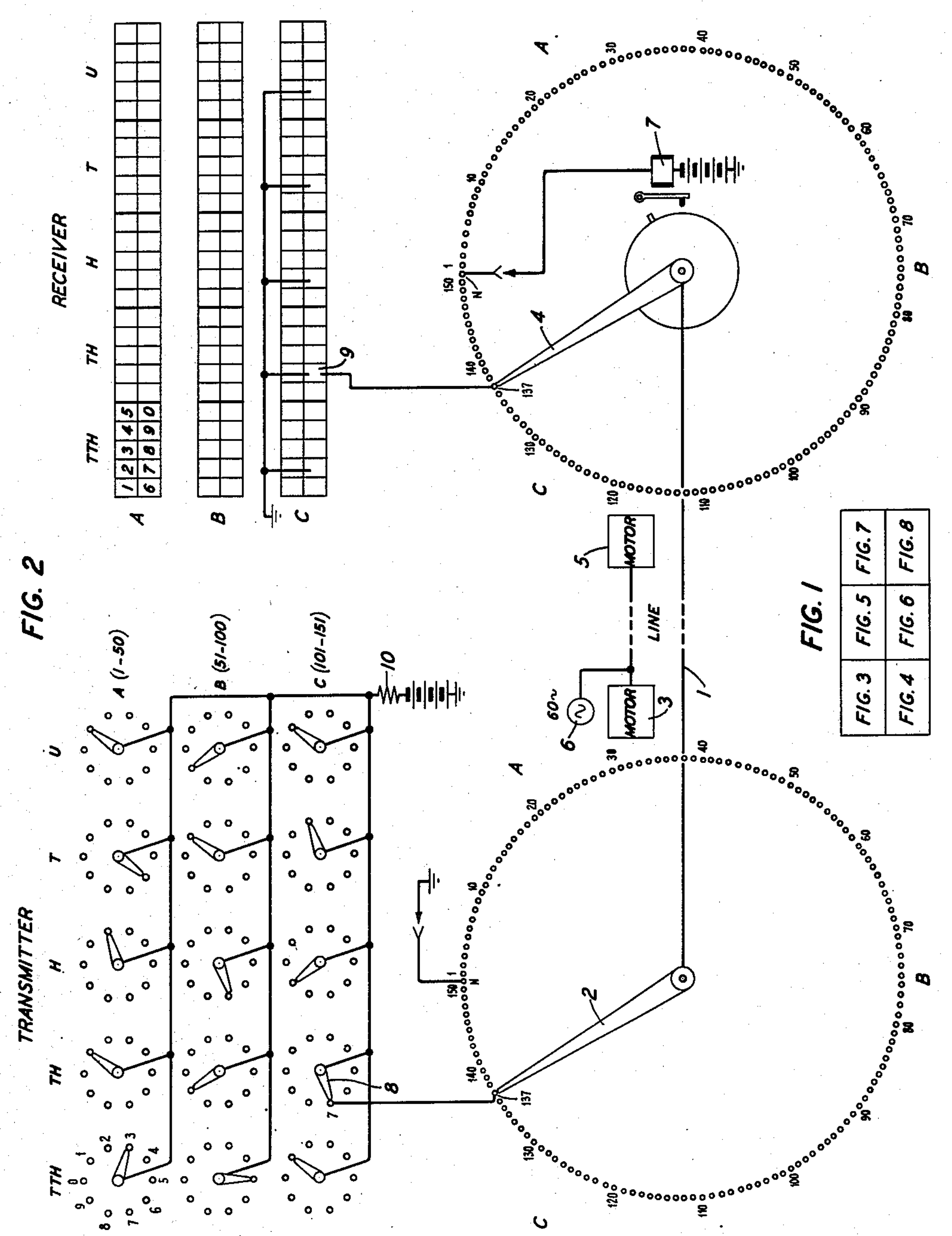
Aug. 14, 1945. O. R. MILLER **2,381,920**

