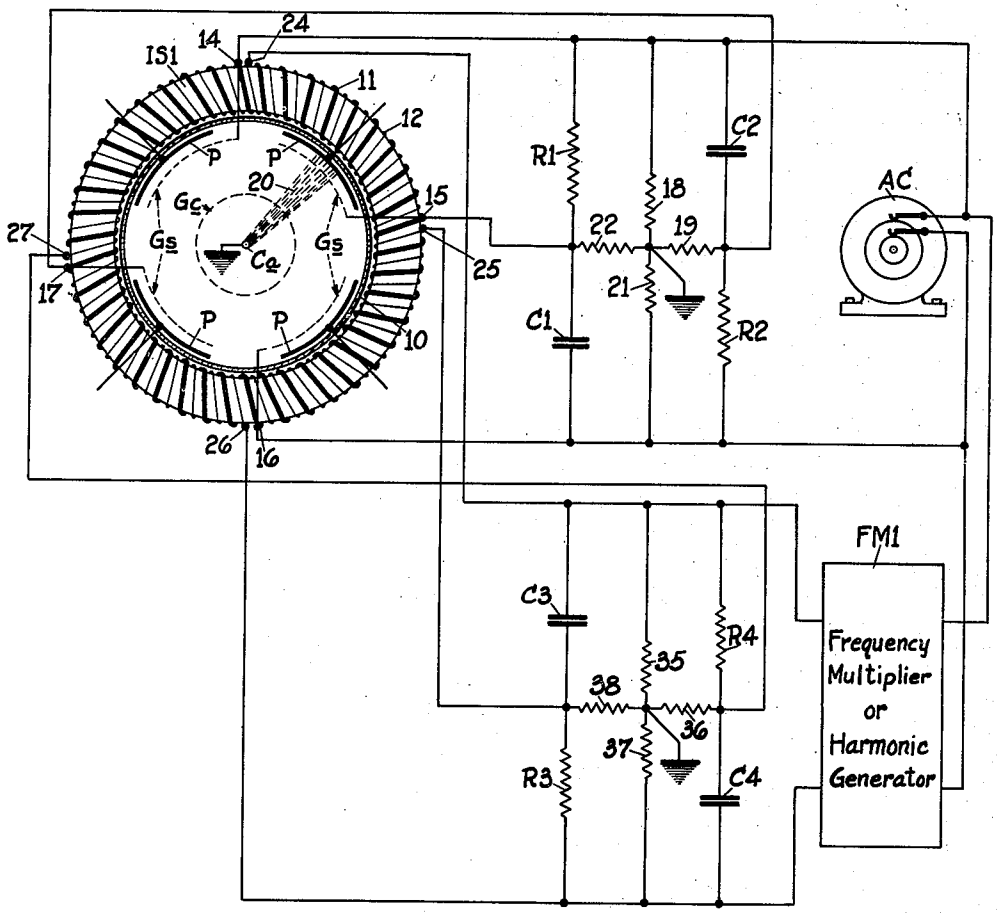
Sept. 12, 1950 J. C. O'BRIEN 2,522,055

ELECTRONIC TRANSLATING DEVICE

Filed Dec. 31, 1945 3 Sheets-Sheet 1

FIG. 1.



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ELECTRONIC TRANSLATING DEVICE

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FIG. 2.

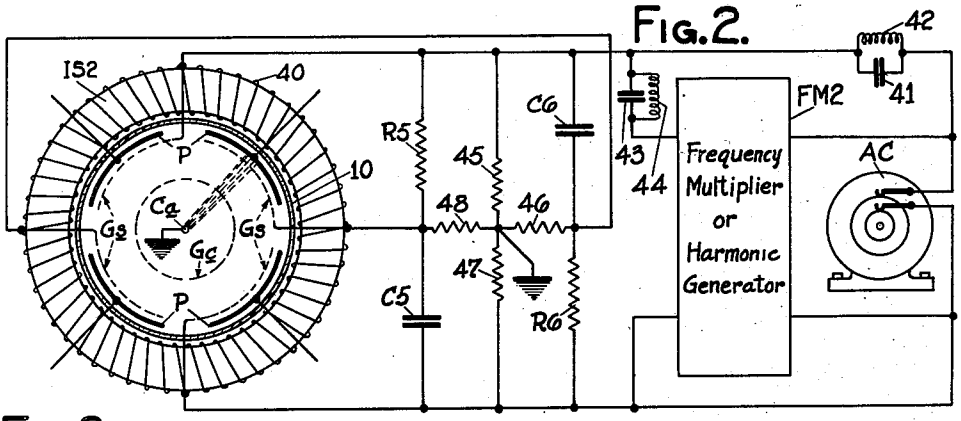


FIG. 3.

