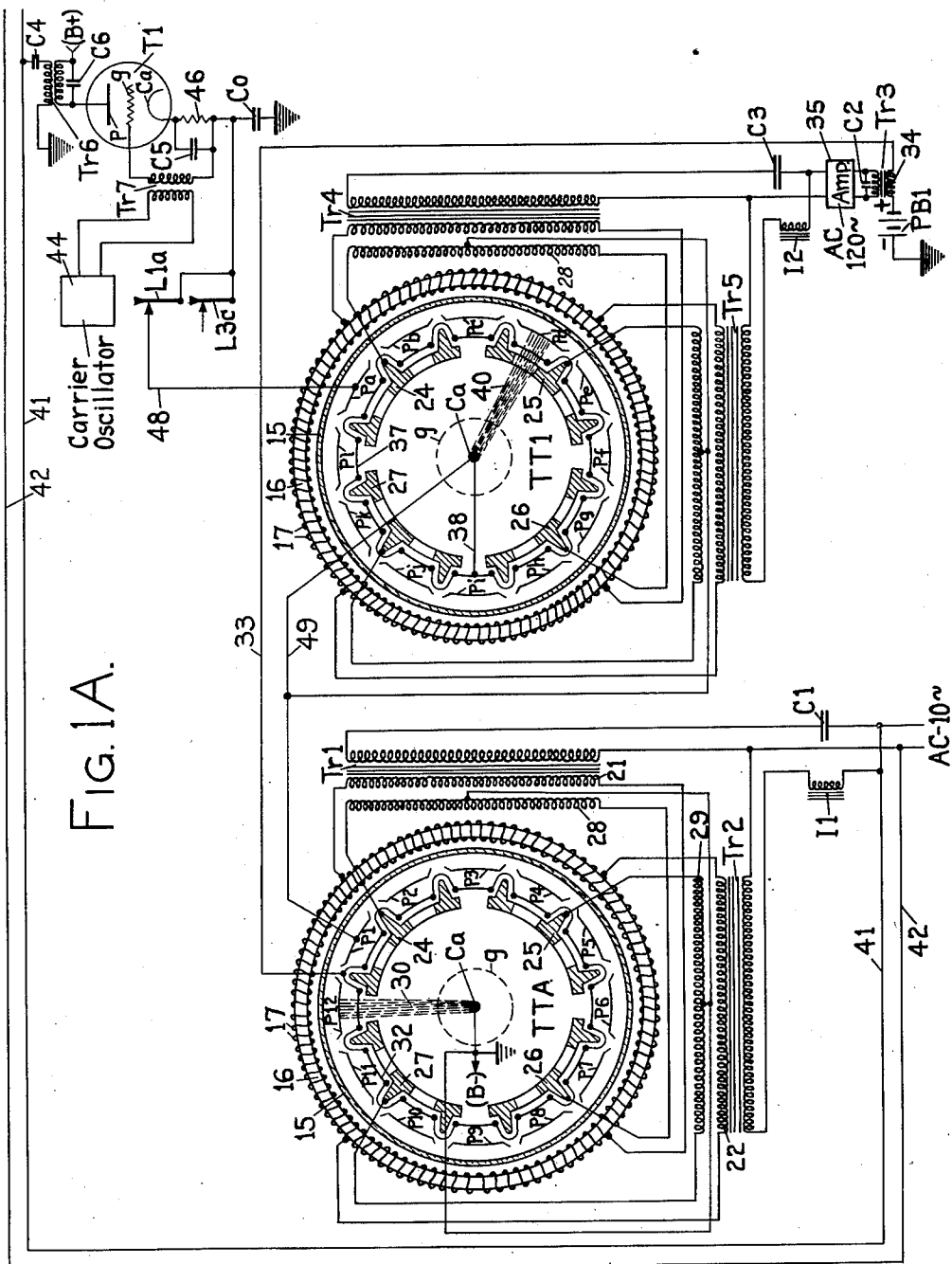


O. S. FIELD ET AL
SELECTIVE SIGNALING SYSTEM

6 Sheets-Sheet 1

Filed June 14, 1945



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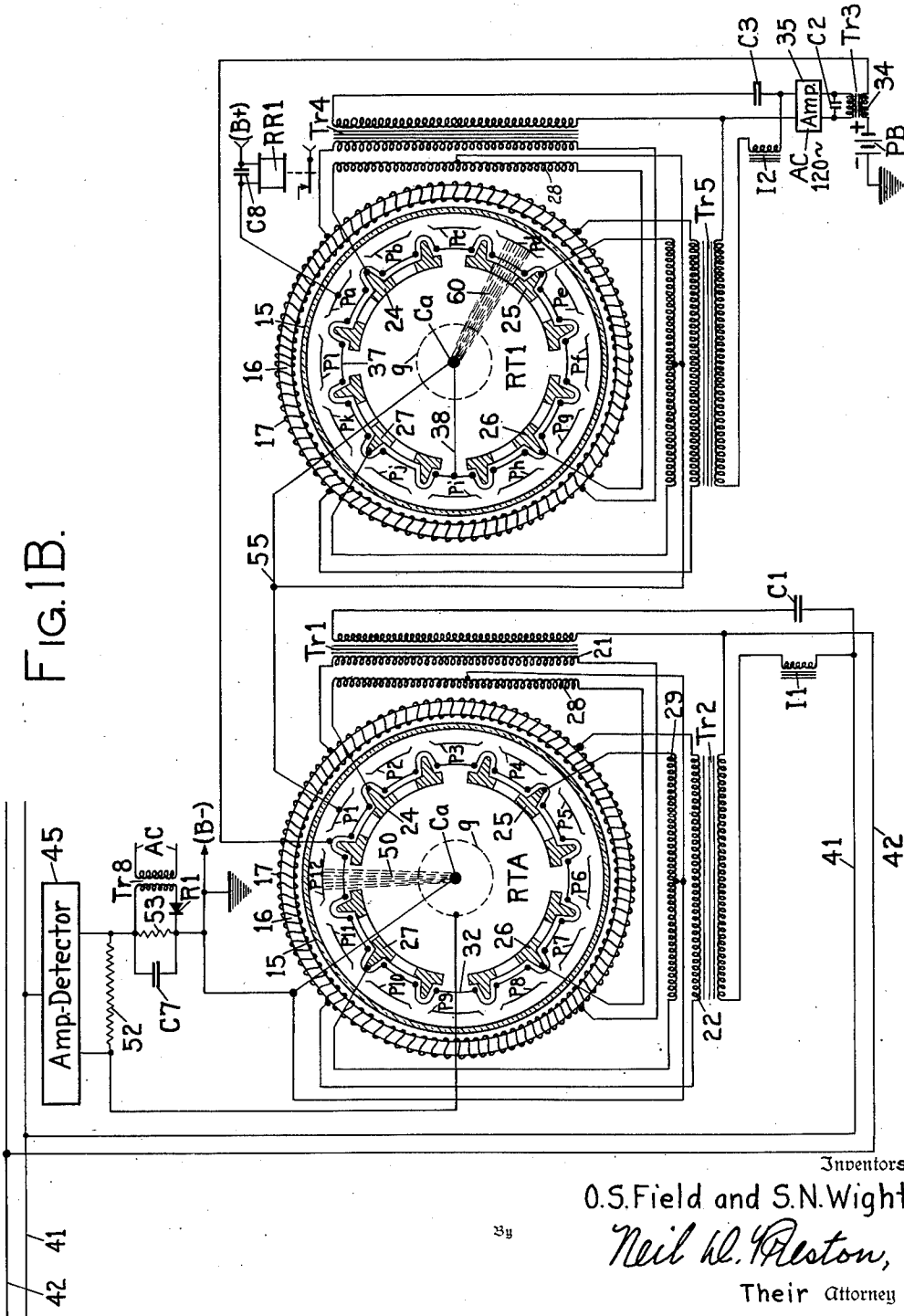
Filed June 14, 1945

O. S. FIELD ET AL
SELECTIVE SIGNALING SYSTEM

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6 Sheets-Sheet 2

FIG. 1B.



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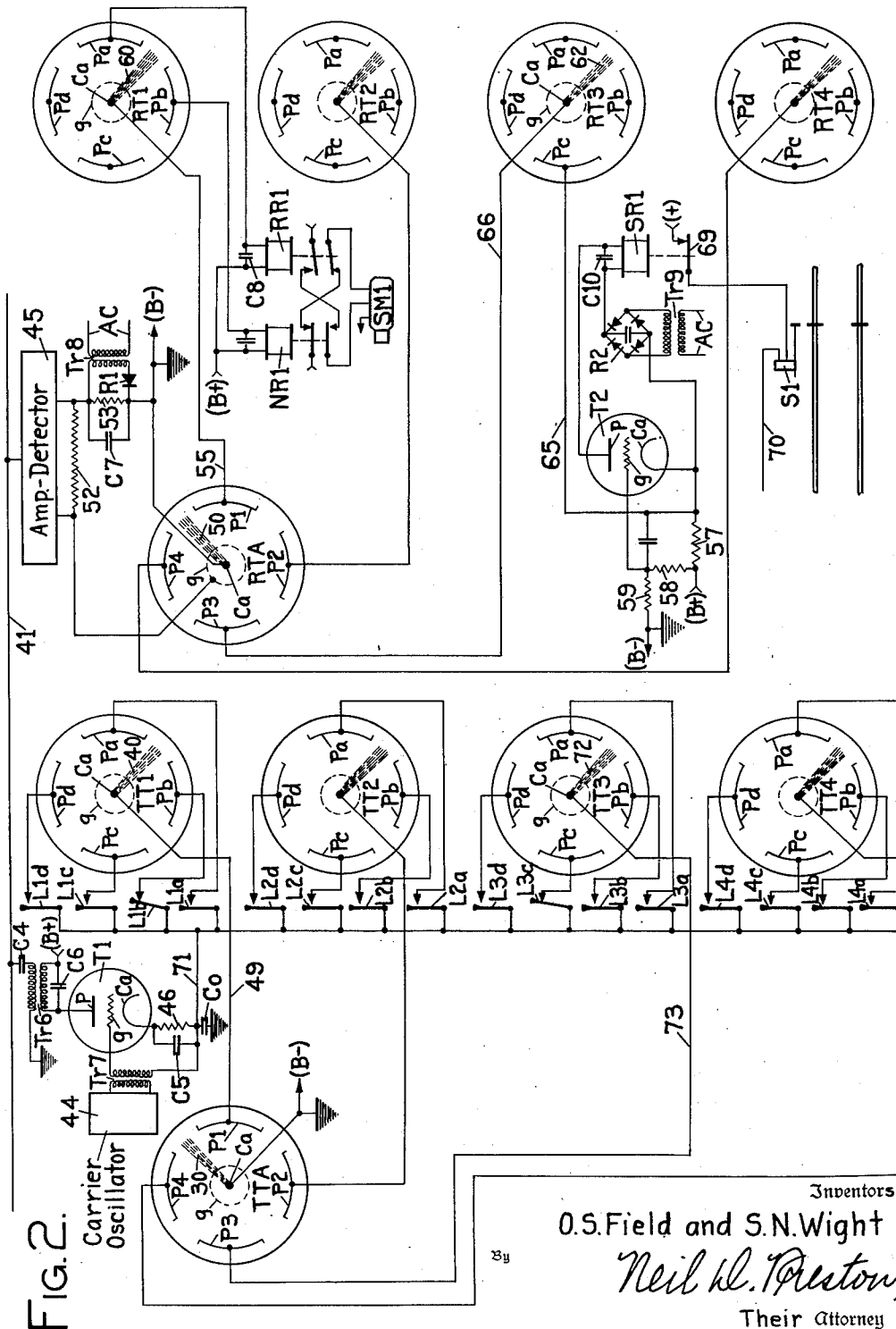
O. S. FIELD ET AL

