

March 5, 1946.

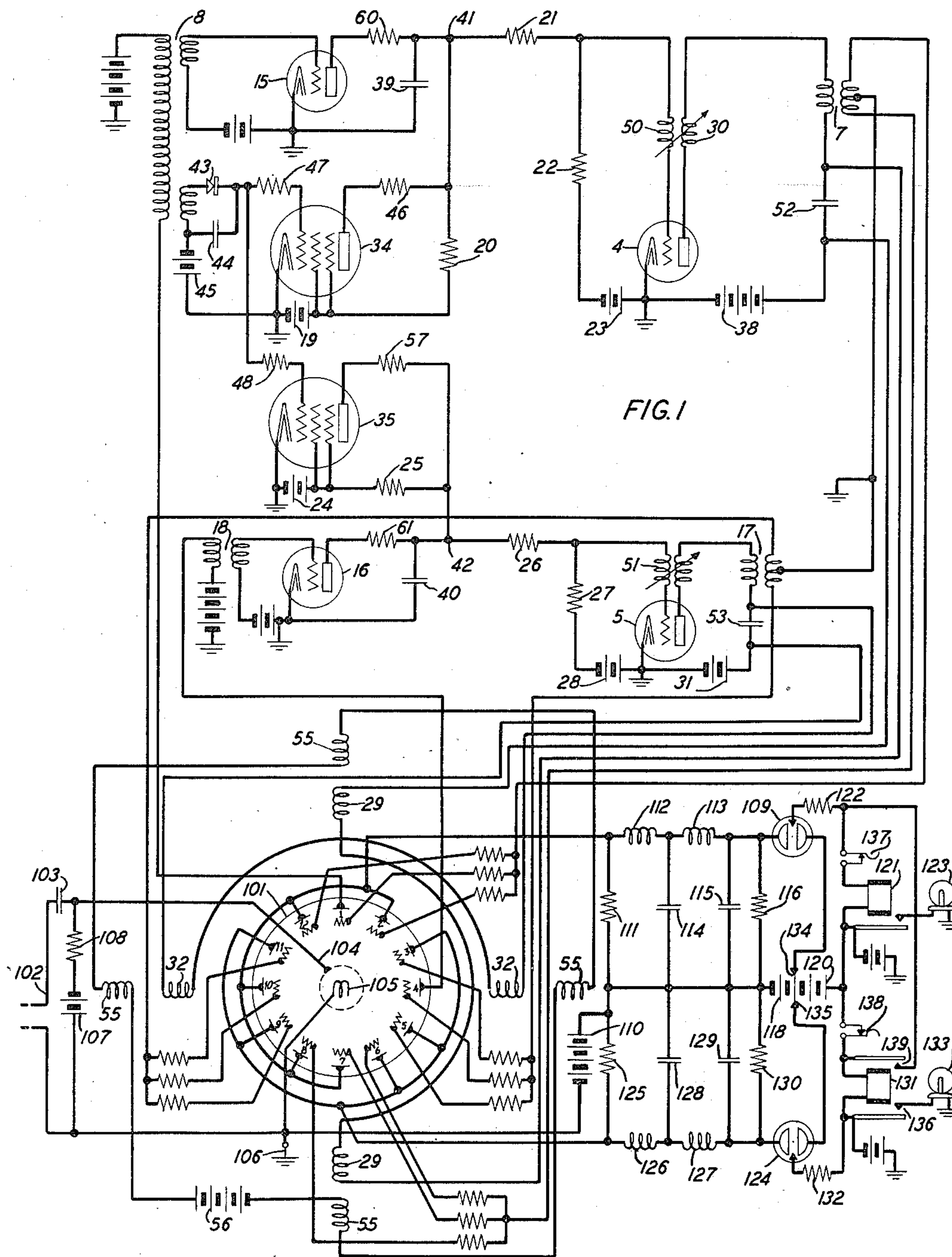
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2,396,211