TELEMETRIC DEVICE

Filed Feb. 17, 1944 13 Sheets-Sheet 1



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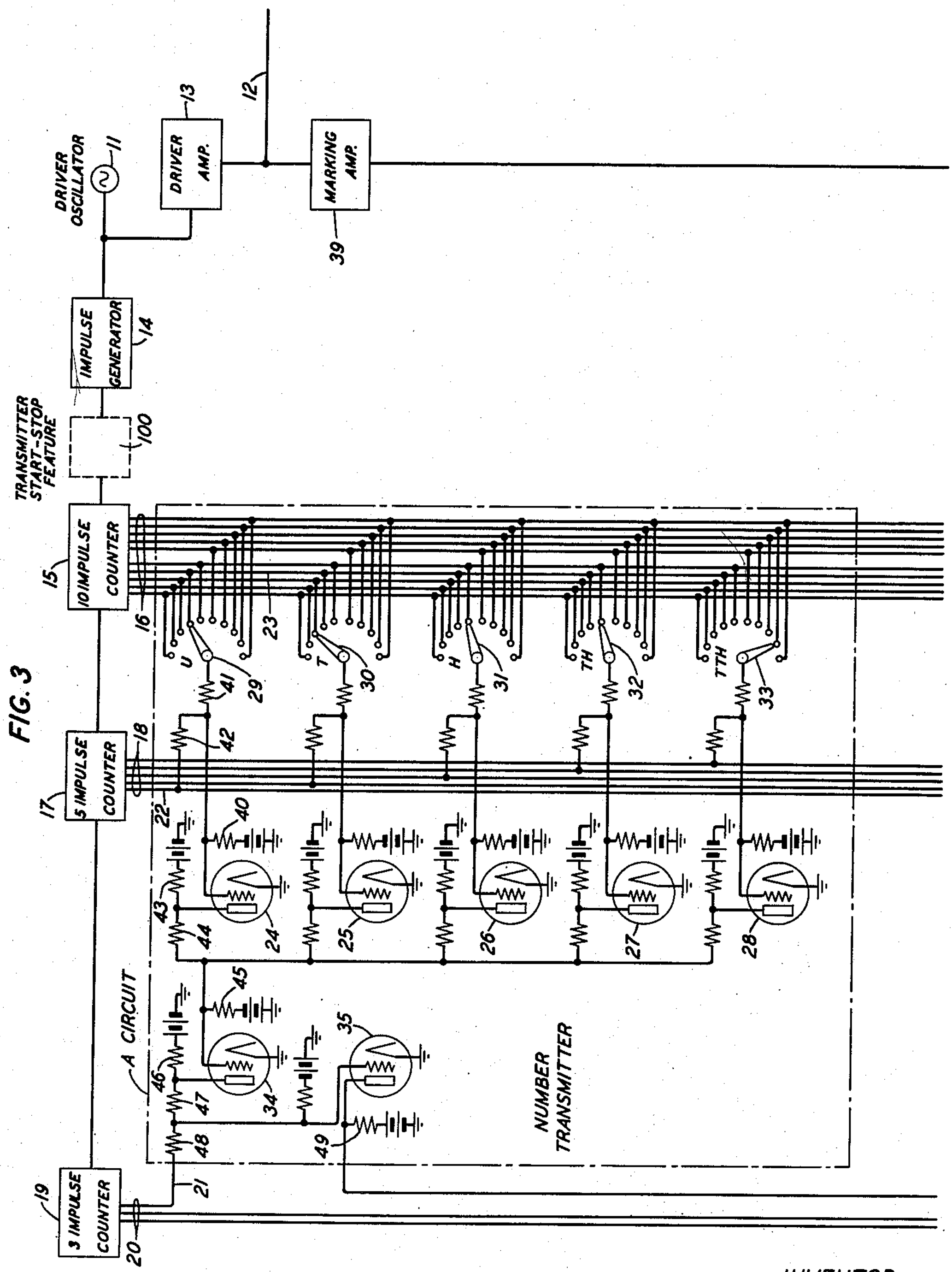