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SELECTIVE SIGNALING SYSTEM

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6 Sheets-Sheet 3



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SELECTIVE SIGNALING SYSTEM

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6 Sheets-Sheet 4

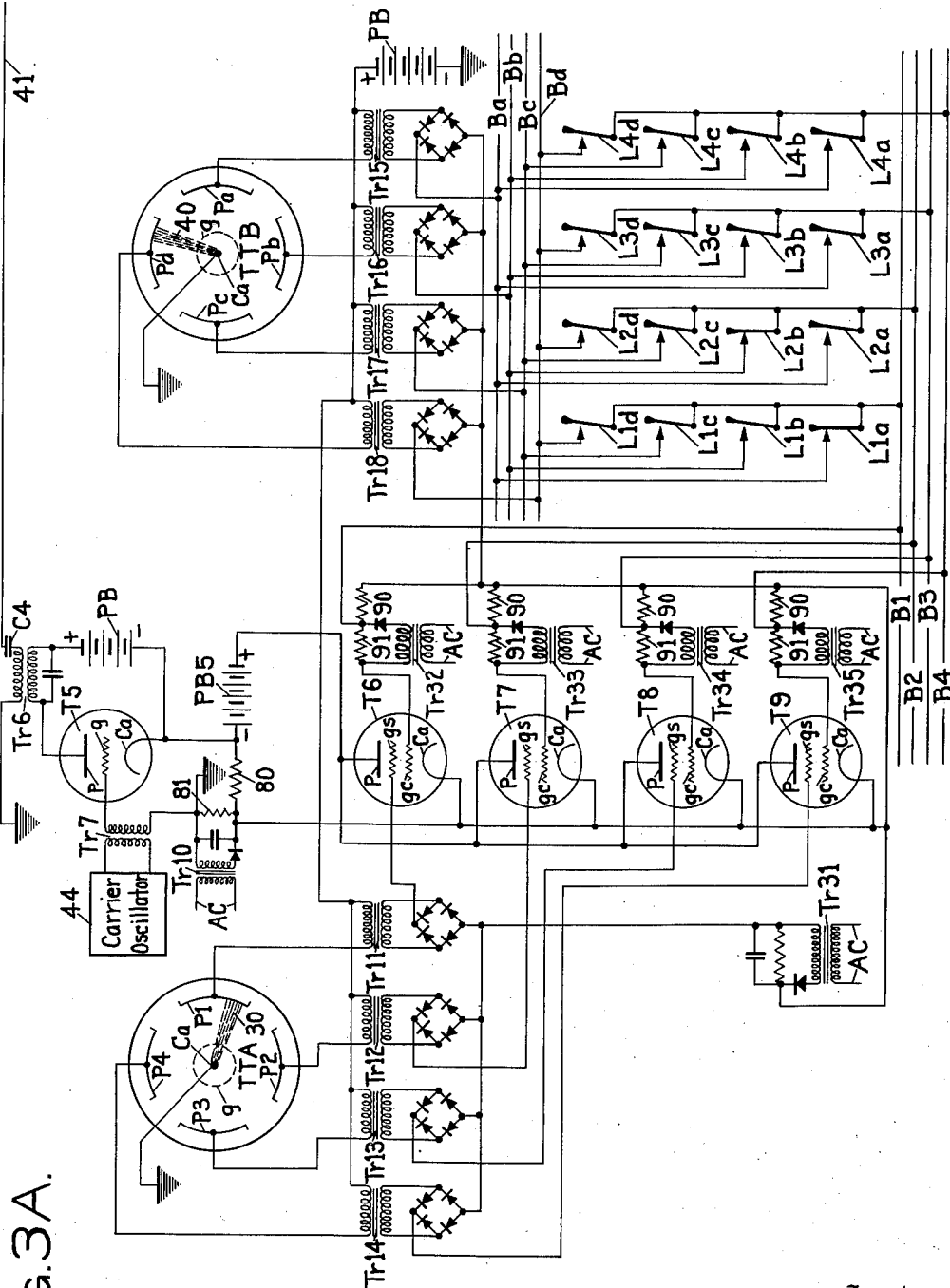


FIG. 3A.

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O. S. FIELD ET AL

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SELECTIVE SIGNALING SYSTEM

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6 Sheets-Sheet 5

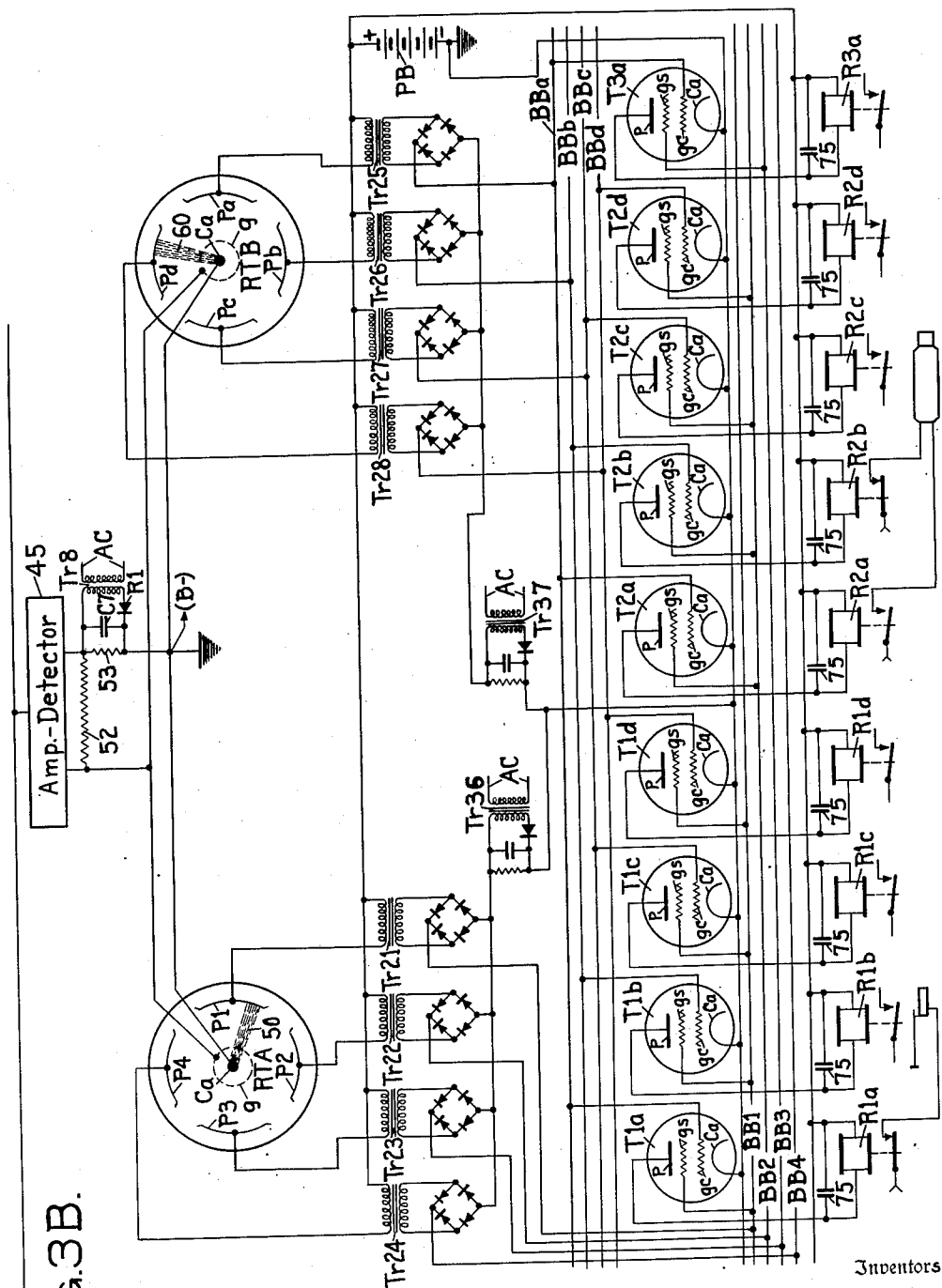


FIG. 3B.

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O. S. FIELD ET AL
SELECTIVE SIGNALING SYSTEM

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Filed June 14, 1945

6 Sheets-Sheet 6

FIG. 4.