SELECTIVE CALLING SIGNAL DEVICE

Filed Sept. 16, 1942

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

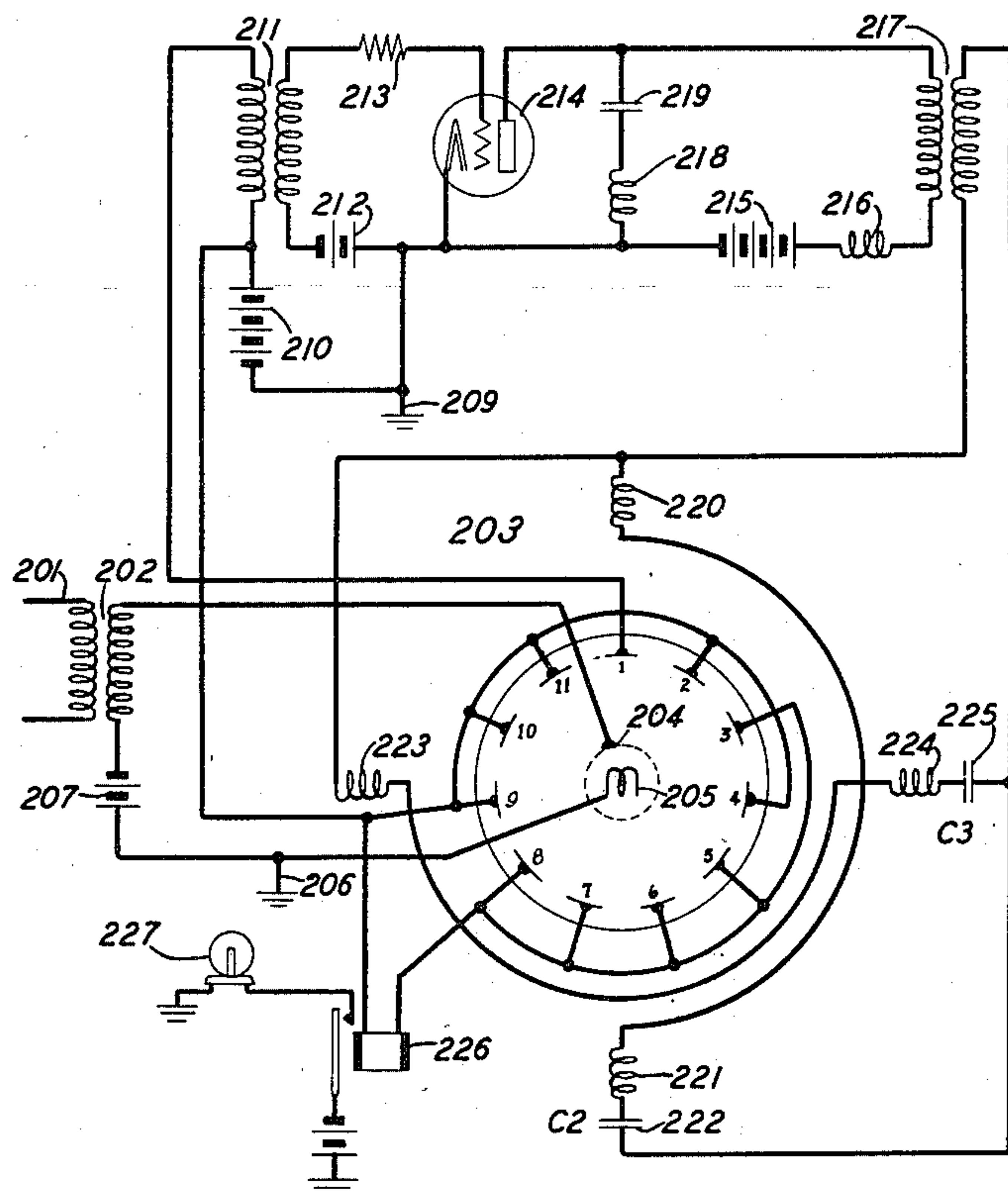


FIG. 2

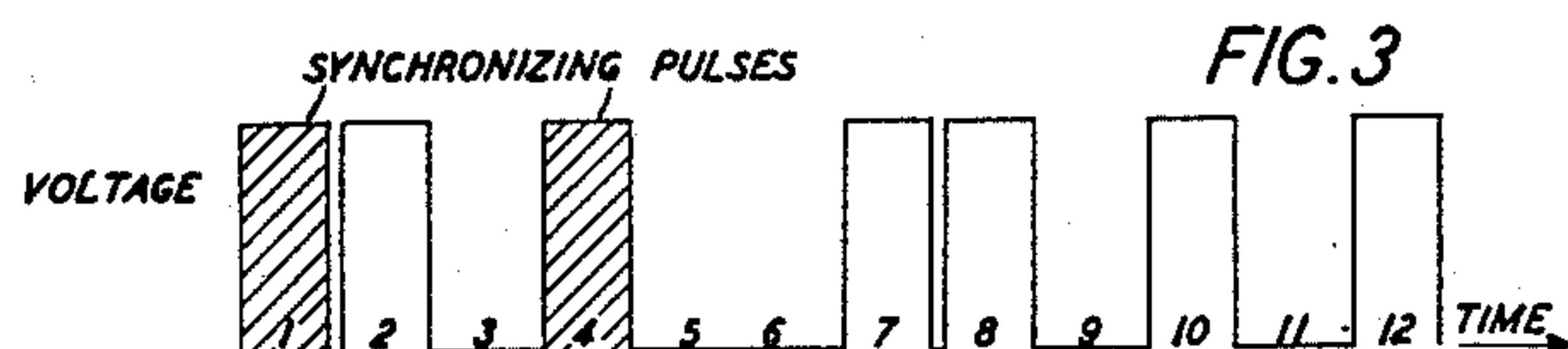


FIG. 3

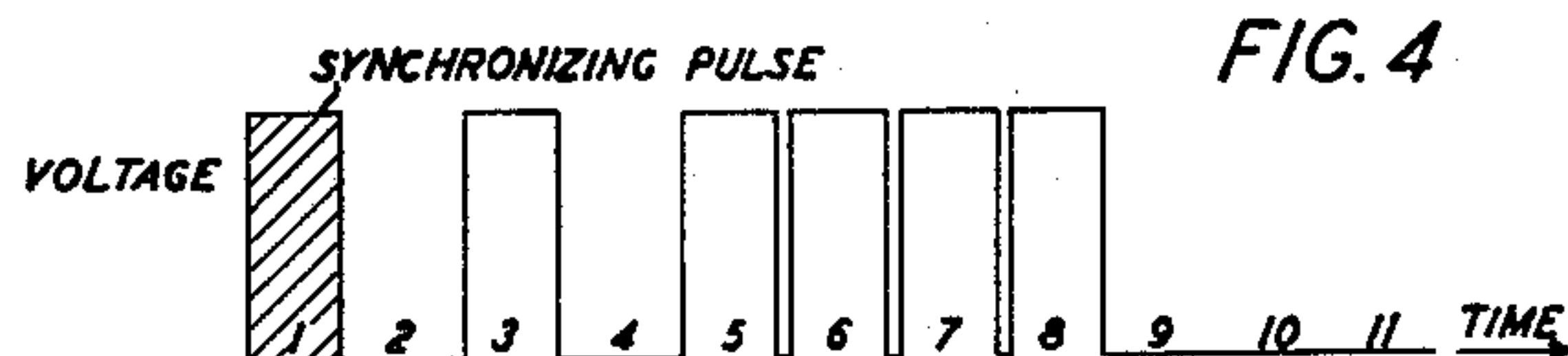


FIG. 4

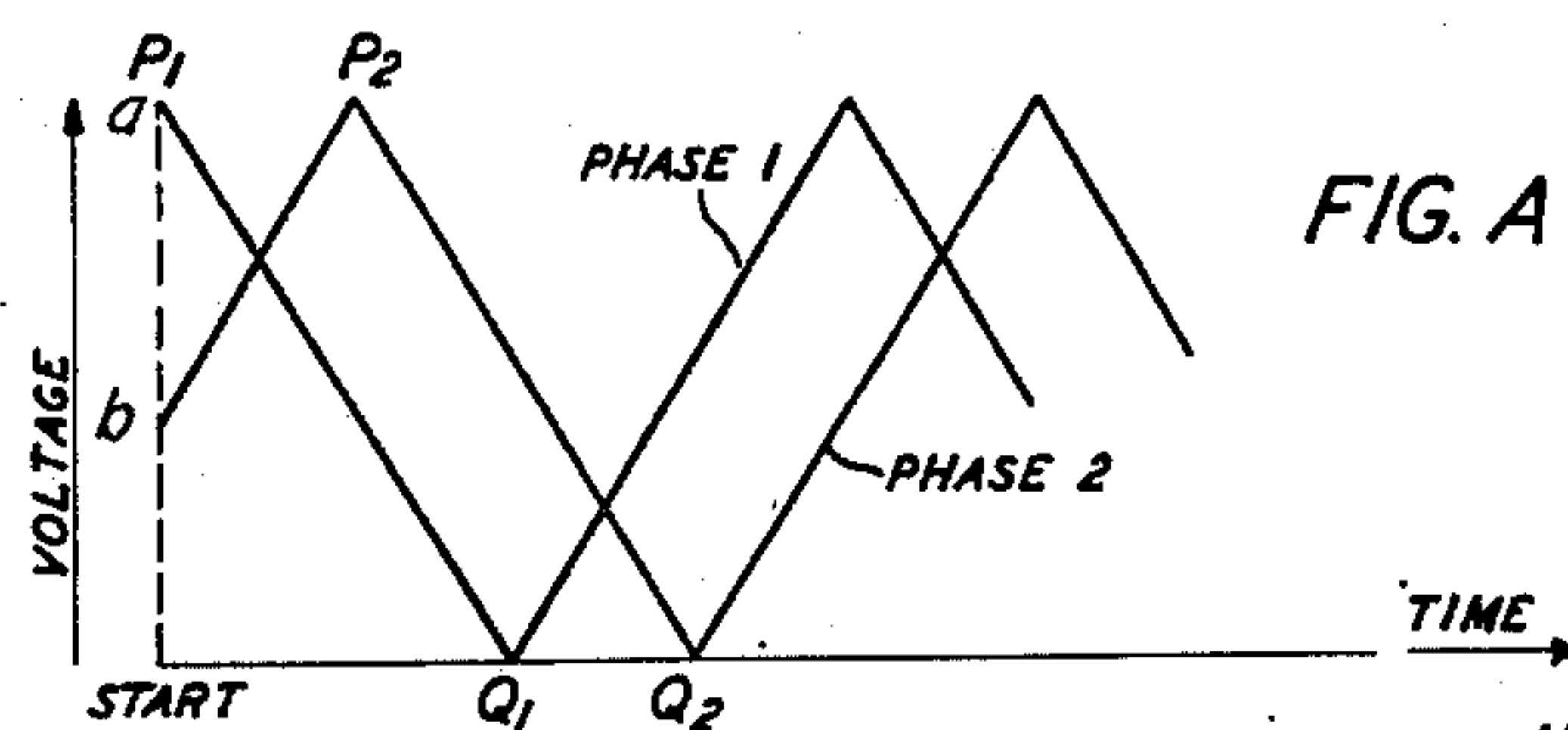


FIG. A

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SELECTIVE CALLING SIGNAL DEVICE

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Application September 16, 1942, Serial No. 458,503

10 Claims. (Cl. 177—353)

This application pertains to selective calling signal systems wherein any one of a large number of receiving stations is selectively called in response to signals transmitted by a calling station.