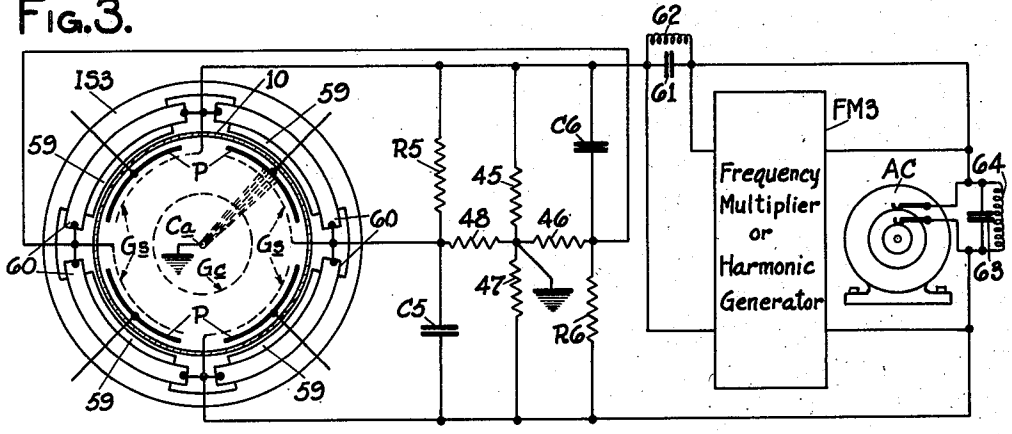
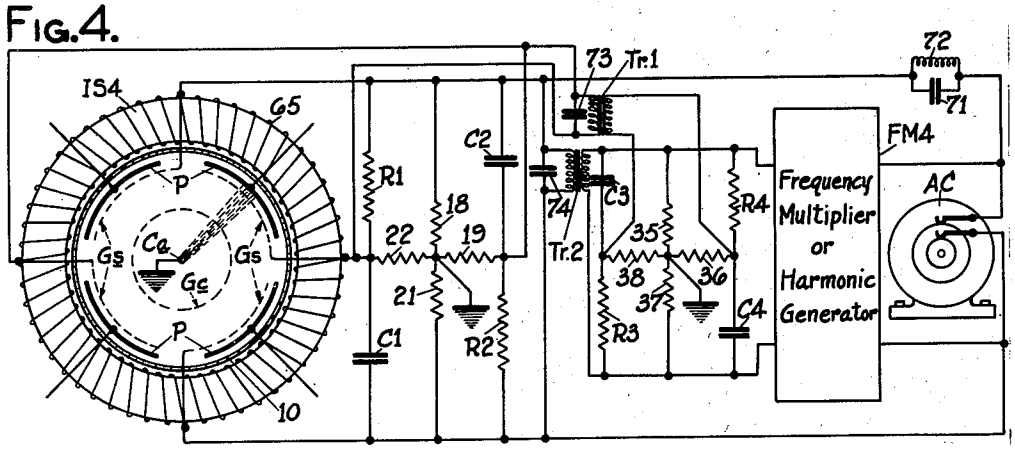


FIG. 4.



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ELECTRONIC TRANSLATING DEVICE

Filed Dec. 31, 1945 3 Sheets-Sheet 3

FIG. 5.