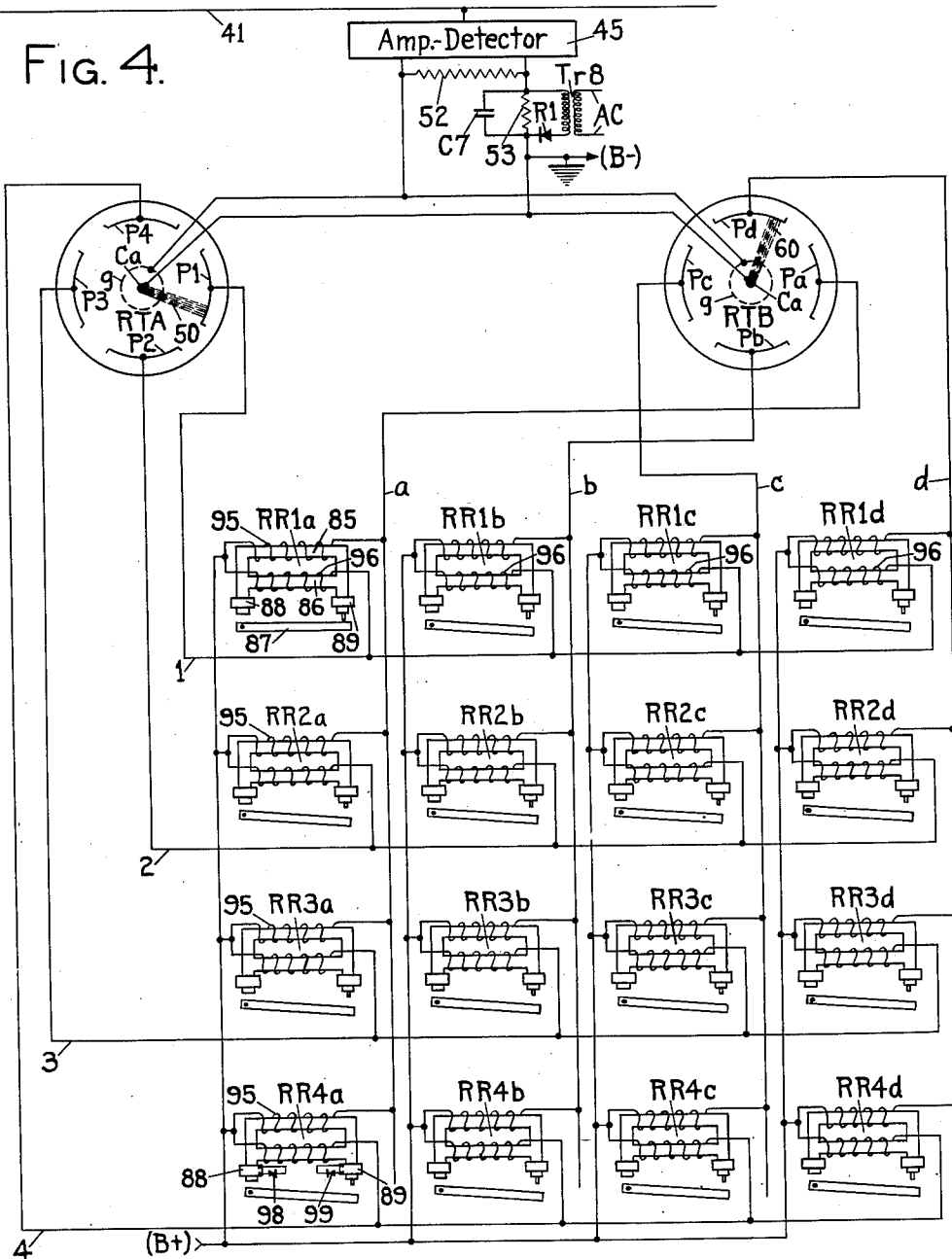
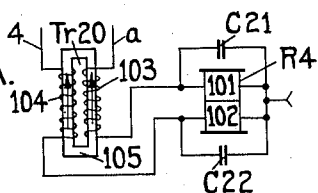


FIG. 4A.



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2,448,487

SELECTIVE SIGNALING SYSTEM

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Application June 14, 1945, Serial No. 599,328

17 Claims. (Cl. 177—353)

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This invention relates to centralized traffic controlling or communicating systems of the synchronous electric type and is an improvement over the synchronous electric communicating system disclosed in the patent to R. C. Leake, No. 2,042,668, dated June 2, 1936, and employs rotating electron beam amplifying and scanning tubes similar to those described by A. M. Skellet in the Bell System Technical Journal dated April, 1944.

By the expression synchronous electric communicating system is meant a system in which repeated time intervals or cycles are divided into a large number of successive time periods, each time period of which is allotted to perform, when required, a particular function. In the system disclosed in the above mentioned Leake patent rotating contact arms wiping over a series of stationary contacts, conveniently called scanning, are used to allot communicating times to different functions. This prior system has the limitation that the speed of rotation of the contact arm must for mechanical reasons be comparatively low by reason of its mechanical nature and the making and breaking of contacts in air is subject to considerable burning and wear resulting in unreliable operation.

In view of the above limitations and other considerations it is proposed in accordance with the present invention to employ rotating electron beams in place of the rotating arms, these electron beams, one or more at a control point and one or more at a receiving point, being kept in synchronism through the medium of alternating current transmitted over a communicating channel. Although it is specifically proposed to use conductors in the establishment of such a communicating channel it should be understood that space radiation channels using radio carrier frequencies may be employed, if desired.

Another object of the present invention resides in the provision of a plurality of synchronous devices including rotating electron beam tubes in combination to obtain cascade operation. In order to obtain such cascade operation it is proposed to have one of the electron beams rotate at a speed which is a multiple of the speed of rotation of another electron beam located at the same transmitting or receiving location. By this construction the second electron beam will operate at a speed to scan all of its stationary electrodes or contact members during the scanning of a single electrode by the first rotating beam.

Another object of the present invention resides in the provision of means in a rotating electron beam tube for generating an alternating current

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which has a frequency equal to the product of the speed of rotation of its electron beam and the number of circumferentially arranged electrodes. The current so generated is proposed to be used to drive the electron beam of the next stage tube.

In accordance with the present invention it is proposed to obtain such cascade operation either by operating tubes containing such rotating electron beams arranged in series, so that a plurality of electron beams are in series, or by having these tubes arranged in multiple. When such tubes are connected in series they function as keying devices. When such tubes are arranged in multiple they must act upon a discriminating device which will respond only if it is controlled or scanned simultaneously by a plurality of the rotating electron beams under consideration.

Another object of the present invention resides in the provision of a multiple core relay structure in which each of several cores acts as a magnetic shunt for the other core as a result of which the relay is actuated only if a plurality of windings are exactly simultaneously energized.

Another object of the present invention resides in the provision of sustaining means whereby an electro-responsive device is maintained in its energized condition continuously in spite of its intermittent energization.

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:

Figs. 1A and 1B disclose in more or less complete form a system embodying the present invention in which only one control lever and one control relay has been illustrated but wherein the apparatus for creating and rotating electron beams has been shown in considerable detail;

Fig. 2 shows conventionally but more completely the system shown in Figs. 1A and 1B but with the rotary electron beam tubes each containing only four anodes and from which system the means for creating and rotating the electron beams has been omitted;

Figs. 3A and 3B illustrate a modified form of the invention in which instead of connecting the rotating beam electron tubes in series they function in multiple and control tetrode amplifying tubes;

Fig. 4 illustrates a modified form of receiving station which may be used with the sending or transmitting station illustrated in Figs. 2 or 3A of the drawings and wherein multiple core electro-responsive devices are employed; and

Fig. 4A illustrates a modified form of the discriminating or multiple core relay shown and described in Fig. 4.

Structure—Figs. 1A, 1B and 2.—In Fig. 1A have been shown rotating beam electron tubes TTA and TT1 which are also shown in simplified form in the left-hand portion of Fig. 2 of the drawings. In this connection it is desired to point out that these rotating electron beam tubes as shown in Fig. 1A contain twelve plates or anodes whereas in the simplified conventional form shown in Fig. 2 they only contain four such plates or anodes. The simplified construction illustrated in Fig. 2 has been resorted to so that all of the apparatus for transmitting over all of the time allotted channels of a particular system may be illustrated in a comparatively simple drawing.

By reference to Figs. 1A and 1B it will be seen that each of the rotating electron beam tubes TTA, TT1, RTA and RT1 comprises a cylindrical envelope or tube 15, preferably constructed of glass, which is evacuated and contains the electron scanning apparatus and which envelope is surrounded by a laminated iron core 16 containing one or more windings 17, as the case may be, to produce a two-pole rotating magnetic field. Although this core 16 and winding 17 has been illustrated as constituting a field structure of the gramme ring type it may, if desired, be a toothed stator having inwardly directed magnetic teeth into which a two-pole two-phase lap winding may be contained. In order to produce the necessary rotating magnetic field a source of polyphase energy, conventionally illustrated as two-phase energy, is applied to the winding 17. Obviously, any multi-phase, such as three or six phase, winding and a corresponding phase source may be used, if desired. This two-phase energy is illustrated as being derived from transformers Tr1 and Tr2 having their primary windings energized from a source AC. These primary windings are split-phase connected so as to be energized by potentials displaced substantially 90° in phase. This phase displacement is preferably obtained through the medium of a condenser C1 included in the primary winding of transformer Tr1 and a choke coil or inductance I1 included in series in the primary winding of the transformer Tr2. The condenser C1 and the choke I1 have such capacity and inductance respectively that each causes a phase displacement of substantially 45°. It is readily understood that by connecting the output terminals of the first set of secondary windings 21 and 22 of the transformers Tr1 and Tr2 respectively to opposite points on the winding 17 and by having these secondary outputs displaced 90° with respect to each other, a two-phase rotating magnetic field will be set up in the evacuated tube or envelope 15.