The invention is particularly applicable where calling and called stations are interconnected by means of a radio telephone circuit using a single wave-length. A selective calling device, such as described herein, would be furnished at each receiving station, which station might be located in mobile units such as boats, airplanes, automobiles, etc. In response to the transmission of a particular signal code assigned to a particular receiving station, the selective calling mechanism at that receiving station only would be operative.

It is an object of the present invention to improve selective calling signal systems.

The invention features a selective calling signal receiving circuit employing a multianode electron beam tube as the principal code discriminating selecting element. Multi-anode radial electron beam tubes are described in my Patent 2,217,774, issued October 14, 1940. In response to an electrical condition imposed between the grid and cathode of such a tube, electrons are emitted from the cathode. An externally applied rotating magnetic field serves to tend to concentrate the electrons emitted from the cathode into a beam and to rotate the beam. In the invention herein electrons are emitted from the cathode in response to time spaced impulses in accordance with a permutation code and are directed at circumferentially spaced anodes in positions corresponding to the code.

Two different forms of electron beam directing and rotation synchronizing devices suitable for use with the embodiment of the invention per Fig. 1 herein are described in detail by applicant in a copending application, Serial No. 451,355, filed July 17, 1942. The invention herein discloses two different embodiments of selective calling signal arrangements. In one embodiment, an electron beam rotation synchronizing arrangement corresponding closely to one disclosed in the above-identified application and shown in Fig. 1 thereof is employed. In the other embodiment, a simplified form of electron beam rotation synchronizing arrangement is employed.

The invention may be better understood from the following description when read with reference to the associated drawings in which:

Fig. 1 shows one embodiment of a selective calling signal device for a receiving station. It is assumed that the mechanism per Fig. 1 is located

at a particular receiving station in the system. The transmitting equipment used for sending out the calling code signals is not shown as such devices are well known. In the arrangement shown in Fig. 1, two anodes in the multi-anode beam tube, anodes 1 and 4 are employed to control the rotation of the electron beam.

Fig. 2 discloses a second embodiment of the invention. In this embodiment one anode only, anode 1, in the radial electron beam tube is employed to control synchronization. The circuit per Fig. 2 includes a simplified form of synchronizing circuit.

Fig. 3 shows a pattern of signal impulses in voltage time relation comprising two synchronizing pulses and a code for a particular called station consisting of five selective signal calling pulses which are assumed to be used when the anodes in tube 101 in Fig. 1 are arranged as shown.

Fig. 4 shows a pattern of signal impulses in voltage time relation comprising one synchronizing pulse and a code for a particular called station consisting of five selective calling signal pulses corresponding to the code to which receiving tube 203 in Fig. 2 is arranged to respond.

Fig. A shows a time voltage diagram of two saw-toothed voltage waves in quadrature developed in the synchronizing circuit per Fig. 1. The figure is used in explaining Fig. 1.

Refer now to Fig. 1. The manner in which the circuit shown in this figure functions will now be described in a general way to facilitate the understanding of the detailed description to follow.

General description of the operation of the circuit per Fig. 1

Trains of signal elements, each having an unvarying number of signal elements are transmitted from the transmitting tube at a distant transmitting station (not shown) and impressed on the input circuit of each receiving tube in the system such as tube 101 in Fig. 1. While each receiving tube is awaiting the reception of the first element of a train of selective calling signals, a magnetic field is set up in the stator surrounding the envelope of each receiving tube, by a pair of locally controlled vacuum tube circuits in the synchronizing circuit connected to each tube, which tends to direct the first stream of electrons, which will be emitted in response to the reception of the first signal element of any signal train, towards a particular one of two preselected synchronizing anodes in each tube. This anode,

anode 1, which is the starting anode, is known as the synchronizing circuit control anode. It occupies the same relative position in each tube. When the first electron beam emitted by each receiving tube in the system, in response to the reception of the first signal element of a train, impinges on preselected starting anode 1 in each tube, the steady magnetic field which has theretofore been set up by the local vacuum tube circuits in the winding of each stator, tending to direct the first electron beam to be emitted towards the preselected starting anode, will be changed instantly to a rotating field which tends thereafter to rotate the electron beams as they are intermittently emitted in response to received signal impulses in accordance with the calling code.

The change from the steady to the rotating field is effected in the following manner. The electron beam impinging on the preselected synchronizing control starting anode immediately starts the operation of two relaxation oscillator circuits connected to the starting anode. The two relaxation oscillators generate two saw-toothed voltage waves. The waves are held in synchronism with the beam in the transmitting tube and in quadrature with respect to each other under control of the two incoming synchronizing pulses received on each cycle which direct beams at the two synchronizing anodes, anodes 1 and 4, which are spaced 90 degrees apart in each tube. The times of impinging of the beams on the two synchronizing anodes determine the times of occurrence of the peaks of the two saw-toothed waves, shown in Fig. A, by firing two gas-filled tubes. The two saw-toothed voltage waves in quadrature are impressed on the input circuits of two vacuum tubes which generate two sinusoidal voltage waves in quadrature which are impressed on the stator windings surrounding the envelope of each multianode receiving tube to rotate the beam in each receiving tube in synchronism with the beam in the transmitting tube.

It is particularly pointed out that in the synchronizing arrangement per Fig. 1 herein, the beam in each receiving tube is first directed at a particular anode, anode 1, occupying the same relative position in the receiving tube at each receiving station. The position corresponds to the position of the starting anode in the transmitting tube. The beam rotates at the same rate in each receiving tube and all rotate at the same rate as the rotation of the beam in the transmitting tube. Each beam emitted in each tube in response to an incoming signal will, therefore, impinge on an anode in a corresponding position in each tube simultaneously.

In the embodiment of the invention shown in Fig. 1, it is assumed that the cooperating transmitting tube has twelve anodes, two of which, namely, anodes 1 and 4, spaced at 90 degrees are arranged to transmit synchronizing pulses and the remaining ten of which may be used to transmit code signals. It is assumed that the multi-anode radial electron beam transmitting tube circuit at the distant station (not shown) is arranged in a manner well known in the art with means for transmitting current pulses resulting from the impinging of electron beams in the transmitting tube at preselected anodes. The anodes from which the current pulses at the transmitting station are transmitted will correspond in their relative position in the transmitting tube with the code number of the called station. A different code will be assigned to each one of the receiving stations. It is assumed that for

each code signal five pulses which may be from any five of the ten anodes in the transmitting tube available for the code will be transmitted. The calling code pulses for any particular receiving station will be spaced in time dependent upon the position of the particular code anodes assigned. Each train of signal elements will, therefore, comprise a starting pulse, which also serves as a synchronizing pulse, a second synchronizing pulse which always is transmitted a quarter cycle later and five code pulses which may be transmitted at any five of the ten intervals available for the transmittal of a code impulse. With such an arrangement, it is possible to assign a different calling signal code to each of two hundred and fifty-two receiving stations.