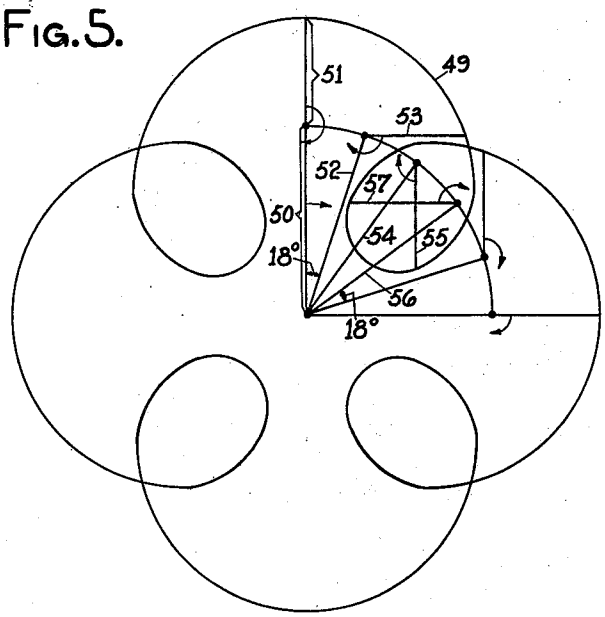
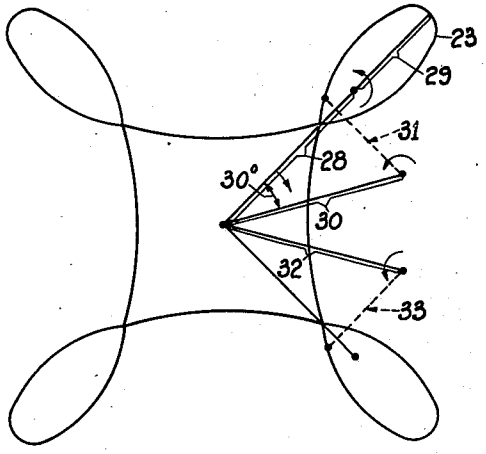


FIG. 6.



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Patented Sept. 12, 1950 2,522,055

UNITED STATES PATENT OFFICE

2,522,055

ELECTRONIC TRANSLATING DEVICE

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Application December 31, 1945, Serial No. 638,546

5 Claims. (Cl. 315—21)

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This invention relates to an electron tube of the rotating electron beam type and more particularly to means for variably rotating and variably focusing its beam during such rotation so that the beam will move quickly from anode to anode and will hesitate while on such anode or plate.

Rotating electron beam type tubes, such as disclosed in the Skellet Patent No. 2,217,774 may be used to perform various kinds of communicating and commutating functions at high speed. Since no useful function can be performed and no electrons should flow from cathode to anode while the electron beam moves from one anode to another anode it is desirable to perform the beam shifting function between plates very quickly.

In accordance with the present invention it is proposed to provide electromagnetic means for concentrating the electrons emitted by the cathode of the tube into a comparatively narrow beam and to cause rotation of such electron beam by causing rotation of the magnetic field which concentrates the electrons into the narrow beam. Since rotating electron beam tubes of the type under consideration preferably employ more than two anodes it is difficult to get slow movement of the rotating magnetic field while the electron beam is on an anode and fast rotation of such electron beam while it is shifting from one anode to another by the wave form of the fundamental wave of the alternating current, and it has been found necessary to superimpose upon the fundamental frequency used for rotating the electron beam a higher frequency wave, the frequency of which higher frequency wave has some relationship to fundamental frequency and to the number of anodes equally spaced about the cathode of the tube, and in accordance with the present invention it is proposed to combine alternating currents of two frequencies or combine alternating current magnetic fields of two frequencies in a manner to produce step-by-step rotation of the magnetic field and the electron beam rotated thereby.

In accordance with one form of the present invention it is proposed to use a laminated iron stator and to wind two different windings thereon and energize these windings with alternating currents, one of which has a frequency which is a multiple of the frequency of the other.

In accordance with another form of the present invention it is proposed to use alternating current voltages of different frequencies in series or in multiple with each other and apply them to the same winding to produce a step-by-step

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rotating magnetic field, this being accomplished either by employing the two alternating current voltages in series, by employing the two alternating current voltages in multiple before phase splitting of such voltages has been accomplished, or by connecting these voltages in series or multiple after such phase splitting has been accomplished to produce a rotating magnetic field of the step-by-step type.

It has been observed that the ratio of the frequencies of the two alternating currents employed is not directly proportional to the number of anodes employed in the tube but is proportional to either the sum of the anodes plus one or the sum of the anodes minus one, depending upon whether the supplemental or high frequency magnetic field is rotated in the same or the reverse direction as the fundamental frequency field is rotated.

Another feature of the present invention resides in the provision of a suppressing screen which has applied thereto alternating current potentials to suppress one end of the double electron beam that is inherently produced by the rotating magnetic field above mentioned.

Other objects, purposes and characteristic features of the present invention will in part be pointed out in the specification hereinafter and will in part be obvious from the accompanying drawings in which:

Fig. 1 illustrates an arrangement wherein magnetic fields of different frequencies are combined to produce a step-by-step rotating magnetic field;

Fig. 2 illustrates a modified form of the present invention in which two alternating currents of different frequencies are applied to the same phase splitting network which is in turn connected to a single polyphase winding to produce a step-by-step rotating magnetic field;

Fig. 3 illustrates a modification of the form of invention illustrated in Fig. 2 in that the stator structure is somewhat different and in that the two alternating current voltages of different frequencies are included in series whereas in Fig. 2 they are included in multiple;

Fig. 4 illustrates a modified form of the invention illustrated in Figs. 1 and 2 and in this case each of the two alternating current frequencies has its own phase splitting network as in Fig. 1 and these networks are then connected in multiple to polyphase windings such as illustrated in Fig. 2.