FIG. 3

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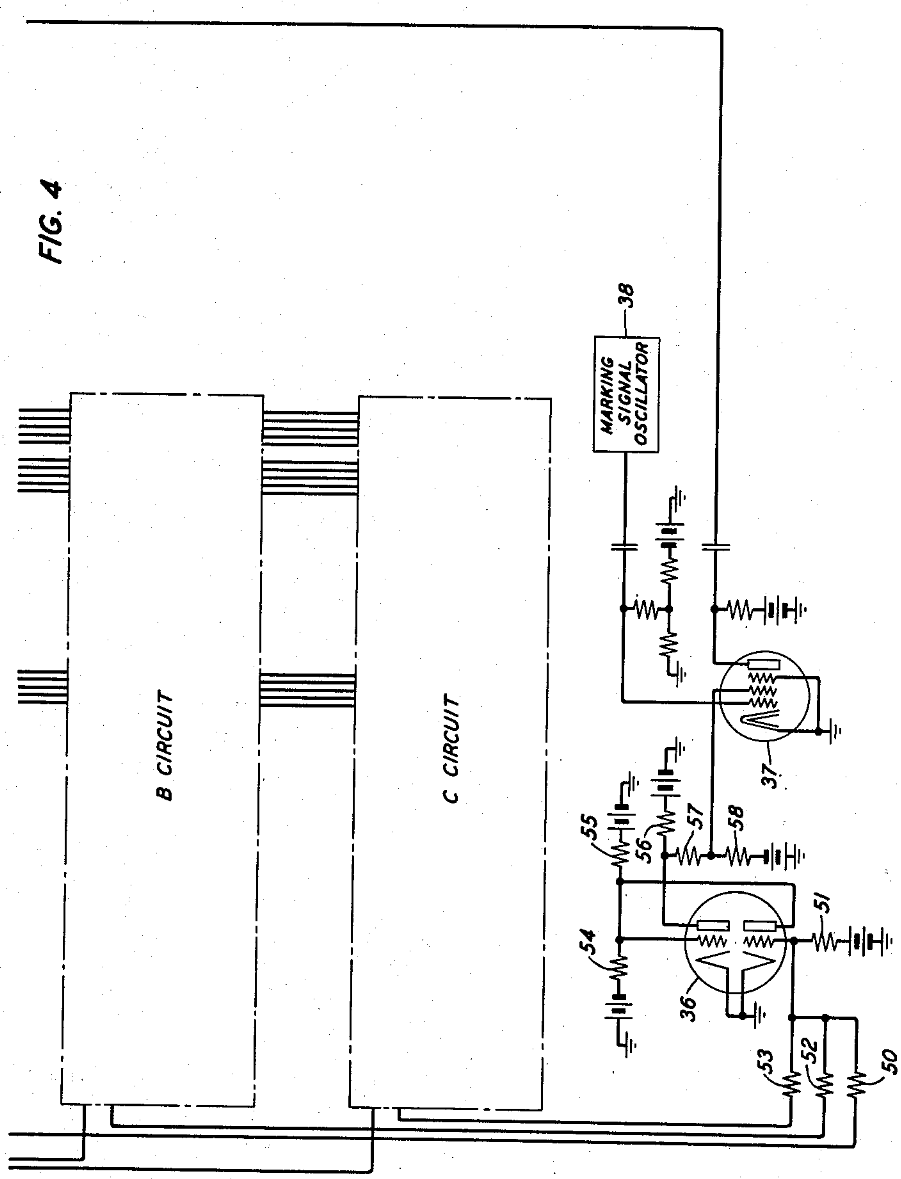
FIG. 4