The transmitted signal impulses will be received by each receiving station. In response to the reception of the first synchronizing signal impulse, a beam of electrons will be directed at anode 1 of each receiving tube. In response to the reception of the first signal impulse and the resulting impinging of the first beam of electrons on the starting anode, rotating fields will be set up in each stator winding tending to rotate the electron beam. It is to be understood that once a directing field is started in rotation it continues to rotate as long as synchronizing pulses are received but electron beams are not emitted from the cathode of each receiving tube continuously. The beams are emitted intermittently in accordance with the code. An electron beam will be emitted by the cathode of each tube each time a signal is received by each tube. As the directing field rotates, it will direct the beam at an anode in a corresponding position only if a signal impulse is received at the instant. This in turn depends upon whether a beam has been directed at a corresponding anode in the transmitter in accordance with the code. As the directing field rotates, a stream of electrons will be directed at each of the five anodes corresponding to the code of the called station. The five anodes corresponding to the code of each receiving station will be wired in parallel at that station and connected through a filter circuit. Current from the output of the filter circuit will develop a potential across a resistance in the input circuit of a first cold cathode tube, such as tube 109 in Fig. 1, to be known as the calling signal enabling tube. The developing of the proper potential across the resistance to fire the enabling tube will depend upon the impinging of an electron beam on each of the five anodes corresponding to the code of the selected station. Thus, in order to obtain the proper potential condition for the firing of the tube, it is necessary that a beam impinge upon each of the five anodes corresponding to the code of the called station.

It was pointed out that there are twelve anodes in each tube 101 in Fig. 1. It has been assumed that two of these anodes are used for synchronizing the rotation of the directing fields with the rotation of the transmitting beam. Five anodes in each receiving tube are used for the reception of the calling code for the station. This leaves five other anodes in each receiving tube. The five other anodes are disabling anodes. They are connected in a parallel circuit and the circuit is extended through a filter to the input of another cold cathode tube, such as tube 124 in Fig. 1, to be known as the disabling tube. At any particular receiving station if a beam impinges on any anode other than the two synchronizing anodes and the five anodes corresponding to the calling code of

that station, the disabling tube will be activated. The second cold cathode tube, therefore, will function if a beam impinges on any of its five associated disabling anodes. It will function, therefore, at each receiving station other than the called station. When the second or disabling cold cathode tube functions, it disables the output circuit of the first cold cathode tube. In order, therefore, for the output circuit associated with the cold cathode tube controlled by the anodes corresponding to the code of the called station to be operative, two conditions are necessary. These conditions are: (1) An electron beam must impinge on each of the five anodes in a receiving tube corresponding to the code assigned to that particular station. (2) An electron beam must not impinge on any of the ten anodes available, for assignment as code anodes, other than the five assigned for the particular station calling code.

Detailed description of the operation of the circuit per Fig. 1

The embodiment of the invention per Fig. 1 will now be described in detail. First, the synchronizing circuit will be explained.

It is assumed that line 102 is connected to a multianode radial beam transmitting tube at a distant transmitting station. The connecting link may be by means of a radio telephone circuit using a single wave-length or, if the receiving stations are not mobile, a telephone or telegraph line circuit of a wide variety of forms may be employed. The incoming circuit extends through condenser 103 to the grid 104 of the multianode radial electron beam vacuum tube 101. Cathode 105 is connected to ground 106. Negative battery 107 is connected between ground 106 and grid 104 through resistance 108.

While tube 101 is awaiting the arrival of the first signal pulse of any train of signal pulses employed in calling a particular station, a magnetic field is set up in the beam rotating stator surrounding the envelope of tube 101 tending to direct the beam emitted by cathode 105, in response to the first signal element impressed upon the input circuit of tube 101, towards anode 1.

In any train of signal elements used in calling any receiving station, two signal elements will be used to rotate the beam in the transmitting and receiving tubes in synchronism. As indicated in Fig. 3, the first signal impulse transmitted is always a synchronizing impulse. The first impulse starts the stator fields rotating. The beam which is directed at the anode in the transmitting tube corresponding to anode 4 is also always a synchronizing impulse. It will arrive when the directing fields in the receiving tubes have been rotated so that they tend to direct an emitted beam at anode 4. The effect of the two controlling beams maintains the speed of rotation of the directing fields in all of the receiving tubes the same as the speed of rotation of the beam in the transmitting tube. In Fig. 3, signal pulses 1 and 4 are cross-hatched to indicate that they are synchronizing impulses and not selective signal calling impulses.

Beam rotation synchronizing circuit

The beam rotation synchronizing circuit described in detail in my above-mentioned application will be described herein in so far as it is necessary to an understanding of the present invention.

Synchronizing anodes 1 and 4 in tube 101 are shown wired to the primary of individual trans-

formers 8 and 18 of the beam rotation synchronizing circuit.

Before any signals are received from the transmitting station, the field in the stator coils 29 and 32, surrounding the envelope of multianode beam tube 101, is of such a magnitude and direction as to tend to direct the first beam that is emitted by cathode 105, in response to the reception of the first element of a train of signals toward anode 1. This is accomplished by generating currents of the proper magnitude in tubes 4 and 5 during the period while the tube 101 is awaiting the reception of calling signals. This in turn is controlled by individual potentiometers connected to the inputs of tubes 4 and 5. The potentiometer for tube 4 comprises grounded positive battery 19, resistance 20, resistance 21, resistance 22 and grounded negative battery 23. The potentiometer for tube 5 comprises grounded positive battery 24, resistance 25, resistance 26, resistance 27 and grounded negative battery 28. Stator coils 29 are connected across condenser 52 in the output circuit of tube 4. Stator coils 32 are connected across condenser 53 in the output circuit of tube 5. The instant the first beam impinges on anode 1, the outputs of tubes 4 and 5 are changed so that they develop sinusoidal voltage waves in quadrature to tend to rotate the beam in tube 101. The period of the sinusoidal voltage waves is controlled by the impinging of the beam on anodes 1 and 4 through relaxation oscillator circuits which develop saw-toothed voltage waves in quadrature which are applied to the inputs of tubes 4 and 5. The saw-toothed voltage waves indicated phase No. 1 and phase No. 2 are shown in Fig. A. The manner in which the saw-toothed voltage waves in quadrature are generated will now be described in more detail.

Tubes 15 and 16 are gas-filled trigger tubes. Tubes 34 and 35 are secondary emission tubes such as described in my Patent No. 2,293,177, issued August 18, 1942. Tubes 15, 16, 34 and 35, unlike tubes 4 and 5 are normally deactivated. That is to say, while awaiting the reception of the first impulse of a train of selective calling signals, all four of these tubes are non-conducting.

Condenser 39 is charged to full voltage, as indicated by ordinate *oa* in Fig. A, by the voltage impressed between point 41 on the potentiometer associated with tube 4 and ground, while awaiting the first synchronized pulse through transformer 8. Condenser 40 is charged to the voltage indicated by ordinate *ob* in Fig. A, by the voltage impressed between point 42 on the potentiometer associated with tube 5 and ground, while awaiting the first pulse.