Fig. 5 illustrates vectorially and graphically the manner in which the electromagnetic field

rotates when the higher frequency is equal to the lower frequency multiplied by the number of anodes plus one and when both vectors rotate in a clock-wise direction as is the case in the specific circuit arrangement shown in Figs. 1 and 4; and

Fig. 6 illustrates vectorially and graphically the manner in which the rotating magnetic field performs its rotating and hesitating function when the higher frequency is equal to the lower frequency multiplied by the number of anodes minus one and when these vectors rotate in different directions as is true of the forms of invention illustrated in Figs. 2 and 3 where the two rotating vectors rotate in opposite directions.

Structure—Fig. 1.—Referring to Fig. 1 the rotating beam electron tube of the present invention comprises a cylindrical envelope or tube 10 preferably constructed of glass which is highly evacuated and contains a cathode Ca, a plurality of anodes P each anode of which is provided with a suppression grid Gs and each tube is preferably provided with a single control grid Gc although a separate control grid for each anode may be employed if desired. This tube 10 is surrounded by an iron stator IS1 preferably built up from laminations of extremely small thicknesses of low hysteretic loss material so as to reduce the eddy current losses and allow high frequency magnetomotive forces to be set up therein. This stator IS1 is preferably circular with suitable windings thereon and is of a size to just barely receive the electron tube 10 and this stator is so constructed that internal rather than external magnetic poles are produced therein. As shown in Fig. 1 this stator IS1 comprises a stator of the Gramme type on which two separate and continuous windings are placed. The winding 11 has been shown by heavy lines and the winding 12 has been shown by light lines although in practice the wire sizes may be substantially the same. As illustrated the heavy winding 11 is energized from an alternating current generator AC through the medium of a phase shifting network including condensers C1 and C2 and resistance units R1 and R2. The condenser C1 and the resistance unit R1 have such electrical values that the potential applied to the point 15 lags the potential applied to the point 14 by substantially 90 electrical degrees and the condenser C2 and resistance unit R2 have electrical constants such as to cause the potential at the point 17 to lag the potential at the point 16 in phase relationship to an extent of substantially 90°.

In order to cause the rotating magnetic field of the higher frequency supplied by the frequency multiplier FM1 to rotate in the opposite direction the phase shifting network C3, R3, C4, R4 have been inversely arranged as illustrated in Fig. 1. As a result of this reversal of elements the potential applied to the point 25 of the winding 12 lags the voltage applied to the point 26 on this winding to an extent of substantially 90 electrical degrees and likewise the voltage applied at the point 27 of this winding 12 lags the voltage applied to the point 24 to substantially the same extent. The voltages applied to the points 16 and 26 of the windings 11 and 12 are respectively of inverse potential to that of the points 14 and 24 respectively. In other words, the rotating magnetic field produced by winding 11 rotates in a clockwise direction whereas the rotating magnetic field produced by winding 12 rotates in a counter-clockwise direction. The two magnetic fields thus rotate in opposite directions. Since however the field produced by winding 11 is dominant the net rotation of the field is in a clockwise direction.

Since the particular embodiment of the invention shown in Fig. 1 employs an electron tube having four equally spaced anodes P and since the two alternating current magnetomotive forces and the resulting magnetic fields rotate in opposite directions it is essential that the high frequency current produced by the frequency multiplier FM1 be of a frequency which is three times that of the frequency of the alternating current produced by the generator AC and it is proposed that the frequency multiplier FM1 be constructed to perform a frequency tripling function. The fundamental frequency current may be of any desired frequency within limits permitted by eddy current and hysteretic losses.