Within the evacuated tube 15 and arranged in the form of a cylinder are provided four suppressor grid elements 24, 25, 26 and 27. The suppressor grid elements 24 and 26 are connected to opposite ends of the secondary winding 28 of the transformer Tr1 whereas the suppressor grid elements 25 and 27 are connected to opposite ends of the secondary winding 29 of the transformer Tr2. By observing the points at which the ends of the secondary winding of a particular transformer Tr1 or Tr2 are connected to the winding 17 and the suppressor grid elements 24—27 it is readily seen that a suppressor grid element has maximum voltage applied thereto when the rotating magnetic field traverses that particular sup-

pressor grid element. From this construction it is readily seen that if electrons are emitted from the cathode Ca of the rotary beam electron tube TTA, for instance, that these electrons will tend to flow only in directions parallel to the lines of the magnetic field so that a double electron beam rotating with the magnetic field would result were it not for the suppressor grid potentials. Since, however, one of these two electron beams will be directed toward a suppressor grid having positive polarity applied thereto whereas the other electron beam will be emitted toward a suppressor having a maximum negative potential applied thereto it is readily seen that such other electron beam will be either entirely quenched or subdued, or substantially so, as a result of which a single rotating electron beam only will be left. By this construction an electron beam emitted only in one direction and rotated about the cathode Ca is obtained. These rotary electron beam tubes are preferably of considerable length along their axis so that the suppression grids 24—27 as well as the plates or anodes P1 to P12, inclusive, each have considerable length and area. It will be seen that the various plates P1—P12 are each located back of an opening or window in or between the suppressor grids 24—27. It will also be seen that the rotated electron beam 30 (tube TTA) is of a width narrower than the space between these windows as a result of which the rotating electron beam can scan only one of the plates P1—P12 at a time. Each of these rotating beam electron tubes TTA, TT1, RTA and RT1 is provided with a grid *g* but only the grid *g* of the tube RTA is used. It will also be observed that there is a second suppression grid 32 which in the case of rotary electron beam tubes TTA and RTA is used as a screen anode, it being arranged circularly between the suppressor grids 24—27 and the plates P1—P12 and being provided with its own plate potential. This structure, which for convenience may be called a secondary anode, is used for generating an alternating current which has a frequency which is equal to the frequency applied to the transformers Tr1 and Tr2 multiplied by the number of plates employed in the tube. In the particular structure illustrated in Fig. 1A if the frequency of the alternating current source applied to the transformers Tr1 and Tr2 is 10 cycle energy then the frequency of the current delivered by the secondary anode 32 is 120 cycles because 12 windows are provided in or between the suppressor grids 24—27. This same tube TTA has been shown in simplified form in Fig. 2 of the drawings and in this case, although the secondary anode has not been illustrated, the frequency of the alternating current applied to the tube TT1 (Fig. 2) is only four times that of the frequency applied to the rotating beam electron tube TTA (Fig. 2). This is true cause only four anodes Pa, Pb, Pc and Pd are used in the Fig. 2 construction.

As illustrated in Fig. 1A, the electrons which reach the secondary anode 32 may flow over wire 33 and through the primary winding 34 of the transformer Tr3 to the positive terminal of the plate battery PB1. The secondary winding of this transformer Tr3 is tuned by the condenser C2 to oscillate at the frequency of the pulses supplied to the primary winding 34 of this transformer, as a result of which a sine wave of alternating current voltage of 120 cycle frequency is applied to the amplifier 35. This alternating current energy is then amplified by amplifier 35, is split phased, and is then supplied to the trans-

formers Tr4 and Tr5 and used for producing a rotating magnetic field in the rotating beam electron tube TT1 or RT1. The primary winding of the transformer Tr4 has included in series therein a condenser C3 whereas the primary winding of the transformer Tr5 as including in series therein in inductance I2. These phase shifting devices C3 and I2, as already pointed out, have such capacity and inductance, respectively, that the condenser C3 causes the current flow there-through to lead by an angle of substantially 45° whereas the current flowing through the inductance I2 lags substantially 45° behind the impressed voltage delivered by the amplifier 35.

The rotating beam electron tube TT1 is of exactly the same construction as the tube TTA, just described, except that for the tube TT1 the secondary anode is used as a suppressor grid 37 to suppress the effect of secondary emission from the plates or anodes Pa, Pb, Pc, Pd, Pe, Pf, Pg, Ph, Pi, Pj, Pk and Pl. It will be observed that this suppression grid 37 is connected to the cathode Ca through the medium of a conductor 38 in accordance with the usual practice. The transformers Tr4 and Tr5 control the winding I1 and suppressor grids 24—27 of the tube TT1 in exactly the same manner as do the transformers Tr1 and Tr2 control like devices in the tube TTA. It will, however, be understood that the electron beams 40 and 60 of the rotating beam electron tubes TT1 and RT1 rotate twelve times as fast as do the electron beams 30 and 50 of the rotating beam electron tubes TTA and RTA (Fig. 1A). In the Fig. 2 illustration the electron beams 40 and 60 rotate only four times as fast as do the electron beams 30 and 50. In other words, the electron beams 40 and 60 traverse all of the anodes Pa to Pl, inclusive, while the electron beams 30 and 50 traverse only one of the plates or anodes Pi to P12, inclusive. In this connection it may be desirable not to use those anodes or plates of the second tube TT1 or RT1 which are traversed or scanned by the electron beam 40 or 60 while the electron beams 30 or 50 are in the course of moving from one plate or anode to another in order to avoid a weak signal impulse being transmitted during this transition.

The rotating beam electron tubes RTA and RT1 shown at the receiving station illustrated in Fig. 1B of the drawings, are of identical construction to that of the tubes TTA and TT1 shown in the transmitting station illustrated in Fig. 1A of the drawings and for this reason the former will not be specifically described. What has been said about the construction of these tubes also applies to the manner in which the electron beams thereof are created and rotated so that the associated transformers and phase shifting apparatus need not be described but will be identified by like reference characters. Although no filaments or heaters have been illustrated for the various cathodes Ca it should be understood that suitable heaters are preferably used and have for convenience not been illustrated.

As illustrated in the drawings the communicating channel between the transmitting station shown in Fig. 1A and the receiving station shown in Fig. 1B comprises line wires 41 and 42 and it will be seen that alternating current of scanning frequency from the source AC is transmitted from the transmitting station of Fig. 1A to the receiving station of Fig. 1B and that the line wire 41 is also used for transmitting car-

rier frequency from the transmitting station to the receiving station. In this connection it should be understood that this scanning frequency is preferably transmitted by modulating a special carrier frequency thereto, transmitting it to the receiving station and by then demodulating it at the receiver station and amplifying it for rotating electron beams at such receiving station. This is preferably done to reduce the possibility of fluctuation of phase shift to a minimum.

In the particular form illustrated this carrier frequency for transmitting the selector impulses is transmitted from a transformer Tr6 preferably tuned to that frequency and is preferably transmitted as through the medium of a condenser C4 to the transmission line 41. At the receiving station this energy is applied to an amplifier-detector 45 having an output load resistance 52.

The primary winding of the transformer Tr6 is included in series with the plate or anode circuit including three tubes in series, namely, the amplifier tube T1, the rotating beam electron tube TT1, and the rotating beam electron tube TTA (Fig. 1A). The tubes TT1 and TTA trigger or key the plate circuit of the tube T1. This anode circuit may be traced from the terminal (B+) of a suitable direct current plate source, primary winding of the transformer Tr6, plate p of the amplifying tube T1, cathode Ca of this same tube, series resistance 46, shunted by a by-pass condenser C5, lever L1a, wire 48, plate Pa, electron beam 40, cathode Ca of rotary electron tube TT1, wire 49, plate P1, electron beam 30 of the rotating beam electron tube TTA, cathode Ca to the other terminal (B-) of this same plate source. It will be observed that the grid g of the amplifying tube T1 has carrier frequency continuously supplied thereto through the medium of a transformer Tr7 preferably tuned to this frequency. This carrier frequency is generated by the carrier frequency oscillator 44. Although this carrier frequency is continuously present on the grid g of the amplifying tube T1, this tube T1 will only deliver such carrier frequency current to the transmission line wire 41 when the plate circuit for this tube T1 is closed. This plate circuit, it will be seen, is controlled by three devices in series, namely, by the contact of the lever L1a, by the electron beam 40 of the rotating beam electron tube TT1 in cooperation with the anode Pa and by the electron beam 30 in cooperation with the plate P1 of the tube TTA. In other words, the fact that the lever contact L1a is closed will be made manifest by a short pulse of radio frequency current applied to the transmission wire 41 at the particular instant when the electron beams 30 and 40 scan plates P1 and Pa, respectively, which may be called keying. It is of course understood that the electron beams 50 and 60 (Fig. 1B) assume corresponding positions to that of the electron beams 30 and 40 (Fig. 1A).

The pulse of radio frequency energy which manifests that the lever L1a has its contact closed, as just explained, will produce a direct current voltage drop across the output load resistance unit 52 (Fig. 1B) of such polarity as to cause the grid g of the rotating beam electron tube RTA to become (+) with respect to its cathode and to thereby overcome the normally negative bias applied to this grid of tube RTA and this occurs at exactly the time when elec-

tron beams 50 and 60 scan plates P1 and Pa respectively of tubes RTA and RT1. The grid bias just mentioned is obtained through the medium of resistance unit 53 shunted by a condenser C7 and energized by the grid bias source comprising a transformer Tr8 energized by alternating current which is rectified by the rectifier R1. As a result of this application of a (+) potential to the grid *g* of tube RTA to cause it to overcome its normal negative bias the electron beam 50 is greatly strengthened. This occurs at the instant the electron beam 50 scans plate P1 and the electron beam 60 scans plate Pa under the assumed condition. Plate current may now flow from the terminal (B+) of a suitable plate source through the winding of the relay RR1, plate Pa of the tube RT1, electron beam 60, cathode Ca of this tube RT1, wire 55, plate P1, of tube RTA, electron beam 50, cathode Ca of this tube RTA, to the ground connection connected to the negative terminal of this same plate source. A short pulse of current is therefore delivered to the relay RR1 once during each rotation of the electron beams 30 and 50 and since we have assumed that the alternating current source AC has a frequency of 10 cycles per second, these pulses are transmitted to the relay RR1 ten times during each second. Although these pulses are very short a condenser C8 is preferably connected across the winding of the relay RR1 so as to prolong the effect of the instantaneous current applied to this relay. In other words, the relay RR1 (Fig. 1B) will remain energized so long as the lever L1a (Fig. 1A) has its contact closed because the condenser C8 serves as a storage reservoir for these pulses of direct current energy.

It is desired to point out that the resistance 46 is used to vary the grid bias for tube T1 in accordance with the plate current flowing through this tube. By this construction a degree of volume control is carried out. The condenser C5 shunting this resistance 46 is used to by-pass the carrier frequency to thereby reduce its attenuation. The condenser C6 is used to by-pass and prevent radio frequency energy reaching the rotating beam tubes that is to prevent feed-back.