In response to the reception of the first signal element of the train of selective calling signals, a voltage pulse is impressed across the primary of transformer 8 and induced in the two secondary windings of the transformer. The input circuit of tube 34 extends from the grounded cathode of tube 34 through the negative grid biasing battery 45, bottom secondary winding of transformer 8, copper-oxide rectifier 43 and resistance 47 to the grid of tube 34. A condenser 44 shunts the transformer winding and rectifier 43. Negative battery 45 normally deactivates tube 34. The first pulse charges condenser 44 to a relatively high potential. Rectifier 43 is poled so that it offers low resistance to the charging of condenser 44. The voltage developed across the condenser is fed through high resistances 47 and 48 to the grids of tubes 34 and 35, respectively. Because of the magnitudes of these resistances,

the grids are maintained at about the same potentials as their cathodes.

On each negative half cycle, condenser 44 starts to discharge through rectifier 43 in the high resistance direction. The discharge is relatively slow. Before it can discharge sufficiently, as a result of the rotation of the beam in a manner to be described, the beam in tube 101 will be positioned so that it again impinges on anode 1 and condenser 44 will be recharged. In other words, once rotation is started, condenser 44 will receive relatively heavy surges of charging current once per rotation of the beam in tube 101 and condenser 44 will be discharged so slowly between charging intervals that tubes 34 and 35 will remain activated as long as the beam rotates.

Attention is especially directed to the fact that tubes 34 and 35 are activated simultaneously. Both tubes 34 and 35 are activated in response to the impinging of the first stream of electrons on anode 1 in tube 101 and the response is instantaneous.

Tube 15 fires instantly in response to the impinging of the first stream of electrons on anode 1 of tube 101. When tube 15 fires, it provides a discharge path through the tube for condenser 39. As condenser 39 discharges through tube 15, its potential decreases from that indicated by ordinate *oa* as shown by the curve phase 1 in Fig. A until it reaches a point at which tube 15 is deactivated. From this point, the potential across condenser 39 increases due to the effect of the current flowing in the output circuit of tube 34, which, as has been explained, remains conducting. The potential across condenser 39 rises again to a peak equal to its original potential *oa* as indicated by the curve phase 1. Then tube 15 is refired by the stream of electrons impinging on anode 1 a second time due to the rotation of the electron beam in a manner to be explained.

Refer now to the curve marked phase 2 in Fig. A. As explained above, the potential across condenser 40 before the first signal impulse is received from the distant station is indicated by ordinate *ob*. It was also explained that tube 35 was activated simultaneously with the activation of tube 34 at the instant the first electron beam impinged on anode 1 in tube 101. Condenser 40 is connected in the output circuit of tube 35. The instant tube 35 is activated, the potential across condenser 40 starts to rise as indicated by the curve phase 2 in Fig. A. The potential across condenser 40 will continue to rise until tube 16 is fired in response to the impinging of the electron beam on anode 4 in tube 101 as the field is rotated.

When the electron beam in tube 101 impinges on anode 4, as the beam is rotated, a voltage pulse will be induced in the primary of transformer 18. At this instant the voltage across condenser 40 will have risen so that it is equal to *oa* as indicated by the point P2 on curve phase 2 of Fig. A. Tube 16 will fire at point P2 on the curve phase 2 in Fig. A. After the tube fires, the condenser 40 will discharge through the tube. The potential across condenser 40 will decline as indicated along the line P2Q2 until a point is reached at which tube 16 is deactivated. Then it will again rise due to the effect of the charging current in the output circuit of tube 35 which tube, as explained, remains conducting.

The potential across condenser 39 between junction 41 and ground will be applied between the grounded cathode and grid of tube 4 through

resistance 21 and coil 50. The potential across condenser 40 will be applied between the grounded cathode and grid of tube 5 through resistance 26 and coil 51. The slopes of the curves phase 1 and phase 2 can be controlled by a proper choice of constants of the elements comprising their circuits.

In response to the impressing of the saw-toothed voltage wave of the curve phase 1 on the input of tube 4, a sinusoidal voltage wave is generated in the output circuit of tube 4 which is applied to the stator coils 29. In response to the impressing of the saw-toothed voltage wave of the curve phase 2 on the input of tube 5, a sinusoidal wave is generated in the output circuit of tube 5 which is applied to stator coils 32. As shown in Fig. A, the two saw-toothed voltages are displaced in phase. The first peak of the curve of phase 1, as has been shown, occurs at the instant when the electron beam in tube 101 impinges on anode 1. The corresponding first peak of the sinusoidal voltage wave impressed on stator coils 29 will occur at the same instant. The generation of the sinusoidal voltage wave in tube 5 will start at the same instant that the beam in tube 101 impinges on anode 1 as the voltage across condenser 40 is raised above the normal voltage at which it is maintained during the interval before the reception of the first signal impulse by tube 101.

Thus, in response to the reception of the first signal impulse by tube 101 and the impinging of the first electron beam on anode 1 of tube 101, two different voltage waves are instantly impressed on the input of tubes 4 and 5. The respective magnitudes of the two voltage waves impressed on the inputs of tubes 4 and 5 are controlled by a choice of circuit constants so that, in response thereto, the outputs of tubes 4 and 5, when impressed on their respective stator coils 29 and 32, rotate the electron beam in tube 101 so that when it impinges on anode 4, separated from anode 1 by 90 degrees, during the first revolution it will receive a synchronizing pulse which has been directed at an anode in a corresponding position in the transmitting tube at the distant station. This second synchronizing pulse, as has been shown, will fire tube 16. The time of occurrence and voltage across the condenser 40 at the instant is indicated by the time and voltage ordinates of the point P2 in Fig. A, at which point in voltage and time tube 16 fires. This point marks the maximum voltage attained by condenser 40. Its magnitude is controlled so that it is equal to voltage *oa*. The time is controlled so that it is separated from P1 by one-quarter of a full voltage change cycle.

After tube 16 fires, the voltage across condenser 40 will decline as indicated in Fig. A by the line P2Q2. Tube 16 is deactivated at point Q2. Then the voltage across condenser 40 will again rise as indicated by the curve phase 2 in Fig. A due to the charging of condenser 40 by the output of tube 35.

Each time the beam in tube 101 is rotated it will receive one synchronizing impulse from the transmitting tube which is directed at anode 1 and a second synchronizing impulse from the transmitting tube which is directed at anode 4. Trigger tube 15 will be alternately activated during the first half of its cycle while condenser 39 discharges through it and inactivated during the succeeding half cycle while the voltage across condenser 39 rises. During a cycle displaced by 90 electrical degrees, trigger tube 16 will be alter-

nately activated during the first half of its cycle while condenser 40 discharges through it and inactivated during its succeeding half cycle while the voltage across condenser 40 rises.

The net result is, as indicated by the curves phase 1 and phase 2 in Fig. A, the generation of two saw-toothed voltage waves displaced with respect to each other by 90 electrical degrees, with the period of each wave controlled by its corresponding synchronizing impulse in the transmitter. Any tendency of either wave to depart from synchronism is corrected once per cycle.

The two saw-toothed voltage waves in quadrature are applied to the inputs of tubes 4 and 5 which in response thereto generate two sinusoidal voltage waves in quadrature which are applied to their respective stator coils to rotate the beam in tube 101 in synchronism with the rotating beam in the distant transmitting tube.

The translation of the two saw-toothed voltage waves into two waves which are substantially sinusoidal is achieved by the filtering action of the tube circuits. It depends upon two factors: (1) Negative resistance furnished by the tube in the regenerative circuit and, (2) the tuning of the stator coils in the plate circuit to resonance at the cyclic frequency of the waves. The regenerative action is adjusted so that the negative resistance introduced is less than the positive resistance of the tube circuit, that is, just under the condition of oscillation.

Coils 55 are connected in series to battery 56. There is one coil 55 for each coil 29 and 32. Their windings are arranged so that they neutralize the effect of the direct current component in the output of vacuum tubes 4 and 5.