Operation—Fig. 1.—Referring to Fig. 6 of the drawings let us assume that the magnetomotive force vector 28 is the magnetomotive force produced by the voltage produced by the generator AC (Fig. 1) and that the magnetomotive force vector 29 is produced by current derived from the frequency multiplier FM1 and that at during the particular instant under consideration these two voltages are in phase as illustrated in Fig. 6. Let us now assume that the low frequency voltage vector shifts to the position 30 to trace a curve 23 of the strength and phase of the voltage or magnetic flux, that is, shifts to the right to an extent of 30°, whereas the high frequency vector shifts to an extent of 90° and assumes the position 31. It is thus seen that although the low speed vector has shifted a considerable extent (30 degrees) the sum of the two vectors has shifted backwards to a small extent. In other words, the magnetomotive force has stood substantially still during this 30° shift of the fundamental frequency vector. As, however, the fundamental magneto-motive force vector shifts to the right another 30° from the position 30 to the position 32, the high speed voltage vector shifts counter-clockwise another 90° as illustrated by the magneto-motive force vector line 33. In other words, during this 30° shift of the fundamental magnetomotive force vector the combined result of the two magnetomotive force vectors has shifted the entire magnetic field to an extent of substantially or slightly in excess of 90° while the fundamental magneto-motive force only shifted to an extent of 30°. In other words, the rotating magnetic field stood substantially still during a 60° shift of the fundamental magneto-motive force and then made a rushing sweep of substantially a 90° shift during a 30° shift of the fundamental magnetic field. It is thus seen that the magnetic field rotates step-by-step in four steps about its circumference by reason of the fact that the higher frequency is three times as high as is the lower frequency and the results accomplished by the construction illustrated in Fig. 1 and graphically analyzed in Fig. 6 lends itself admirably to the employment of four anodes in an electron tube surrounded by the rotating magnetic field producing means shown in Fig. 1.

Another thing that can be readily seen from the curve 23 of Fig. 6 is that the magnetic field is strongest during those times when it hesitates on a plate or anode and is weakest during those times of quick sweep from one anode to another. This is true because the sum of the magneto-

motive forces are accumulative when they are substantially in phase, and are subtractive when they are substantially out of phase it being of course understood that the fast rotation of the magnetic field takes place when these magnetomotive forces are substantially out of phase. In practicing the invention it may be desirable to have the strongest magnetic fields while the electron beam is being swept from one anode to another. This is true because when the magnetic field is strong a narrow electron beam exists and it is desirable to have a narrower electron while it is swept from anode to anode whereas a wider electron beam may be tolerated while the electron beam hesitates or stands still on a particular anode during its rotation. In view of these considerations it may be desirable to have a strong magnetic field while the electron beam is being swept from anode to anode and such a construction has been illustrated in Figs. 2 and 3 and has been graphically illustrated by the curve 49 in Fig. 5.

The operation of the Fig. 1 structure merely involves an observation of how the application of alternating current of fundamental frequency derived from the generator AC and applied to winding 11 in combination with a triple frequency produced by the frequency multiplier FM1 and applied to the winding 12 may cause step-by-step rotation of the electron beam 20 in the tube or envelope 10. This is especially true in that it is to be understood that a rotating beam electron tube may be used in many situations where fast commutation or circuit switching is to be accomplished. As illustrated, this electron beam 20 is not a double beam such as would ordinarily be produced by a magnetic field of the type just described concentrating the electron emission from the cathode into a narrow path, that is, a two pole magnetic field. It should however be understood that the invention may be applied in the same way to a tube having a double electron beam. In order to suppress one of the two electron beams that would be inherently produced by a two poled magnetic field of the type under consideration, the electron tube 10 illustrated in Fig. 1 is provided with suppression grids Gs, one for each anode or plate P. These suppression grids Gs are, as shown, energized electro-statically directly from the fundamental alternating current frequency supplied by the generator AC and these potentials are such that their application to one suppression grid Gs aids the flow of electrons to the associated anode whereas the oppositely located suppression grid Gs being exposed to the other end of the electron beam opposes and suppresses the flow of electrons. From this it is readily seen that as the electron beam 20 rotates, the electrostatic potentials applied to the grids Gs also rotate and always suppress one end, namely the end not shown, of the two beams whereas they aid electron flow for the other end, namely the beam 20, of the two beams that would ordinarily result. It should be understood that the stator IS1 is rotatably positioned on the electron tube 10 so that the relative position of the rotating magnetic field may be shifted with respect to the relative position of the anodes and screen grids as to produce the proper phase of relationship between these elements, the stator IS1 of course being locked in position after it has once been moved to the proper phase shifted position. As shown, the stator IS1 (Fig. 1) is shown shifted clockwise substantially 45° with respect to the anode, the suppression grid of which is fed by the potential producing the particular magnetic pole. This has been thus illustrated because the magnetism actually lags the potential producing it and in practice this lag may be more nearly 90 degrees so that additional shifting of the stator IS1 in a clockwise direction may be necessary.