Referring now to Fig. 2 of the drawings the system illustrated in Figs. 1A and 1B has been illustrated in Fig. 2 in more complete forms insofar as the various transmitting channels are concerned but has been shown in more simplified form in that each rotating beam electron tube is provided with only four plates P1, P2, P3 and P4 for tube TTA and Pa, Pb, Pc and Pd for tube TT1, and in that the means for creating and rotating the electron beams has for convenience been omitted.

The tubes TTA and RTA illustrated in Fig. 2 may for convenience be called first stage tubes whereas the rotating beam electron tubes TT1, TT2, TT3, TT4, RT1, RT2, RT3 and RT4 may be called second stage electron tubes. It will be observed that the tubes TT1, TT2, TT3 and TT4 have their cathodes connected to the plates or anodes P1, P2, P3 and P4 respectively, of the first stage tube TTA and that the second stage tubes RT1, RT2, RT3 and RT4 have their cathodes connected respectively to the plates P1, P2, P3 and P4 of the first stage tube RTA. All parts and devices illustrated in Fig. 2 which are common to devices illustrated in Figs. 1A and 1B have been identified by like reference characters. It may, however, be pointed out that in Fig. 2 a normal switch machine control relay NR1 has

been shown controlled by the plate Pb of tube RT1 which was not illustrated in Fig. 1B of the drawings. This normal relay NR1 in combination with the reverse relay RR1, illustrated in both Figs. 1B and 2, is used to control the switch machine SM1 which in practice will control the switch points of a railway track switch or some other suitable apparatus depending upon the manner in which the present invention is practiced.

Although as above described, relays, such as relay RR1, may be directly controlled by the rotating beam electron tubes and without the employment of amplifiers between the second stage tube and the respective relays, such an amplifier may be employed, if desired, and has been illustrated by the amplifying tube T2 in Fig. 2 of the drawings. This tube T2 is provided with its own, and separate, plate source comprising the full-wave rectifier R2 which is fed from the transformer Tr9. In this connection it should be observed that the output voltage delivered from the plate Pc of the rotary beam electron tube RT3, which is negative in polarity, is applied directly to the cathode Ca of the tube T2 instead of being, as is usually the case, applied to the grid *g*. That is, the negative output voltage delivered from tube RT3 causes the cathode Ca of tube T2 to become negative (—) with respect to the grid *g* of this tube to thereby cause the tube to become active. Since this grid *g* is normally held negative (—) with respect to the cathode Ca by current flowing through grid bias resistance 58 and series resistance 59, and derived from the plate energy source for the rotating beam electron tubes, the flow of current in the plate circuit of amplifying tube T2 is prevented until current flows through load resistance 57 to overcome this normal negative grid bias. In other words, normally current flows from the terminal (B+) of the plate source for the rotating beam tubes through resistance units 58 and 59 in series to thereby cause the grid *g* of tube T2 to become slightly negative (—) with respect to the cathode Ca. If, however, a pulse of direct current is delivered by the amplifier-detector 45 (Fig. 2) at a time when the electron beam 50 scans plate P3 of tube RTA and the electron beam 62 scans plate Pc of the rotating electron tube RT3 a plate current will flow from the terminal (B+) through the load resistance 57, wire 65 plate Pc of tube RT3, electron beam 62, cathode Ca of tube RT3, wire 66, plate P3 of electron tube RTA, electron beam 50, cathode Ca of tube RTA, to ground which is connected to the minus (—) terminal of this plate source, this bias is overcome. The flow of current in the load resistance 57 in the direction just indicated causes the cathode Ca to become minus (—) with respect to the grid *g* as a result of which the amplifier tube T2 passes current from its plate source R2 and through the signal control relay SR1. This signal control relay is preferably shunted by a condenser C10 into which the electrical impulse may be temporarily lodged to store the energy until it is dissipated in the winding of the relay SR1. This flow of current through the signal control relay SR1 is of course due to the fact that the signal control lever L3c is closed. This signal control relay SR1 through the medium of its closed contact 69 will hold the signal S1 in its clear position providing traffic conditions in advance of said signal are clear as determined by suitable traffic controlled contacts (not shown) included in the wire 70 extending to the next signal in

advance. This relay SR1 will of course remain energized so long as the signal control lever L3c has its contact closed.

Operation—Figs. 1A, 1B and 2.—Under normal non-signal transmitting conditions and with all of the lever contacts, including the contacts of levers L1b and L3c open, no signal pulses of carrier frequency are transmitted over the line wire 41. The frequency multiplying portion of the apparatus will, however, function even though none of the plates P have a plate source connected thereto. This is due to the fact that the screen plate 32 of tube TTA is provided with its own plate source PB1 (Fig. 1A). It is thus seen that electron beam rotation takes place irrespective of how many or whether any of the control levers assume their active position.

If, now, for instance, we assume that lever L3c is operated to clear signal S1, the closure of the lever contacts L3c closes the plate circuit for amplifier tubes TTA and TT3 momentarily once during each revolution of the electron beams 30 and 50 (Fig. 2). This plate circuit may be traced from the positive terminal (B+) of the plate source at the sending station (left side of Fig. 2) through the primary winding of transformer Tr6, plate p and cathode Ca of tube T1, resistance 46, wire 71, contact of lever L3c, plate Pc, electron beam 72 and cathode Ca of rotating beam electron tube TT3, wire 73, plate P3, electron beam 30 and cathode Ca of rotating beam electron tube TTA, which is connected to ground and to the minus (—) terminal of this same plate source. The flow of current in this circuit will be modulated at carrier frequency between the positive terminal of the plate source and ground through the condenser C6, in that this condenser C6 bypasses the rest of the plate circuit insofar as the flow of the carrier frequency component of the current is concerned. Since the transformer Tr6 is tuned to this carrier frequency, as by condenser C6, a pulse of carrier frequency is transmitted through condenser C4 and line wire 41 to the receiving station shown in the right-hand portion of Figure 2. This pulse of carrier frequency current is then amplified and detected or demodulated by the amplifier-detector 45 to cause a pulse of plus polarity energy to appear at the left-hand terminal of the load resistance 52. This plus potential overcomes the grid bias, produced by direct current flowing in resistance 53, on grid g of tube RTA to thereby cause this tube to pass current at the instant electron beam 50 sweeps over anode P3 and electron beam 62 (tube RT3) sweeps over anode Pc. Current may therefore flow during this instant from the terminal (B+), resistance unit 57, wire 65, elements Pc, 62 and Ca of tube RT3, wire 66, elements P3, 50 and Ca of tube RTA to ground which is connected to the negative terminal of this same source. During this instant the flow of current in resistance unit 57 neutralizes or even reverses the negative bias normally applied to grid g of triode T2 by the resistance drop over resistance unit 58, so that amplifying tube or triode T2 passes current in its plate circuit including plate source R2 in series with the relay SR1 and condenser C10 in multiple. The relay SR1 will pick up in response to one or more such pulses of current, one for each revolution of electron beams 30 and 50, and will then stay up as long as lever contact L3c remains closed. With relay SR1 in a picked-up condition and its contact 69 closed, the signal S1 will be controlled in accordance with traffic conditions in advance. Simultaneously with the

closing of lever contacts L3c any one or more of the remaining lever contacts L1a—L4d may be closed with similar results so that any number from one to sixteen relays, only NR1, RR1 and SR1 of which have been shown, may be controlled from a distant point either simultaneously or in overlapped relationship by the system shown in Fig. 2.

Structure—Figs. 3A and 3B.—In Figs. 3A and 3B has been illustrated a system of synchronous selector communication which employs rotating beam electron tubes such as already described but wherein these rotating beam electron tubes function in multiple instead of in series as was the case in the Figs. 1A, 1B and 2 structures. In the Figs. 3A and 3B construction a tetrode amplifying tube including two grids is used as a discriminating tube in that it discriminates between impulses delivered simultaneously and successively by a first stage tube such as TTA and RTA and a second stage tube such as TTB and RTB. It should be particularly noted that in the Fig. 2 construction a second stage rotating beam electron tube is necessary for each plate of the first stage tube whereas in the Figs. 3A and 3B construction only one such second stage rotating beam electron tube is necessary irrespective of the number of plates employed in the first stage tube. This economy in second stage rotating beam electron tubes comes about by the fact that the tubes are not connected in series but are connected in multiple to control double grid amplifying tubes. In other words, a particular tetrode tube will only function if its suppression grid gs is energized from a first stage rotating beam electron tube at the same instant that its control grid gc is energized from a second stage rotating beam electron tube.

The output amplifying tube T5 (Fig. 3A) conforms in many respects to the output amplifying tube T1 (Fig. 2) the principal difference between the two being that the triode T5 is provided with the usual grid bias structure including the transformer Tr10 and its associated rectifier, load resistance 81 and condenser, whereas no such grid bias is required for the tube T1. For this reason all like parts have been designated by like reference characters. The grid produced by current flowing through resistance 81 is at times overcome and reversed by current flowing through resistance 80.

As illustrated in Fig. 3A four tetrode tubes T6, T7, T8 and T9 are employed as discriminators, these tubes being controlled by the rotating beam electron tubes TTA and TTB. Since the output from these tubes TTA and TTB constitute (—) polarity direct current impulses the transformers Tr11 to Tr18, inclusive, having associated therewith full-wave rectifiers are employed to reverse these potentials. The output leads of the rectifiers associated with transformers Tr11—Tr14 are applied to the four suppressing grids gs of the tetrode tubes T6—T9, whereas the outputs from the full-wave rectifiers associated with transformers Tr15—Tr18 are connected to bus wires Ba, Bb, Bc and Bd which bus wires may each be connected to any one of the bus wires B1, B2, B3 or B4 as through the medium of control levers such as levers L1a—L1d, L2a—L2d, L3a—L3d and L4a—L4d. The bus wires B1, B2, B3 and B4 are connected respectively to the control grids gc of the tetrode tubes T6, T7, T8 and T9 through circuits each including a load resistance 91, the applied potentials resulting from current flowing through load resistances 90. It will be observed

that the control grids *gc* of the tetrode tubes T6, T7, T8 and T9 are biased negatively through the medium of the transformers Tr32, Tr33, Tr34 and Tr35 respectively, and their associated rectifiers and load resistances 91. Similarly the suppression grids *gs* of these tetrode tubes are biased negatively through the medium of the transformer Tr31 and its associated rectifier and load resistance. These separate grid biasing means are employed because tubes of the tetrode type require different degrees of normal negative bias for their two grids for satisfactory operation.

