplementary transistors 13', 13'' and the base of the corresponding transistors 11' or 11''.

The operation of the arrangement improved in this way is as follows: during the period of each increase in current i'_{c0} in the field coil 1', the current I'_{b0} extracted at the bottom end of the other field coil 1'' is amplified by the base-emitter of the supplementary transistor 13', of which the collector current I'_{c0} flowing through the

limiting resistance 14' and the base-emitter path of the transistor 11' consequently has the value:

$$(11) \quad I'_{c0} = \beta' I'_{b0}$$

β' representing the amplification in current of the supplementary transistor 13'. Since, moreover, in this case

$$(12) \quad I'_{c0} = \frac{i'_{c0}}{\beta}$$

the comparison of the Formulae 11 and 12 as given above shows that:

$$(13) \quad I'_{b0} = \frac{i'_{c0}}{\beta \beta'}$$

as the intensity of the current i'_{c0} which flows through the field coil 1' only depends at any time on the value of the potential v_b , applied to the base b' of the control transistor 2', the comparison of the above Formulae 7 and 13 shows that, by virtue of the improvement under consideration, the current I'_{b0} derived at the bottom end of the field coil 1'' has a value which is clearly smaller than in the case of the arrangement shown in FIGURE 1, in the case where the current amplification β' of the supplementary transistor 13' has a value greater than one. The amplitudes of the discontinuities to which the current i'_{c0} is subjected in the field coil 1'', respectively at the start and end of a rapid increase in the current i'_{c0} , and which are given respectively by the above Formulae 9 and 10, being multiplied, in the case of the arrangement shown in FIGURE 3, these discontinuities are greatly reduced, as are the amplitudes of the corresponding sudden displacements of the spot of the cathode ray; the result is that the path of the said spot between its initial position and its final position, corresponding respectively to the first and second constant operation, differs very little from a straight segment. An even more perfect linearisation of this path could be obtained by the interposition between, on the one hand, the base of each transistor 11' or 11'' and, on the other hand, the lower end of the other field coil 1'' or 1', the emitter-base paths, mounted in series with one another, of several supplementary transistors, the collectors of which would moreover be directly connected to the auxiliary supply voltage source. It is obvious that in the aforesaid formulae, the current amplification of the transistors 11', 11'' would then be replaced by the product of β and the current amplifications of the different supplementary transistors, of which the emitter-base paths would be mounted in series with one another.

What we claim is:

1. A circuit arrangement for electromagnetically controlling very rapid deflections of an electron beam in a vacuum tube, comprising two identical field coils, disposed for push-pull actions on said electron beam, a main D-C voltage supply, two diodes connected to said main supply and to respective first ends of said field coils for passing currents therethrough, two electronic control devices with control electrodes, on which respectively two balanced control signals are impressed, said electronic control devices being respectively connected to said field coils for simultaneously increasing the current through one and decreasing the current through the other of said field coils, an auxiliary D-C supply having a voltage superior in absolute value to that of said main supply, two switching transistors with their respective emitter-collector paths being inserted between said auxiliary supply and said respective first ends of the field coils, and low resistance D-C connection means inserted between the second end of each one field coil and the base of the switching transistor connected to the first end of the other field coil, whereby only the transistor connected to the one field coil having an increasing current therethrough and the diode connected to the other field coil are transiently conductive, and the first end of only said one field coil is

brought thereby to a voltage superior in absolute value to that of the main supply.

2. The circuit arrangement of claim 1, in which the low resistance D-C connection means inserted between the second end of each one field coil and the base of the switching transistor connected to the first end of the other field coil comprises the emitter-base path of at least one further transistor, the collector of which is conductively connected to the auxiliary supply.

3. A circuit arrangement for electromagnetically controlling very rapid deflections of an electron beam in a vacuum tube, comprising a right and a left identical field coils, disposed for push-pull actions on said electron beam, a main D-C voltage supply, two diodes respectively inserted between said main supply and first ends of said field coils for passing currents therethrough, two semiconductor control devices respectively connected to the second ends of said field coils, said two semi-conductor devices having control electrodes, on which respectively two balanced control signals are impressed for simultaneously increasing the current through one and decreasing the current through the other of said field coils, an auxiliary D-C supply having a voltage superior in absolute value to that of said main supply, a right and a left switching transistors with their respective emitter-collector paths inserted between said auxiliary supply and said respective first ends of the right and left field coils, the respective bases of said right and left transistors being conductively connected to the respective second ends of said left and right field coils, whereby only the transistor connected to said one field coil having an increasing current therethrough is made temporarily conductive by the voltage surge on the base thereof, and the first end of only said one field coil is brought thereby to a voltage superior in absolute value to that of the main supply.

4. A circuit arrangement for electromagnetically controlling very rapid deflections of an electron beam in a vacuum tube, comprising two identical field coils, dis-

posed for push-pull actions on said electron beam, a main D-C voltage supply, an auxiliary D-C supply having a voltage superior in absolute value to that of said main supply, two controllable, electronic switches, each of said switches having a control input, means for connecting one terminal of said switch to the first end of one of said field coils for switching said first coil end from said main supply to said auxiliary supply only during the time a current pulse of predetermined polarity is applied on its control input, means for connecting a second terminal of said switch to said main supply, means for connecting a third terminal of said switch to said auxiliary D-C supply, two electronic control devices with control electrodes, on which respectively two balanced control signals are impressed, means for connecting said electronic control devices to said field coils for simultaneously decreasing the current through one and increasing the current through the other of said field coils, and means for transmitting a current pulse having said predetermined polarity from the second end of said one field coil having a decreasing current therethrough to the control input of the electronic switch which is connected to the first end of the other field coil, whereby the first end of said other field coil having an increasing current therethrough, is brought thereby transiently to a voltage superior in absolute value to that of the main supply.

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