Since the various voltages applied to the various screen grids Gs should have potentials with respect to ground, a grounding network including resistances 18, 19, 21 and 22 has been provided for the main winding 11 whereas similar grounding resistances 35, 36, 37 and 38 have been provided for the supplemental winding 12. It will be observed that these resistances 18, 19, 21 and 22 and 35–38 are connected in star fashion with the star point connected to ground as conventionally shown. By the employment of these resistances, a definite voltage gradient exists between the cathode Ca which is also grounded and the various screen grids Gs.

Structure—Fig. 2.—In Fig. 2 has been illustrated an electron tube 10 of identical construction as that shown in Fig. 1. This tube is surrounded by a Gramme type core structure IS2 provided with a single winding 40 instead of the two windings shown in Fig. 1. In this case a single phase shifting network comprising the condensers C5 and C6 and the resistance units R5 and R6 is employed and this phase shifting network is fed by the fundamental frequency alternating current derived from the generator AC and in multiple therewith is also fed by alternating current derived from the frequency multiplier FM2. Since in this construction, only one phase shifting network is employed, the low frequency alternating current and the high frequency alternating current applied to the winding 40 will of necessity rotate in the same, namely, the clockwise, direction and for this reason and reasons already pointed out hereinbefore, the supplemental frequency derived from the frequency multiplier FM2 must be equal to the fundamental frequency multiplied by the number of anodes plus one. That is, must be five times that of the fundamental frequency since a four anode electron tube 10 has been illustrated in Fig. 2. The phase splitting network C5, R5, C6, R6 is designed to obtain the desired phase shift for the fundamental frequency current and thus will produce slightly more but less than 90° phase shift for the supplemented and higher frequency current. It will therefore serve admirably for currents of both frequencies. It will be observed that a tuned unit 41—42, comprising a condenser 41 and an inductance 42 in multiple, is used to pass the low frequency current and block the flow of high frequency current, and that a similar tuning unit 43—44, comprising a condenser 43 and an inductance 44 is employed to pass the high frequency current and block the flow of low frequency current. These tuning units 41—42 and 43—44 are resorted to to allow the flow of current only into the circuits for which they are intended and to prevent one source of current from becoming a load or short circuit for the other source of curent.

In oder to properly ground the cathode Ca (Fig. 2) with respect to the midpoint of all of the potentials applied to the winding 40 and the screen grids connected thereto, the ground network, including resistance units 45, 46, 47, and 48, has been provided in Fig. 2. The purpose of this group of resistances connected in star

fashion has already been explained in connection with Fig. 1 of the drawings.

Operation—Fig. 2.—As already pointed out the fundamental or low frequency current and the supplemental or high frequency current applied to the structure of Fig. 2 produces rotating magnetic fields which rotate in the same direction because the same phase splitting network is used for both alternating currents and also for reasons heretofore pointed out, the frequency of the supplemental alternating current is five times that of the fundamental alternating current frequency. Referring now to Fig. 5 of the drawings, let us assume that the voltage vector **50** is the voltage derived from the generator AC (Fig. 2) and that the voltage vector **51** is derived from the frequency multiplier FM2 and that these two voltages are in phase as illustrated in Fig. 5. Since the fundamental frequency is only one-fifth that of the auxiliary frequency let us assume that an instant of time later when the fundamental frequency has shifted 18° (one-fifth of 90°) as illustrated by the vector **52**, at which time the high frequency vector has shifted to an extent of 90° as illustrated at **53**. It is thus seen that the magnetic phase rotation produced by the stator IS2 and its winding **40** has shifted from a position midway between two anodes to a position substantially directly over one anode during an 18° shift of the fundamental magnetomotive force and that the sum of the magnetomotive forces was greatest when the speed of magnetic field was greatest, as shown by curve **49** (Fig. 5) .Let us further observe that during the next 18° of rotation of fundamental magnetomotive force to the position indicated by the vector **54**, the auxiliary frequency again rotates through an angle of 90° so that practically no net rotation of magnetic field has taken place in that the high speed vector **55** when added to the fundamental vector **54** results in practically no net phase shift. Let us now observe that during the next 18° of rotation of the fundamental magnetomotive force vector as illustrated by the vector **56** the high speed vector **57** actually rotates backwards to a greater extent so that the magnetic field does not only not advance but actually rotates in the reverse direction during this one-twentieth of a revolution (18°) of the magnetic field. By studying the graphic analysis illustrated by the curve **49** in Fig. 5 of the drawings it is readily seen the anodes should be placed at points 45° displaced from the vertical and horizontal lines of the diagram as is also true of the Fig. 6 structure. It is also readily seen that in the Fig. 5 diagram the magnetomotive forces are strongest when the field shifts forwardly at a high speed whereas in the Fig. 6 structure the magnetomotive forces are the smallest during such fast shifting of the magnetic field. Conversely the rotating beam is less sharply focused when the electron beam is aimed at an anode in the Fig. 5 structure whereas it is most sharply focused when in communication with an anode in the structures the analysis of which are shown in Fig. 6.