Referring now to the receiving station illustrated in Fig. 3B of the drawings the amplifying detecting and grid bias structures included between line wire 41 and rotating beam electron tubes RTA and RTB are the same as illustrated in the right-hand portion of Fig. 2 of the drawings and for this reason like parts have been designated by like reference characters. The output leads from the four plates or anodes P1, P2, P3 and P4 of tube RTA have their output potentials reversed through the medium of transformers Tr21, Tr22, Tr23 and Tr24 and their associated full-wave rectifiers. The output from these rectifiers is applied to bus wires BB1, BB2, BB3 and BB4 respectively. These rectifiers as well as the suppression grids connected thereto are biased negatively through the medium of the transformer Tr36 and its associated rectifier and load resistance. The plates or anodes Pa, Pb, Pc and Pd of the rotating beam electron tube RTB are connected to and have their output potentials reversed through the medium of transformers Tr25, Tr26, Tr27 and Tr28, and their associated full-wave rectifiers, respectively. These output rectifiers as well as the bus wires BBa, BBb, BBc and BBd and the control grids *gc* connected thereto, are biased negatively through the medium of transformer Tr37, and its associated rectifier and resistance unit. The suppression grids *gs* and the control grids *gc* just mentioned comprise parts of tetrode tubes T1a, T1b, T1c, T1d, T2a, T2b, T2c, T2d and T3a (seven more tetrode tubes may be used but have for convenience been omitted). These tetrode tubes are used to control relays designated by reference letter R followed by like character suffixes respectively.

From the foregoing it is readily seen that if the suppression grid *gs* of any particular tetrode tube (Fig. 3B) has its negative bias overcome by an impulse delivered from the rotating beam electron tube RTA at the same instant when its control grid *gc* has its negative bias overcome by an output impulse from the rotating beam electron tube RT1, such tetrode tube will conduct current, and this will result in the energization of its associated control relay. It may be pointed out that each of these control relays R1a, R1b, etc., is rendered slow dropping, as through the medium of a condenser 75 connected across its winding so that these relays will maintain their front contacts closed when intermittent impulses are supplied thereto by the associated tetrode tubes.

Operation—Figs. 3A and 3B.—Under normal non-signal transmitting conditions and with all of the various levers L1a, L1b, etc., in their contact-open position the electron beams 30, 40, 50 and 60 (Figs. 3A and 3B) will rotate for reasons heretofore described, the electron beams 40 and 60 rotating four times as fast as do the electron beams 30 and 50. The electron beams 30 and 40 produce momentary flow of current in their plate circuits as such electron beams scan these plates as a result of which the transformers Tr11,

Tr12, Tr13, and Tr14 are successively energized in that order at a comparatively slow rate whereas the transformers Tr15, Tr16, Tr17 and Tr18 are successively momentarily energized in that order during each scanning of one of the plates P1, P2, P3 or P4. The momentary energization of the transformers Tr11—Tr18, however, produce no result insofar as transmission of a carrier frequency impulse is concerned because even though the suppression grids *gs* of the tetrode tubes T6—T9 are successively energized no current flows in the plate circuits of these tetrode tubes because their respective control grids *gc* are not energized by reason of the fact that all of the control levers L1a, L1b, etc., are in their open-circuit position, as above assumed. At the receiving station, however, no plate circuit flows at any time during this normal condition of the apparatus because the grids *g* of the rotating beam electron tubes RTA and RTB are biased negatively through the medium of the transformer Tr8 and its associated rectifier R1 and load resistance 53 and for this reason neither of these tubes RTA and RTB nor any of the tetrode tubes illustrated in Fig. 3A will conduct current.

Let us now assume that the lever L1a (Fig. 3A) is moved to its abnormal circuit closing position, as shown on the drawing. This causes the control grid *gc* of the tetrode tube T6 to become positive, momentarily, each time that the electron beam 40 sweeps by the plate Pa of the rotating beam electron tube RTB which happens four times during each rotation of the electron beam 30 of the tube TTA. The tetrode tube T6 is, however, rendered active only once instead of four times because the suppression grid *gs* of this tetrode tube T6 is only rendered positive when the electron beam 30 sweeps over the plate P1 of this tube TTA. In other words, during each cycle (revolution of electron beam 30) the electron tube T6 is rendered active once due to lever contact L1a being closed and that is when the electron beam 30 sweeps the plate P1 and the electron beam 40 sweeps plate Pa. At this instant the electron tube T6 becomes active and causes current to flow from the (+) terminal of the plate battery PB5, anode *p* and cathode Ca of tetrode T6, through the load resistance 80 to the (—) terminal of this plate battery PB5. This instantaneous flow of load current in the resistance 80 neutralizes the effect of the grid bias due to grid bias current flowing in load resistance 81, to thereby render the amplifying tube T5 active. The carrier frequency potential continuously applied to the grid *g* of the tube T5 which is now sufficiently positive causes carrier current to flow in its plate circuit and to in turn cause carrier current to be applied to the line wire 41 through the medium of the transformer Tr6 and condenser C4.

This carrier current through the medium of the amplifier-detector 45 at the receiving station (Fig. 3B) will cause a momentary impulse of plus (+) potential to be applied to the grids *g* of the rotating beam electron tubes RTA and RTB. This occurs at the exact instant when the electron beams 50 and 60 sweep over the plates P1 and Pa respectively. This of course results in a momentary impulse being applied simultaneously to the transformers Tr21 and Tr25. The transformer Tr21 through its associated rectifier and bus wire BB1 momentarily applies plus (+) potential to the suppression grid *gs* of the tetrode tube T1a whereas the trans-

former Tr25 through its associated rectifier and bus wire BBa applies a plus (+) potential to the grid *gc* of this same tetrode tube T1a so that tube T1a becomes active whereas no other tetrode tube has both its control grid *gc* and its suppression grid *gs* energized at this instant. That is, the transformer Tr21 applies plus (+) potential to the suppression grids *gs* of the tetrode tubes T1a, T1b, T1c, T1d whereas the transformer Tr25 applies plus (+) potential momentarily to the control grids *gc* of the tetrode tubes T1a, T2a, T3a (and T4a not shown) and it is readily seen that the tetrode tube T1a is the only tube that is common to both of these groups of tetrode tubes. With the tetrode tube T1a having both its suppression grid *gs* and its control grid *gc* rendered positive a momentary impulse of current will flow in its plate circuit including the relay R1a. Since this operation is repeated ten times each second, it being assumed that a frequency of 10 cycles per second is used for rotating the electron beams 30 and 50, this relay R1a will remain continuously energized, its associated condenser 75 serving as a hold-over reservoir so that this relay will not drop between successive impulses.

In the same manner as just described for controlling the relay R1a by the lever L1a the remaining fifteen relays R1b—R4d (of which relays R3b—R4d have not been shown) can be controlled by the remaining fifteen levers—L1b—L4d either simultaneously or in any selected groups and this is true whether these relays are all located at one field station or are distributed among several field or moving vehicle stations. The result is that any or all of the sixteen relays may be simultaneously held energized if their associated levers assume their active position.

Structure—Fig. 4.—In Fig. 4 has been illustrated apparatus which is the same as the receiving apparatus illustrated in Fig. 3B except that the transformers and associated rectifiers have been omitted in that reversal of the output potential delivered by the rotating beam electron tubes is no longer necessary, and in that special double core relays have been substituted for the tetrode tubes and simple relays illustrated in Fig. 3B. In other words, the control relays RR1a to RR4d, inclusive, illustrated in Fig. 4 each serve both as a relay and as a discriminator. These relays RR1a, etc., as conventionally illustrated, have two important low reluctance paths. One path includes the two core portions 85 and 86 in series and a second path includes the core portions 85 and 86 in multiple and in turn in series with the armature 87. From this consideration it is readily seen that if only the coil 95 is energized the core 86 will serve as a shunt to shunt the magnetism away from the armature 87. Likewise, if only the coil 96 is energized, the core 85 will serve as a shunt to shunt the magnetism resulting from such energization away from the armature 87. If, however, both of the coils 95 and 96 are energized simultaneously the magnetomotive forces produced thereby act in the same direction through these core portions in multiple and thereby cause the magnetism to flow through the armature 87 to cause its actuation. As illustrated the legs of the relay RR1a, as is also true of all of the other multiple core relays, are provided with shorted coils or rings 88 and 89 which maintain magnetism in the armature 87 sufficiently long to prevent dropping of the armature between successive impulses delivered simultaneously to the coils 95 and 96. It may be pointed out that this core structure is composed of laminated soft iron

having low hysteresis losses and which laminations may be as thin as $\frac{1}{1000}$ of an inch thick so that eddy currents are also reduced to a minimum. Core structures of this type may be used in connection with alternating currents of frequencies as high as one megacycle. Each of the other fifteen relays RR1b—RR4d illustrated are of like construction and for a more detailed description of a relay of this type attention is directed to the application of Field, Ser. No. 588,749, filed April 17, 1945, now U. S. Patent 2,435,001 granted January 27, 1948.

Operation—Fig. 4.—Let us assume that the lever L1a (Fig. 3A) is closed and that the apparatus of Fig. 4 is substituted for the structure of Fig. 3A. As a result of the closure of this lever contact an impulse of carrier frequency current is transmitted over a line wire 41 to the apparatus illustrated in Fig. 4 at the instant when electron beam 50 of rotating beam electron tube RTA (Fig. 4) sweeps past the plate P1 and the electron beam 60 of the tube RTB (Fig. 4) sweeps past the plate Pa. At this instant the windings 96 of each of the relays RR1a, RR1b, RR1c and RR1d is energized over wire 1 as is also the winding 95 of each of the relays RR1a, RR2a, RR3a, and RR4a over wire a whereas all of the remaining relays have no potentials applied to either of their windings. It is readily seen that the relay RR1a is the only relay that has both of its windings 95 and 96 simultaneously energized and for this reason this relay RR1a is the only relay in which magnetism to any appreciable extent passes through its armature 87. Putting this in other words the relays RR1b, RR1c and RR1d have only their lower windings 96 energized so that the upper core 85 serves as an effective shunt for the magnetism produced, and the relays RR2a, RR3a and RR4a have only their upper windings 96 momentarily energized so that the lower core 86 serves as an effective shunt for the magnetism produced by the coils 95. It is thus seen that the relay RR1a is the only relay that is effectively energized. These relays RR1a, etc., therefore serve two functions, namely, an armature controlling function and an impulse discriminating function in that only those relays which have impulses simultaneously applied to both windings will respond. The other relays RR1b—RR4d are effectively energized in a like manner over wires 2, 3, 4 and b, c, and d as shown on the drawings.