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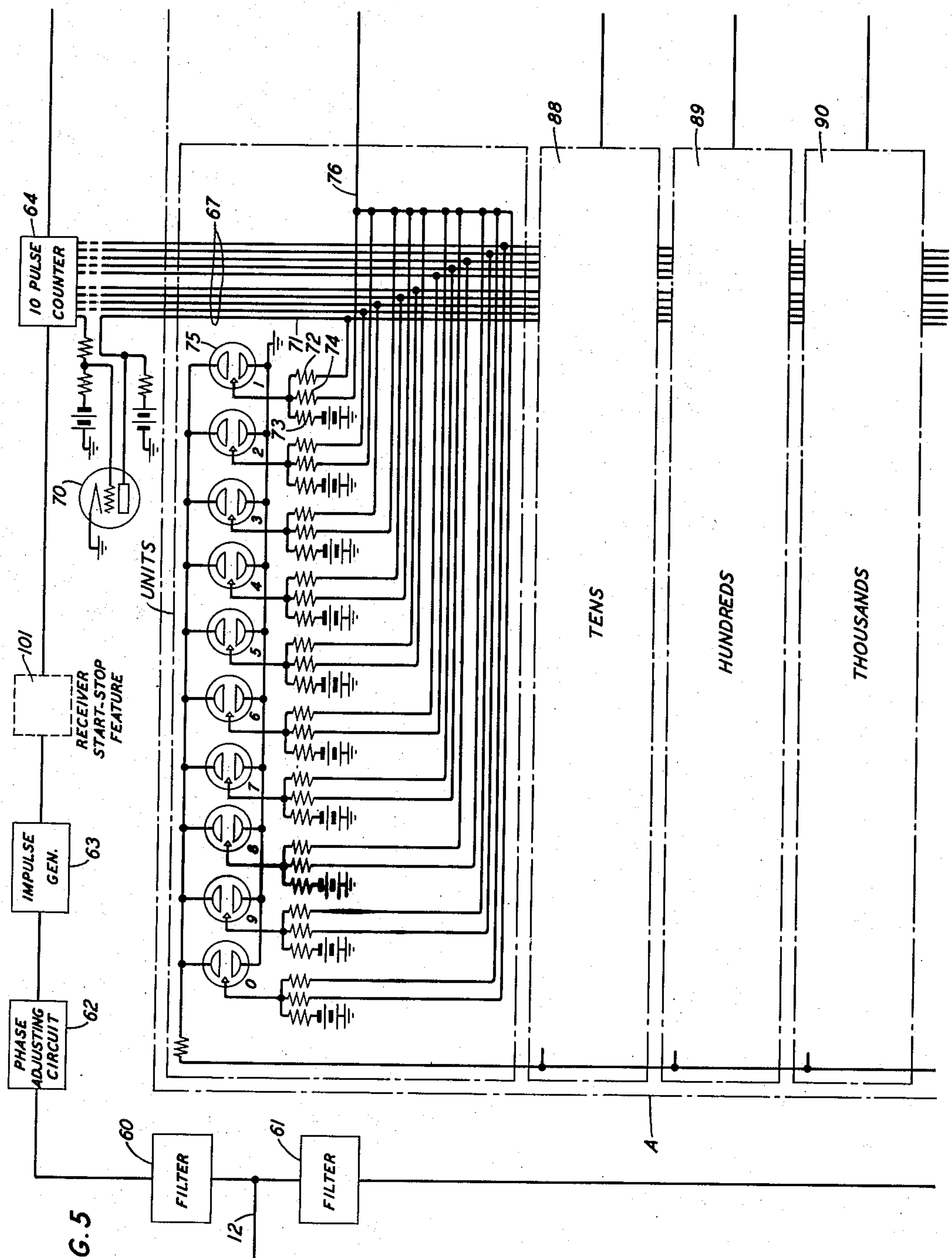