Structure and Operation—Fig. 3.—The embodiment of the invention illustrated in Fig. 3 is identical to that illustrated in Fig. 2 except that the iron stator IS3 illustrated in Fig. 3 is a stator employing a magnetic structure having as many salient poles **59** as there are anodes, there being a single coil winding **60** for each salient pole **59**, and that the voltages derived from the sources AC and FM3 are connected in series in Fig. 3 as distinguished from being connected in multiple as they are in Fig. 2. In the Fig. 3 structure there are provided two by-pass tuning units **61—62** and **63—64**. The tuning unit including the condenser **61** and the inductance **62** in multiple has electrical constants such that it permits the flow of low frequency current derived from the generator AC but blocks the flow of high frequency current derived from the frequency multiplier FM3 and the tuning unit **63—64** comprising a condenser **63** and an inductance **64** in multiple, has electrical constants such as to block the flow of low frequency current derived from the generator AC and to by-pass the high frequency current derived from the frequency multiplier FM3. Since the operation of the structures illustrated in Figs. 2 and 3 are identical no specific operation or discussion of vector diagrams or other graphical analysis need be given except to say that the analysis illustrated by curve **49** of Fig. 5 is applicable.

Structure and Operation—Fig. 4.—The apparatus illustrated in Fig. 4 is very similar to that illustrated in Fig. 1, these devices differing particularly in that only one winding **65** is contained on the stator IS4. This winding **65** is supplied by alternating current from two independent phase shifting and grounding networks similar to those illustrated in Fig. 1, these networks being supplied by alternating currents of different frequencies as already explained in connection with Fig. 1 of the drawings. It should be observed that a tuning unit including the condenser **71** and inductance **72** has been provided in Fig. 4 to pass alternating current of low frequency derived from the alternating current source AC, and to block the flow of high frequency current derived from the frequency multiplier FM4. The condenser **71** and inductance **72** of this unit **71—72** of course have electrical constants so as to perform both a tuning function for the low frequency current and a blocking function for the high frequency current. It should also be noted that condensers **73** and **74** have been provided to tune the transformers Tr1 and Tr2 respectively so that the two alternating current sources are properly isolated from each other by a suitable tuned unit. That is, the secondary windings of transformers Tr1 and Tr2 are tuned to pass high frequency current and block the flow of low frequency current. In all other respects the structure of Fig. 4 is similar to that of Fig. 1 and since both of these structures produce the same operating results it is unnecessary to specifically discuss the operation of the apparatus illustrated in Fig. 4. It may, however, be pointed out that the functional results of the Fig. 4 structure are graphically illustrated by the curve **23** in Fig. 6 of the drawings, the frequency of the high frequency current being three times the frequency of the low frequency current.

It should be understood that independent generators connected to the same shaft or interconnected by gear connections may be used instead of the generator AC and its associated frequency multiplying unit FM4 illustrated. In this connection it should be borne in mind that the two alternating currents must have a constant and fixed frequency ratio. It should however be understood that any desired voltage relationship within limits may be employed but the voltage of the higher frequency energy per unit of impedance should always be less than the voltage of the low frequency energy.

It is further desired to point out that the rotating electron beam tube of the present invention lends itself particularly well to systems where such tubes are connected in cascade or in tandem as is the case for systems illustrated in the prior filed pending application of Field and Wight, Ser. No. 599,328, filed June 19, 1945, which has resulted in Patent No. 2,488,487, dated August 31, 1948. In that patent two rotating beam electron tubes are so connected in circuits and are so controlled that the electron beam in one tube makes a complete revolution while the electron beam in another tube sweeps from engagement with one anode to engagement with another anode. In such a system it therefore becomes important that as little time as possible be lost by the beam of the slow tube in moving from one anode to the next anode in that it should be in communication with any particular anode during substantially the entire rotation of the electron beam of the fast tube and should then shift very quickly to another anode. The importance of rotating electron beam tubes whose rotating beam rotates in step-by-step fashion with varying sharpness of focusing should now be apparent not only where individual tubes are used separately but also where such tubes are connected in tandem.