Attention is directed to the fact that rotating beam electron tube RTA (Fig. 1B) is provided with negative grid bias for at times preventing electron flow to plates P1—P12 but that this grid bias should never prevent sufficient electron flow to the frequency multiplying anode 32. This may be accomplished in two ways either of which may be practiced in accordance with the present invention. First, this may be accomplished by biasing the grid *g* negative only to an extent to prevent the picking up of a relay, such as RR1, and at the same time allow enough electron flow to deliver the necessary multiplied frequency current to the amplifier 35 to result in necessary current for field winding 17. Secondly, the two sets of anodes P1—P12 and 32 (tube RTA) may be only partly overlapped axiswise with the grid *g* located in alignment with anodes P1—P12 and with at least part of the anode 32 not controlled by the grid *g*. In this way a substantial amount of multiple frequency pulsating current may at all times flow through the plate circuit of tube RTA including screen plate 32 and transformer Tr3, even though none of the lever contacts

11a—14d are closed and the normal grid bias is fully effective. Also, it should be understood that, if desired, a separate rotating beam electron tube may be used solely for the purpose of frequency multiplication, in which event current of the higher frequency may be generated in substantial volume so that less amplification of such current is necessary.

In practicing this invention it is probable that either the complete sending station or the complete receiving station will be all located at a central control point whereas the apparatus to be communicated with will be scattered among many field stations. By reason of the flexibility of the system disclosed the receiving apparatus need, for instance, not be duplicated in all respects at each field station. By referring to Figs. 3A and 3B let us assume that a second receiving station (not shown) comprising part of the system has the remaining seven relays R3b, R3c, R3d, R4a, R4b, R4c and R4d (not shown) located therein. In this case transformer Tr24 and its associated apparatus including bus wire BB4 would be omitted from the Fig. 3B station. The second station (not shown) would omit transformers Tr21 and Tr22 and all their associated apparatus including bus wires BB1 and BB2 and the first eight tetrode tubes T1a to T2d and their associated relays R1a to R2d, inclusive, would also be omitted from such second station. In all other respects the second receiving station (not shown) would be the same as the one illustrated in Fig. 3B.

In the same way all of the receiving apparatus may be located at a central station whereas the transmitting equipment would be subdivided among various field stations. In that case some of the tetrode tubes T6, T7, T8 and T9 would, for instance, be located at one field station whereas the remaining tubes would be located at one or more other field stations. In each case the apparatus would be so connected and phase shifted, where required, that all of the first stage electron beams would rotate at low speed and in synchronism whereas the electron beams of all second stage tubes would operate at high speed and in synchronism. It should also be understood that since the communicating channel may be a space radiation channel some or all of the field stations may be located on moving vehicles or conveyances. Although in the system specifically illustrated only from 16 to 144 individual functions can be performed, it should be understood that by reason of the high speed at which the electron beams may operate (up to 10,000 R. P. S.) a much larger number of individual functions may be performed. It is believed that 1000 individual functions is sufficient, and three tubes connected in cascade or tandem, as disclosed, each containing ten anodes would perform that number of functions.

Referring to Fig. 4 of the drawings it will be seen that double magnetic circuit relays RR1a—RR4d have been illustrated each of which has each of its legs provided with a choke or slug 88 or 89. These slugs are intended to serve as a hold-over feature for the relay so that each time the two coils 85 and 86 are simultaneously energized the magnetism that passes through these slugs will thereafter be sustained for a time so as to render the relays slow dropping. In practicing the invention it may be desirable to use wound coils instead of single-turn copper bands 88 or 89 and to short-circuit these coils through a half-wave rectifier, this rectifier being so poled

in the circuit that when fluxes build up in the relay leg the rectifier will block the flow of current and thereby allow free building up of the flux in the relay. Upon termination of each impulse on the two windings simultaneously these rectifiers in coils 88 and 89 will allow the free flow of current through such coil and will thereby cause retarded decay of the magnetic flux in the relay leg and associated armature 87. Such a construction has been shown for the relay RR4a of Fig. 4 of the drawings where these rectifiers for coils 88 and 89 have been designated 98 and 99 respectively.

Another form of discriminating relay which responds only if very short impulses in two circuits occur simultaneously has been illustrated in Fig. 4A of the drawings. In this construction a relay R4 is provided which is provided with two coils or windings 101 and 102 which windings are respectively shunted by condensers C21 and C22. A transformer choke Tr20 is provided and this transformer has two windings thereon designated 103 and 104 in the usual manner. As shown, the coil 103 is included in series with a circuit including wire a and winding 101 whereas the coil 104 is included in a circuit including the wire 4 and the coil 102. The windings 101, 102, 103 and 104 are so wound and connected in circuits that the coils 103 and 104 buck each other when simultaneous pulses of direct current flow in wires a and 4 whereas the windings 101 and 102 carrying such pulses of direct current act accumulatively upon the relay R4. In other words, when pulses flow simultaneously in wires a and 4, for reasons explained in connection with Figs. 3A, 3B and 4 of the drawings, the transformer choke Tr20 will not materially restrict the flow of current because practically no magnetism is set up in the core 105 of this transformer choke Tr20 and these pulses will act accumulatively on the relay R4 and will cause its armature to either pick up on the first impulse or pick up after the condensers C21 and C22 have been charged up to an extent where the relay R4 does pick up. If, however, there is only a pulse on the wire 4 or on the wire a but not on both of these wires, the inductive reactance of the transformer choke Tr20 together with the inductive reactance of the relay R4 will be sufficient to allow a very small amount of current to reach the condenser C21 or C22 but not enough to pick up the relay. In other words, when two direct current pulses flow simultaneously over wires a and 4 the impedance offered by the choke Tr20 is practically nil and both of the coils 101 and 102 of the relay R4 will receive energy whereas if only one of these pulses of current flow at a particular instant the transformer choke Tr20 offers a very large impedance to the flow of a single pulse of direct current which impedance together with the impedance of a single winding of the relay R4 serves to restrict the flow of current to an extent to prevent picking up of the relay R4. It should be understood that each of the relays RR1a—RR4d (Fig. 4) may be replaced by a relay and transformer choke such as disclosed in Fig. 4A of the drawings.

Having thus shown and described a plurality of rotating beam electron tube systems for performing synchronous scanning communicating functions it is desired to be understood that the invention is not limited to the specific constructions illustrated, in that the specific systems illustrated have been merely selected to show the principle of operation of the system and the man-

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ner in which this principle may be applied in practicing the invention, and it should be understood that various changes, modifications and additions may be made to adapt the invention to the particular problems encountered in practicing the invention without departing from the spirit or scope of the invention, except as demanded by the scope of the following claims.

What we claim as new is:

1. A centralized traffic controlling and/or indication system comprising, a first stage multiple anode rotating beam electron tube at a control point and at each receiving point, a second stage multiple anode rotating beam electron tube for each anode of each first stage tube, means connecting the cathode of each second stage tube to an anode of the associated first stage tube at said control point, a communicating channel, means for applying an impulse to said communicating channel when the electron beam of a first stage tube and the electron beam of a second stage tube at said control point are each simultaneously directed at a particular anode, and electro-responsive means included in a circuit including the corresponding particular anodes at a particular receiving point.

2. A centralized traffic controlling and/or indication system comprising, a first stage multiple anode rotating beam electron tube at a control point and at each receiving point, a second stage multiple anode rotating beam electron tube for each anode of each first stage tube, means connecting the cathode of each second stage tube to an anode of the associated first stage tube at said control point, a communicating channel, a control switch, means for applying an impulse to said communicating channel when the electron beam of a first stage tube and the electron beam of a second stage tube at said control point are each simultaneously directed at a particular anode and said control switch, and electro-responsive means included in a circuit including the corresponding particular anodes at a particular receiving point and rendered active only when said control switch is closed.

3. A centralized traffic controlling and/or indication system comprising, a first stage multiple anode rotating beam electrode tube at a control point and at each receiving point, a second stage multiple anode rotating beam electron tube for each anode of each first stage tube, a circuit including a source of current for each cathode of each second stage tube and each including an anode of the associated first stage tube at said control point, a communicating channel, means for applying an impulse to said communicating channel when the electron beam of a first stage tube and the electron beam of a second stage tube at said control point are each simultaneously directed at a particular anode and the corresponding circuit is closed, electro-responsive means for each of said circuits of which one is included in a circuit including the corresponding particular anodes at a particular receiving point, and means for each of said circuits at the control point for at times closing such circuit.

4. A centralized traffic controlling and/or indication system comprising, a first stage rotating beam electron tube located at each of a control point and a receiving point, each first stage tube including a center electrode and a plurality of circumferential electrodes, a second stage rotating beam electron tube for each circumferential electrode of each first stage tube, each second stage tube including a center electrode and a plu-

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ality of circumferential electrodes, means for producing an electron beam rotating about the center electrode in each of said tubes, a communicating channel connecting said control point and said indication point, control means for controlling the intensity of said electron beams at the various points in their rotation in said tubes at the control point and in turn through the medium of said communicating channel at said receiving point, and a relay for each circumferential electrode of each second stage tube at said receiving point connected to such electrode and energized by current proportional to the electrons in the electron beam when such beam connects the circumferential electrode to which such relay is connected and the associated center electrode, whereby said relays are controlled in accordance with the intensities of said electron beams when cooperating with corresponding circumferential electrodes of the second stage tubes at said control points as determined by said control means.

5. A centralized traffic controlling and/or indication system comprising, a first stage rotating beam electron tube located at each of a control point and a receiving point, each first stage tube including a center electrode and a plurality of circumferential electrodes, a second stage rotating beam electron tube for each circumferential electrode of each first stage tube, each second stage tube including a center electrode and a plurality of circumferential electrodes, means for producing an electron beam rotating about the center electrode in each of said tubes, a communicating channel connecting said control point and said indication point, control means for controlling the intensity of said electron beams at the various electrode points in their respective rotation in said tubes at the control point and in turn through the medium of said communicating channel at said receiving point, an amplifier for each circumferential electrode of each second stage tube at said receiving point connected to such electrode and activated by potential proportional to the electrons in the electron beam when such beam connects the circumferential electrode to which such amplifier is connected and the associated center electrode, and a relay included in the output circuit of each amplifier, whereby said relays are controlled in accordance with the intensities of said electron beams when cooperating with corresponding circumferential electrodes of the second stage tubes at said control point as determined by said control means.