FIG. 5

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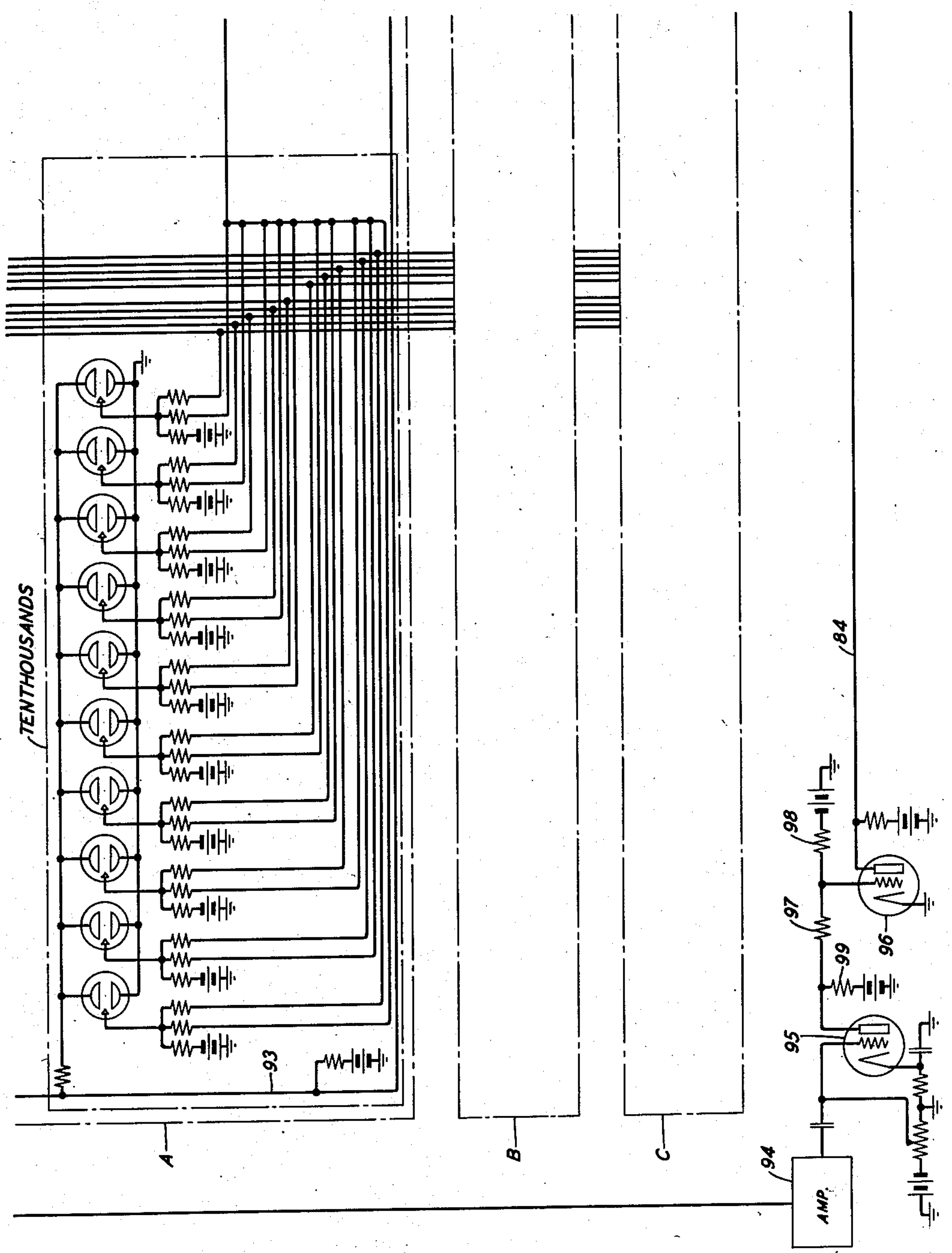