During the interval while the stator field is being rotated, electron beams will be directed at anodes in tube 101 in positions corresponding to the signal code sent out by the transmitting tube. This will operate the selective calling mechanism in a manner to be described below.

When the rotation of the electron beam in the distant transmitting tube stops, synchronizing pulses will no longer be received. Condenser 44 will have time to discharge. Tubes 34 and 35 will be deactivated by negative battery 45 connected to their grids. The potentiometers connected to tubes 4 and 5 will impress the proper potentials of the input circuit of tubes 4 and 5 so that the magnetic field developed by the stators in their output circuits will again tend to direct electrons emitted in response to the first signal impulse of the next train received by tube 101 toward anode 1. The potentials impressed across condensers 39 and 40 under control of their individual potentiometer circuits will again be as indicated by the ordinates *oa* and *ob* and the circuit will be again in condition to start.

It is necessary to suppress one of the electron beams, as two electron beams separated by 180 degrees tend to be emitted by the cathode. The manner in which this is performed is described in A. M. Skellett Patent 2,217,774 of October 14, 1940.

The two phase voltage supply required for suppressing one of the two electron beams is obtained from transformers 7 and 17 in the anode circuits of tubes 4 and 5.

As is well understood, the electrons, under the influence of the directing field of the stator, tend to be emitted as two beams separated by 180 degrees. For reasons, which will become apparent below, in the description of the selective call-

ing circuit per Fig. 1 to follow, it is necessary to suppress one of the beams. This is performed by impressing the sinusoidal voltages in quadrature obtained from tubes 4 and 5 on the twelve suppressor grids one of which is located opposite each of the twelve anodes in tube 101. Ground is connected to the mid-points of the secondaries of transformers 7 and 17. The top terminal of the secondary of transformer 7 is connected through three resistances in parallel to suppressor grids opposite anodes 12, 1 and 2. The bottom terminal of the secondary of transformer 7 is connected through three resistances in parallel to suppressor grids opposite anodes 6, 7 and 8 spaced 180 degrees, respectively, from the suppressor grids opposite anodes 12, 1 and 2. The top terminal of the secondary of transformer 17 is connected through three resistances in parallel to the suppressor grids opposite anodes 9, 10 and 11. The bottom terminal of the secondary of transformer 17 is connected through three resistances in parallel to the suppressor grids opposite anodes 3, 4 and 5. As thus arranged, as one-half of the electron beam tends to be directed at anodes 1 to 12 in succession as the field set up by the stator windings is rotated, the second beam is suppressed.

Attention is called to the fact that the one set of apparatus per Fig. 1 will be located at each receiving station. From the above it should be apparent that when each station in the system is idle, its apparatus per Fig. 1 is in condition to be called. The tubes such as tubes 4 and 5 at each station set up a field in the stator surrounding each tube, such as tube 101 at each station, such that the beam emitted in response to the reception of the first signal element of a calling signal train will be directed at the anode corresponding to anode 1 at each station. In response to this the stator field which theretofore has been tending to direct the first emitted beam at anode 1 in each tube, is instantly started in rotation. The rotation of the field of each tube is maintained in synchronism with the rotation of the electron beam in the tube at the transmitting station.

The manner in which the selective calling apparatus per se operates will now be described in detail.

Operation of the selective calling apparatus per Fig. 1

The transmitting tube and each receiving tube have twelve anodes located at corresponding positions in each tube. Two anodes in each tube, as has been explained, are reserved for synchronization. This leaves 10 anodes available as selective calling anodes. Five of these 10 anodes in each tube in positions corresponding to 5 numbers assigned as a code for each station are reserved for selective calling anodes. This makes it possible to assign a different five-element calling code to each of 252 stations served by one transmitting tube.

The anodes of each tube per Fig. 1 will be wired differently to correspond to its particular five-number calling code. It is assumed that the code of the station where the particular tube shown in Fig. 1 is located is 2, 7, 8, 10, 12. Anodes 2, 7, 8, 10 and 12 are, therefore, wired in parallel and connected to a filtering circuit associated with the input of cold cathode enabling tube 109. A circuit may be traced from ground 106 through positive battery 110, resistance 111 to anodes 2, 7, 8, 10 and 12 in parallel. Whenever an electron

beam impinges on any one of anodes 2, 7, 8, 10 or 12, the voltage across resistance 111 changes.

A filter comprising series inductance elements 112 and 113 and shunting condenser elements 114 and 115 interconnect the output circuit of the calling signal anodes 2, 7, 8, 10 and 12 and the input of tube 109. Voltage changes across the output of the filter are impressed across resistance 116 which is connected between negative battery 118 and the grid of cold cathode enabling tube 109.

As the stator directing fields of tube 101 are rotated by the beam synchronizing circuit, tube 101 will be conditioned so that if a signal impulse is received, the resulting emitted electron beam will be directed at an anode in the receiving tube in a position corresponding to the position of the anode in the transmitting tube where the impulse originated. Thus if current impulses resulting when beams directed at anodes 2, 7, 8, 10 and 12 in the transmitting tube are transmitted, as a result of the operation of the calling code mechanism at the transmitting station, beams will impinge on anodes 2, 7, 8, 10 and 12 at the receiving station. Current will flow from battery 110 through resistance 111 to each anode in turn and to ground through cathode 105. Each corresponding voltage pulse across resistance 111 will be impressed on the input of the filter.

Negative battery 118 connected through resistance 116 between the cathode and grid of tube 109 normally maintains tube 109 in the deactivated condition. The constants of the filter elements, resistance 116, battery 118 and tube 109 are so chosen that the output of the filter, when beams impinge on anodes 2, 7, 8, 10 and 12, impresses a voltage across resistance 116 in the input circuit of tube 109 such that tube 109 fires. The purpose of the filter is to smooth out the individual pulses of current into a substantially direct current. The time constant of the filter is much longer than the duration of one pulse and it smooths out the pulses into a substantially direct current. At the start of the reception of the train of pulses the voltage at the output of the filter starts to rise in a substantially exponential manner. For a cycle having five pulses impinging on the five selected anodes, the output voltage of the filter attains the highest ultimate maximum value. For a cycle having less than five pulses, such as four or three pulses, impinging on the five selected anodes the output voltage of the filter attains correspondingly lower maximum output voltages.

There may be slight variations in the voltage as it builds up to a maximum for particular spacings of the pulses but this is unimportant since the maximum voltage output for the filter, when less than five pulses are received, is always less than the maximum voltage, whatever the spacing of the pulses, when fewer than five are received.

When the output voltage of the filter has reached a value of say 95 per cent of the highest maximum attainable for five pulses per cycle, the gas tube 109 is fired, since the gas tube voltages are adjusted so that the tube will fire at values of voltage just below the maximum voltage attainable for five pulses, but will not fire for the maximum voltage attained for fewer than five pulses per cycle. When tube 109 fires current flows from the positive terminal of battery 120 through the winding of relay 121, switch 137, resistance 122, anode of tube 109 to the cathode of tube 109 and back to the negative terminal of

battery 120. The operation of relay 121 will in turn light lamp 123 over an obvious circuit.

A circuit may also be traced from ground 106 through positive battery 110 and resistance 125 to anodes 3, 5, 6, 9 and 11 in parallel. As the directing fields produced by the stator under control of the beam synchronizing circuit are rotated, if a signal impulse is received while the directing fields are in position to direct any emitted beam at any of anodes 3, 5, 6, 9 and 11, current will flow through resistance 125 impressing voltage on the input of the filter comprising series inductance elements 126 and 127 and shunting condenser elements 128 and 129.