Briefly stated the rotating beam electron tube, if used in accordance with the present invention, may be used to transmit a plurality of telephone conversations simultaneously but on the time allotment basis or may be used in a synchronous type control or indication system by controlling simultaneously or in sequential relationship a plurality of devices from a distant point either over line wires or through the medium of space radiation, and performs these functions more efficiently and more accurately than do mechanical devices.

Having thus shown and described numerous ways and means for causing an electron beam in an electron tube to rotate in step-by-step fashion and how to more sharply focus this electron beam either as it is moved from anode to anode, or as it hesitates on an anode, it is desired to be understood that these various examples in which the present invention may be practiced have merely been resorted to for the purpose of explaining the nature of the invention and its underlying principles and that various other structures may be employed to accomplish the same or similar results and it should be understood that various changes, modifications and additions may be made in practicing the invention without departing from the spirit or scope thereof except as demanded by the scope of the following claims.

What I claim as new is:

1. In an electronic translating device, the combination with a sealed envelope, a cathode near the axis of said envelope, a plurality of anodes surrounding said cathode, suppression grids between the cathode and the anodes, and an electromagnet having a multiple phase winding surrounding said anodes, of circuit means for energizing said winding simultaneously by multiple phase alternating currents of two different frequencies, one frequency being a multiple of the other, whereby the resultant magnetic field rotates in a step-by-step manner, and means for electrostatically energizing said suppression grids with respect to said cathode from both of said frequency currents, whereby the electrons emitted by said cathode are formed into a radial beam rotated from anode to anode in accordance with the rotation of said resultant magnetic field.

2. In an electronic translating device, the combination with a sealed envelope, a cathode near the axis of said envelope, a plurality of anodes circumferentially disposed about said cathode, suppression grids between the anodes and the cathode, and a two-phase electromagnet surrounding said anodes, of circuit means for energizing said electromagnet by two-phase energy from two different frequency currents simultaneously, one frequency being a multiple of the other, whereby the resultant magnetic field rotates in a step-by-step manner, and means for electrostatically energizing each of said suppression grids with energy of varying potential with respect to said cathode in synchronism with said rotating field whereby the electrons emitted by said cathode are concentrated into a beam extending radially from said cathode and scanning the respective anodes step-by-step in synchronism with the rotation of said resultant magnetic field.

3. A rotating beam tube organization comprising, a centrally located cathode in an evacuated envelope, a plurality of anodes circumferentially disposed about said cathode, a suppressor grid between each anode and the cathode, a source of two-phase alternating current at a particular frequency, a source of two-phase alternating current at a multiple frequency of said particular frequency, circuit means for applying each of said frequency currents to said suppressor grids electrostatically in a manner to render such grids alternately positive and negative with respect to said cathode, a two-phase electromagnet surrounding said anodes, circuit means governing the energization of said electromagnet from both of said sources of alternating current simultaneously, whereby the electrons emitted from the cathode are concentrated into beams by the respective rotating fields of said electromagnet and a single radial beam of increased concentration is formed each time that the two frequencies are in phase.

4. In a rotated beam tube organization of the character described, the combination with a single cathode centrally located in an evacuated envelope and a plurality of anodes circumferentially located about said cathode, of a two-phase electromagnet surrounding said anodes, and circuit means governing the energization of said electromagnet wherein rotating fields of different frequencies are set up in said electromagnet by the energization of said electromagnet with two-phase alternating current of two different frequencies, one frequency being a multiple of the other, and the lower frequency current providing a relatively stronger field than the higher frequency current, whereby the electrons are concentrated into beams by the respective rotating magnetic fields, a more concentrated beam being provided by the field set up by the lower frequency current, and that beam being intermittently concentrated to a still greater extent when both frequency currents are substantially in phase.

5. A rotating beam tube organization comprising, a single cathode centrally located in an evacuated envelope, a plurality of anodes circumferentially located about said cathode, a two-phase electromagnet surrounding said anodes, circuit means governing the energization of said electromagnet wherein said electromagnet is ener-

gized simultaneously by two-phase alternating currents of two different frequencies, one frequency being a multiple of the other, whereby the electrons emitted from the cathode are concentrated into beams by the respective rotating fields of said electromagnet in response to energization simultaneously by the two different frequency currents and a single beam of increasing concentration is formed each time that the two frequencies are in phase.

JOHN C. O'BRIEN.

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