6. A centralized traffic controlling and/or indication system comprising, a first stage rotating beam electron tube located at each of a control point and a receiving point, each first stage tube including a center electrode and a plurality of circumferential electrodes said first stage tube at said receiving point also including a grid, a second stage rotating beam electron tube for each circumferential electrode of each first stage tube, each second stage tube including a center electrode and a plurality of circumferential electrodes, means for producing an electron beam rotating about the center electrode in each of said tubes, a communicating channel connecting said control point and said indication point, control means for controlling the intensity of said electron beams at the various points in their rotation in said tubes at the control point and in turn through the medium of said communicating channel and said grid at said receiving point, and a relay for each circumferential electrode

of said second stage tube at said receiving point connected to such electrode and energized by current proportional to the electrons in the electron beam when such beam connects the circumferential electrode to which such relay is connected and the associated center electrode, whereby said relays are controlled in accordance with the intensities of said electron beams when cooperating with corresponding circumferential electrodes of the second stage tubes at said control point as determined by said control means.

7. A centralized traffic controlling and/or indication system comprising, a first stage rotating beam electron tube located at each of a control point and a receiving point, each first stage tube including a center electrode and a plurality of circumferential electrodes, a second stage rotating beam electron tube for each circumferential electrode of each first stage tube, each second stage tube including a center electrode and a plurality of circumferential electrodes, means for producing an electron beam rotating about the center electrode in each of said tubes, a communicating channel connecting said control point and said indication point, control means for controlling the intensity of said electron beams at the various points in their rotation in said tubes at the control point and in turn through the medium of said communicating channel at said receiving point, and a plurality of two-winding relays at said receiving point each having one winding connected in a circuit including a circumferential electrode of the first stage tube and having its other winding connected in a circuit including a circumferential electrode of the second stage tube, said relays being of such construction that they will not be actuated unless both of their windings are simultaneously energized.

8. A centralized traffic controlling and/or indication system comprising, a first stage rotating beam electron tube located at each of a control point and a receiving point, each first stage tube including a center electrode and a plurality of circumferential electrodes and the first stage tube at said receiving point also including a control grid, a second stage rotating beam electron tube, each second stage tube including a center electrode and a plurality of circumferential electrodes and said second stage tubes at said receiving point also each including a control grid, means for producing an electron beam rotating about the center electrode in each of said tubes, a communicating channel connecting said control point and said indication point, control means for controlling the intensity of said electron beams at the various points in their rotation in said tubes at the control point and in turn through the medium of said communicating channel and said grids at said receiving point, and a plurality of two-winding relays at said receiving point each having one winding connected in a circuit including a circumferential electrode of the first stage tube and having its other winding connected in a circuit including a circumferential electrode of the second stage tube, said relays being of such construction that they will not be actuated unless both of their windings are simultaneously energized.

9. A centralized traffic controlling and/or indication system comprising, a first stage rotating beam electron tube located at each of a control point and a receiving point, each first stage tube including a center electrode and a plurality of circumferential electrodes and the first stage

tube at said receiving point also including a control grid, a second stage rotating beam electron tube, each second stage tube including a center electrode and a plurality of circumferential electrodes and said second stage tubes at said receiving point also each including a control grid, means for producing an electron beam rotating about the center electrode in each of said tubes, a communicating channel connecting said control point and said indication point, control means for controlling the intensity of said electron beams at the various points in their rotation in said tubes at the control point and in turn through the medium of said communicating channel at said receiving point, a plurality of multiple grid amplifying tubes at said receiving point each having one grid connected in a circuit including a circumferential electrode of the first stage tube and having its other grid connected in a circuit including a circumferential electrode of the second stage tube, and a relay for each amplifying tube.

10. In a centralized traffic controlling and/or indication system; a communicating channel extending from a central point to one or more fixed or movable stations, a first stage rotating beam electron tube at said central point and at each of said stations, a second stage rotating beam electron tube at said central point and at each of said stations, the speed of rotation of the electron beam of said second stage tubes being a multiple of the speed of rotation of the beam of said first stage tubes, a tetrode amplifier tube at said central point and at each of said stations, the control tetrode tube having two grids and located at such point or station and effective when one grid is rendered active by a low speed electron beam assuming a first specific position and the other grid is rendered active by a high speed electron beam assuming a second specific position to transmit an impulse over said communicating channel, and the indication tetrode tube having two grids and located at such station or point and having both grids rendered active to render the tube active if an impulse is received while the low speed electron beam assumes said first specific position and the high speed electron beam assumes said second specific position.

11. In a centralized traffic controlling and/or indication system; a communicating channel extending from a central point to one or more fixed or movable stations, a first stage rotating beam electron tube at said central point and at each of said stations, a second stage rotating beam electron tube at said central point and at each of said stations, the speed of rotation of the electron beam of said second stage tubes being a multiple of the speed of rotation of the beam of said first stage tubes, a tetrode grid amplifier tube at said central point and at each of said stations, the control tetrode tube having two grids and located at such point or station and effective when one grid is rendered active by a low speed electron beam assuming a first specific position and the other grid is rendered active by a high speed electron beam assuming a second specific position to transmit an impulse over said communicating channel, the indication tetrode tube having two grids and located at such station or point and having both grids rendered active to render the tube active if an impulse is received while the low speed electron beam assumes said first specific position and the high speed electron beam assumes said second

specific position, and electro-responsive means controlled by said indication tetrode tube.

12. In combination, two separated stations, a two-grid tetrode electron tube at each of said stations, two rotating beam electron tubes at each of said stations the electron beams of the two tubes at each station having different speeds of rotation, a communicating channel connecting the two stations, means for rendering one of said tetrode tubes active which through the medium of said communicating channel renders the other tetrode tube active only if the two low speed electron beams assume specific corresponding positions and the two high speed electron beams assume specific corresponding positions simultaneously.

13. In combination, two separated stations, a two-grid tetrode tube at each of said stations, two rotating beam electron tubes at each of said stations the electron beams of the two tubes at each station having speeds of rotation such that the speed of one beam is a multiple of the speed of the other beam, a communicating channel connecting the two stations, means for rendering one of said tetrode tubes active which through the medium of said communicating channel renders the other tetrode tube active only if the two low speed electron beams assume specific corresponding positions and the two high speed electron beams assume specific corresponding positions simultaneously.

14. In combination, two separated stations, a two-grid tetrode electron tube at each of said stations, two rotating beam electron tubes at each of said stations the electron beams of the two tubes at each station having speeds of rotation such that the speed of one beam is a multiple of the speed of the other beam, a communicating channel connecting the two stations, a control contact at one station, means for rendering one of said tetrode tubes active which through the medium of said communicating channel renders the other tetrode tube active only if the two low speed electron beams assume specific corresponding positions and the two high speed electron beams assume specific corresponding positions simultaneously and said control contact is closed, and electro-responsive means controlled by said other tetrode tube.

15. A centralized traffic controlling system for communicating between a control point and one or more stations comprising, transmitting means at said control point including two rotating beam electron tubes, each tube consisting of a cathode for emitting electrons, a plurality of anodes, and beam rotating means for creating a rotating magnetic field to concentrate said electrons into a beam and rotating said beam for transmitting impulses to each of the stations at respective time intervals in the rotation of said beam, said beam rotating means for one tube being effective to rotate the beam of that tube at a multiple rate of the rate of the other tube, and receiving means at each station comprising electron beam tubes governed in correspondence with said electron beam tubes at the control point, an amplifier tube controlled by simultaneous conduction through the rotating beams of both electron tubes at that station, and a relay controlled by said amplifier tube.

16. A centralized traffic control system for communicating between a control point and one or more stations comprising, transmitting apparatus at said control point including two rotating beam

electronic tubes, each tube consisting of a cathode for emitting electrons, a plurality of anodes, and a rotating magnetic field to concentrate said electrons into a beam and rotate the beam, said transmitting apparatus being effective to rotate the beam of one tube at a rate which is a multiple of the rate of rotation of the beam of the other tube, said transmitting means including means for transmitting pulses formed when said beam sweeps the respective anodes of the higher rate tube, each pulse consisting of a large number of cycles of currents, and manually operable means for selectively increasing the amplitude of each pulse when the beams of the respective tubes sweep predetermined anodes of both tubes simultaneously.

17. In a centralized traffic control system for communicating a plurality of controls simultaneously from a control office to at least one field station for the control of a plurality of devices at that station, a source of alternating current, first and second stage rotating beam tubes at the control office and first and second stage rotating beam tubes at the field station, means including said source of alternating current governing the rate of said first stage tubes and rendering them normally active, means responsive to the output of said first stage tubes governing the rate of the associated second stage tubes as a multiple frequency in accordance with the number of anodes of said first stage tubes, manually operable means for designating controls to be transmitted from the control office for the respective devices at the field station, transmitting means at the control office responsive to said manually operable means by transmitting a modulated current to said field station, said modulated current being transmitted to the field station for the control of each device only at a time when the rotating beams are conductive in cooperation with predetermined anodes of both said first and said second stage tubes simultaneously, and receiving means at the field station, including said first and said second stage tubes for governing each of said devices in accordance with the modulated current transmitted from the control office, said receiving means requiring conductivity through the beams of both first and second stage tubes simultaneously to predetermined anodes of such tubes for the control of any one device.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,545,025	Auspach	July 7, 1925
1,945,665	Stewart	Feb. 6, 1934
2,036,350	Montani	Apr. 7, 1936
2,057,773	Finch	Oct. 20, 1936
2,073,333	Chireix	Mar. 9, 1937
2,122,102	Lundell	June 28, 1938
2,217,774	Skellett	Oct. 15, 1940
2,265,216	Wolf	Dec. 9, 1941
2,396,211	Skellett	Mar. 5, 1946
2,401,729	Goldsmith	June 11, 1946

FOREIGN PATENTS

Number	Country	Date
365,956	Germany	Dec. 23, 1922