The grid of tube 124 is normally maintained sufficiently negative with respect to its cathode, by negative battery 118 connected through resistance 130 between the grid and cathode of tube 124, that the tube is normally deactivated. The constants of the filter elements, resistance 130, battery 118 and tube 124 are so chosen that the output of the filter, when a beam impinges on any one of anodes 3, 5, 6, 9 or 11, impresses a voltage across resistance 130 in the input circuit of tube 124 such that tube 124 fires.

When tube 124 fires current flows from the positive terminal of battery 120, switch 138 through the winding of relay 131, resistance 132, anode of tube 124 to the cathode of tube 124 and back to the negative terminal of battery 120. Relay 131 will operate. The operation of relay 131, by closing contact 139, establishes a short circuit around the winding of relay 121. Relay 121 cannot operate therefore if relay 131 operates.

It is emphasized that enabling tube 109 will be activated only if an electron beam impinges on each one of the five anodes corresponding to the code of the called station. Tube 124, however, will be activated if an electron beam impinges on any one of the ten anodes reserved for code anodes other than the five anodes corresponding to the code of the particular station. In order to achieve this, the elements comprising the filter associated with each tube must be specially chosen for each station, according to well-known procedure, which is not a part of the present invention.

As is well-known in the art, once gas-filled trigger tube 109 or gas-filled trigger tube 124 has been activated, current continues to flow in the output circuit notwithstanding changes of potential in the input circuit. Relay 121 if operated, will remain operated unless it is shunted by the operation of relay 131. Relay 131 if operated will also remain operated.

After a signal has been recorded by lamp 123, the lamp may be extinguished by opening the path through the winding of relay 121 in any convenient manner. Switch 137 connected between the cathode of tube 109 and battery may be opened to perform this function. Relay 131 may control a lamp such as 133 through a second contact such as 136. The lighting of lamp 133 would indicate that a station other than the station corresponding to code 2, 7, 8, 10, 12 has been called and that relay 131 is, therefore, operated. In response to this switch 138 would be opened to release the relay and inactivate tube 124 so that the selective calling circuit would be in condition to receive a calling signal. As an alternative arrangement, for service where the number of calls in a given time is high, the lamp circuit for lamp 133 may be eliminated. Key 138 may be replaced by break contacts on relay 131 which are arranged to open after contact 139 closes.

Description of the operation of the circuit per Fig. 2

The embodiment per Fig. 2 will now be described.

The embodiment of the invention per Fig. 2 comprises a selective calling circuit, different from the selective calling circuit per Fig. 1, together with a simplified electron beam rotation synchronizing circuit requiring only one anode, anode 1, in multianode radial beam tube 203 and a single gas-filled trigger tube, tube 214, to maintain synchronism. Tube 203 has eleven anodes. Any five of the ten anodes other than the single synchronizing anodes may be used for code anodes.

Description of the operation of synchronizing circuit per Fig. 2

The gas-filled trigger tube 214 is part of a relaxation inverter circuit controlled by the grid of tube 214. A steady signal is put on the channel for anode number 1 in the multianode radial electron beam vacuum tube at the distant transmitter so that with both beams effective anode number 1 receives two pulses of current per cycle of the rotating field.

A circuit may be traced from ground 209 through positive battery 210, primary of transformer 211, anode 1 of tube 203, cathode 205 and to ground 206. When the first pulse of a train of pulses is received over line 201 and impressed on the primary of transformer 202, electrons are emitted from the cathode 205. Some of the electrons will be attracted to anode 1, sufficient to cause a positive voltage pulse to be impressed between the grid 204 and grounded cathode 205 of tube 203. Grid 204 is normally biased by negative battery 207 connected between grounded cathode 205 and grid 204 through the secondary of transformer 202. When a beam impinges on anode 1, a positive voltage pulse will be impressed between the grid and grounded cathode of tube 214. The grid of tube 214 is normally biased by negative battery connected through the secondary of transformer 211 and resistance 213 to the grid.

A circuit may be traced from the grounded cathode of tube 214 through positive battery 215, inductance 216, primary of transformer 217, anode of tube 214 and back to the cathode of tube 214. Inductance 218 and condenser 219 are connected between the anode and cathode of tube 214. Tube 214 is normally deactivated. Condenser 219 is normally charged to the voltage of battery 215. When tube 214 is fired, condenser 219 starts to discharge through tube 214. Condenser 219 and inductance 218 form an oscillatory circuit. The voltage impressed between the anode and cathode of tube 214 and across the primary of transformer 217 will first decline to a point at which tube 214 is deactivated and will then again rise to its peak voltage. During this cycle the beam separated 180 degrees from the beam which inaugurated the oscillation will impinge on anode 1. At this instant, however, the voltage of the anode of tube 214 will be at the bottom of its cycle so that there is no effect. When the beam which inaugurated the cycle is in position so that it again impinges on anode 1, tube 214 will be in the deactivated condition but the voltage on its anode will again be at a peak. Tube 214 will again fire to inaugurate another voltage cycle. The secondary of transformer 217 is connected to two circuits arranged in parallel,

one circuit may be traced through stator windings 220 and 221 in series with condenser 222. The other circuit may be traced through stator windings 223 and 224 arranged in series with condenser 225. Substantially sinusoidal voltages in quadrature will be impressed on these parallel branches to tend to rotate the electron beam in tube 203 in synchronism with the rotation of the beam in the transmitting tube at the distant station. Attention is called to the fact that the rotation of the field set up by the stator winding surrounding tube 203 is controlled in response to incoming pulses received from the distant transmitting tube.

Before the circuit is set in operation there is no field in the stator and the grid of the radial beam tube 203 is at cut-off so that no electrons are flowing. When the transmitter is turned on, the grid of the radial beam tube 203 receives a pulse when the transmitter beam goes past the number 1 anode position. This pulse allows electrons to flow to all anodes and the amount that flows to anode number 1 is sufficient to set off trigger tube 214 and start the rotating field. Subsequent pulses from anode number 1 will be much greater in amplitude since the electrons will then be focused on it, but resistance 213 shown in series with the grid of tube 214 prevents the grid from swinging excessively in the positive direction. With an odd number of anodes as shown and using both beams, there will be the equivalent of one beam rotating at twice the frequency of the magnetic field. With an even number of anodes with diametrically opposed anodes connected together the same will be true. The odd number of plates results in a smaller diameter tube for the same number of anodes. For either of these arrangements since there are two complete cycles of operation for one cycle of the rotating field, it does not matter which of the two pulses per cycle from the transmitter starts operation.

This gas-filled trigger tube relaxation inverter circuit gives an approximate sine wave form of current variation in the stator coils and this should be sufficiently good to maintain synchronism for fairly simple applications.

Description of the operation of selective calling circuit per Fig. 2

It is assumed that the calling code of the particular receiving station where the Fig. 2 we are considering is assumed to be located is 3, 5, 6, 7, 8.

In response to the transmission of current resulting from the direction of beams at anodes 3, 5, 6, 7 and 8 in the transmitting tube at the distant station, electron beams will be directed at corresponding anodes in the tube corresponding to tube 203 at each receiving station in the system. At the particular station which we are considering, and at this station only, anodes 3, 5, 6, 7 and 8 in tube 203 are connected in parallel. At this station, a circuit will be established from ground 209 through positive battery 210, winding of relay 226, to anodes 3, 5, 6, 7 and 8 in parallel, to cathode 205 and back to ground 206. The electron beam directing field for each circuit per Fig. 2 at each of the stations in the system is synchronized with the rotation of the beam in the transmitting tube so that an electron beam will impinge on anodes 3, 5, 6, 7 and 8 in succession in synchronism in each tube. Current will flow through the winding of relay 226 as a result of the transmission of this particular code and the impinging of beams on these particular anodes

at this one receiving station only. Attention is called to the fact that anodes 2, 4, 9, 10 and 11 are all connected in parallel in Fig. 2, representing the particular receiving station under consideration, and are connected to the left-hand terminal of the winding of relay 226. If an electron beam impinges on any of this group of anodes, a circuit is established which may be traced from ground 209 through battery 210, anodes 2, 4, 9, 10 or 11, cathode 205 and to ground 206. Current flowing in this path short-circuits the winding of relay 226. The circuit is arranged so that in order to be effective current must flow through the winding of the relay corresponding to relay 226 at the called station as a result of the direction of an electron beam at each of the five anodes representing the code of the called station and the winding must not be short-circuited by current flowing to any of the other group of five anodes not included in the code of the particular called station. Thus relay 226 at the called station only will respond to light lamp 227 as a signal that the station has been called.

*Operation without disabling feature
Figs. 1 and 2*

Attention is particularly called to the fact that the disabling feature in both Fig. 1 and Fig. 2 is not essential to the operability of the selecting mechanism per Fig. 1 and Fig. 2. The disabling feature simply provides insurance against false selection.

What is claimed is:

1. In a selective signal code calling system, a receiving circuit, a multianode tube, an input circuit for said tube connected to said receiving circuit, an output circuit for said tube including in parallel a plurality of selected anodes of said tube, means in said tube responsive to a signal impulse train received by said receiving circuit and corresponding to the selected anodes for affecting the output circuit through all of the selected anodes, a storage filter in said output circuit, said filter comprising means for developing a higher potential in response to the affecting of the output circuit through all of the selected anodes than in response to the affecting of the output circuit by less than all of said selected anodes and a calling signal device responsive only to said higher potential.

2. In a selective signal code calling system, a multianode radial beam tube, an input circuit connected to said tube, a first output circuit connected to said tube, a plurality of selected spaced anodes connected in parallel in said tube, a storage filter external to said tube, said anodes and said filter interconnected in said first output circuit, a second output circuit connected to said tube, a beam rotation synchronizing anode in said tube, a beam rotation circuit external to said tube, said synchronizing anode and said rotation circuit interconnected in said second output circuit, means for impressing a train of signal impulses on said input circuit, said train including a synchronizing impulse and a plurality of selective calling impulses, all of said impulses at intervals in correspondence with the spacing of said synchronizing anode and said plurality of spaced anodes in said tube, means, comprising said second output circuit, for directing electron beams at said synchronizing anode and at said selected anodes in response to said impressing of said train of impulses on said input circuit, means in said filter for developing a higher potential in response to the impinging of an electron beam

on each of said selected anodes than in response to the impinging of an electron beam on less than all of said selected anodes, and a calling signal device responsive only to said higher potential.

3. In a selective signal code calling system, a multianode electron beam tube, an input circuit connected to said tube, a first group of n selected anodes, spaced in a particular selected pattern, connected in parallel in said tube, a second group of spaced anodes connected in parallel in said tube, a first storage filter, a second filter, a calling signal, a first output circuit for said tube interconnecting said first group of anodes through said first filter to said calling signal, a second output circuit for said tube interconnecting said second group of anodes through said second filter to said calling signal, means for impressing a train of n selective calling signal impulses on said input circuit at intervals in correspondence with said spacing of said n anodes, means responsive to the impressing of said train of calling signal impulses on said input circuit for directing a stream of electrons at each of said n anodes in said first output circuit, means in said storage filter responsive to the impinging of an electron beam on each of said n anodes for developing a potential p in said first storage filter, means responsive to the developing of said potential p in said first filter for operating said calling signal, means in said storage filter responsive to the impinging of an electron beam on less than all of said n anodes in said first output circuit for developing a potential less than p in said first filter to prevent the operation of said calling signal, and means responsive to the impinging of an electron beam on any of said second group of anodes for developing a potential in said second filter to prevent the operation of said calling signal.

4. A multianode radial electron beam tube, a beam rotation synchronizing device connected thereto, and means, comprising a relaxation inverter circuit in said device, responsive to the reception, by said circuit, through said tube, of a single synchronizing pulse per cycle of rotation of an electron beam in said tube, for synchronizing the rotation of said beam.

5. A multianode radial electron beam vacuum tube, an input and an output circuit connected thereto, an electron beam rotation device connected to said output circuit, and means comprising a relaxation inverter circuit in said device, responsive to the reception of a single synchronizing pulse per cycle of rotation of said beam by said input circuit for controlling the speed of rotation of an electron beam in said tube.

6. In a selective calling system, a receiving device selectively responsive to multielement permutation code calling signals, said device comprising a multianode electron beam tube, an input and an output circuit connected to said tube, said output circuit including selected anodes in said tube, means connected to said tube for impressing a plurality of signal impulses on said input circuit, means connected to said tube for selectively directing electron beams, corresponding to said impulses, at said selected anodes in response to said impulses, a storage filter in said output circuit connected to said selected anodes, said filter having a time constant longer than the duration of any of said impulses, a calling signal connected to said filter, means in said filter for controlling the output potential developed by said filter so that it attains a predetermined value when said beams impinge on all of said selected

anodes, and means for operating said calling signal when said predetermined potential value is attained.

7. A selecting system operating under control of a code of a number m of mixed marking and spacing conditions, distributor means for distributing sequences of such conditions, means whereby each of n marking conditions in particular positions in said code supplies an increment of electrical energy to an energy accumulator whereas marking conditions in other positions in said code supply no energy increment, and means controlled by the supply of x times n such increments of energy to effect a selection, x being an integer or mixed number greater than about 2, said means being unresponsive to make a selection by the storage of x times $(n-1)$ marking conditions in the time required for the reception of x complete codes.

8. The method of selecting one device from a large number which comprises transmitting repeated sequences of a fixed number m of mixed marking and spacing conditions, allocating a particular combination of such conditions in which n are marking to each device, producing a definite electrical effect as a result of each of the n marking conditions, and summing up each of said n conditions over several sequences of said fixed number m to effect a selection of a desired device, and causing the total summed effect of less than n marking conditions over the same several sequences to be insufficient to produce a selecting effect.

9. A selecting system comprising a source supplying successive groups of m signaling conditions in groups of which n conditions per group are of one kind and $m-n$ are of the other kind, means for distributing said conditions over m elements whereby said n conditions are directed to control a common circuit, and means controllably associated with said circuit selectively responsive to a repetition of a selected combination of n particular ones of said m conditions and unresponsive to a single combination of n particular ones of said m conditions as well as all other combinations of n of said m conditions.

10. A high speed selecting system for effecting selections at greater speeds than may be accomplished by selective movement of ponderable bodies and relatively independently of errors incident to occurrence of a single false impulse which comprises space discharge means operating synchronously with incoming impulses occurring in codes of a definite number of code elements of two mixed conditions to distribute them to receiving elements, storage means supplied by code elements of one of said conditions in particular positions in said code, and electronic discharge means conditionable to be actuated by the storage due to a plurality of said elements in said particular positions repeated over more than one code.

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