FIG. 6

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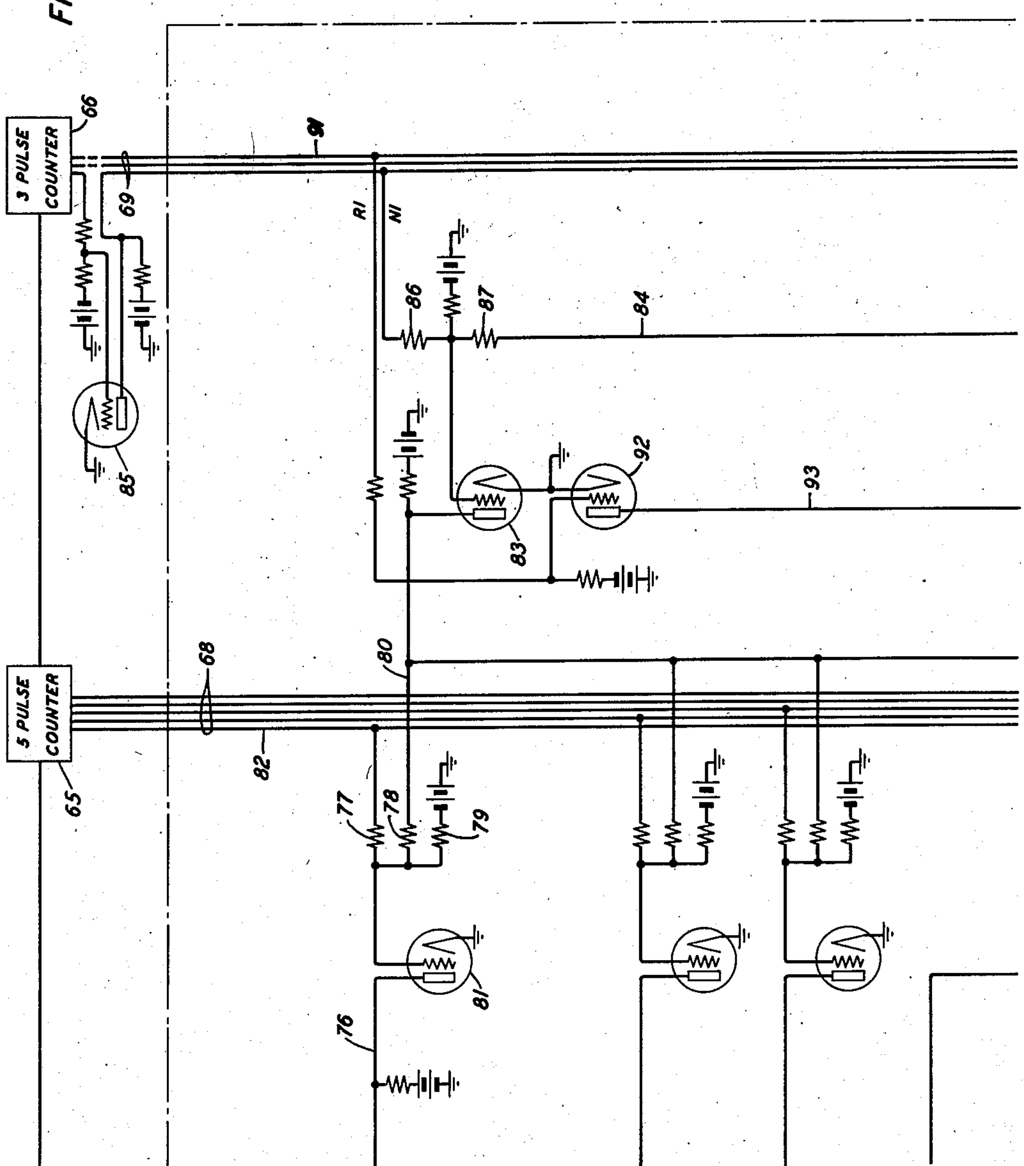
FIG. 7



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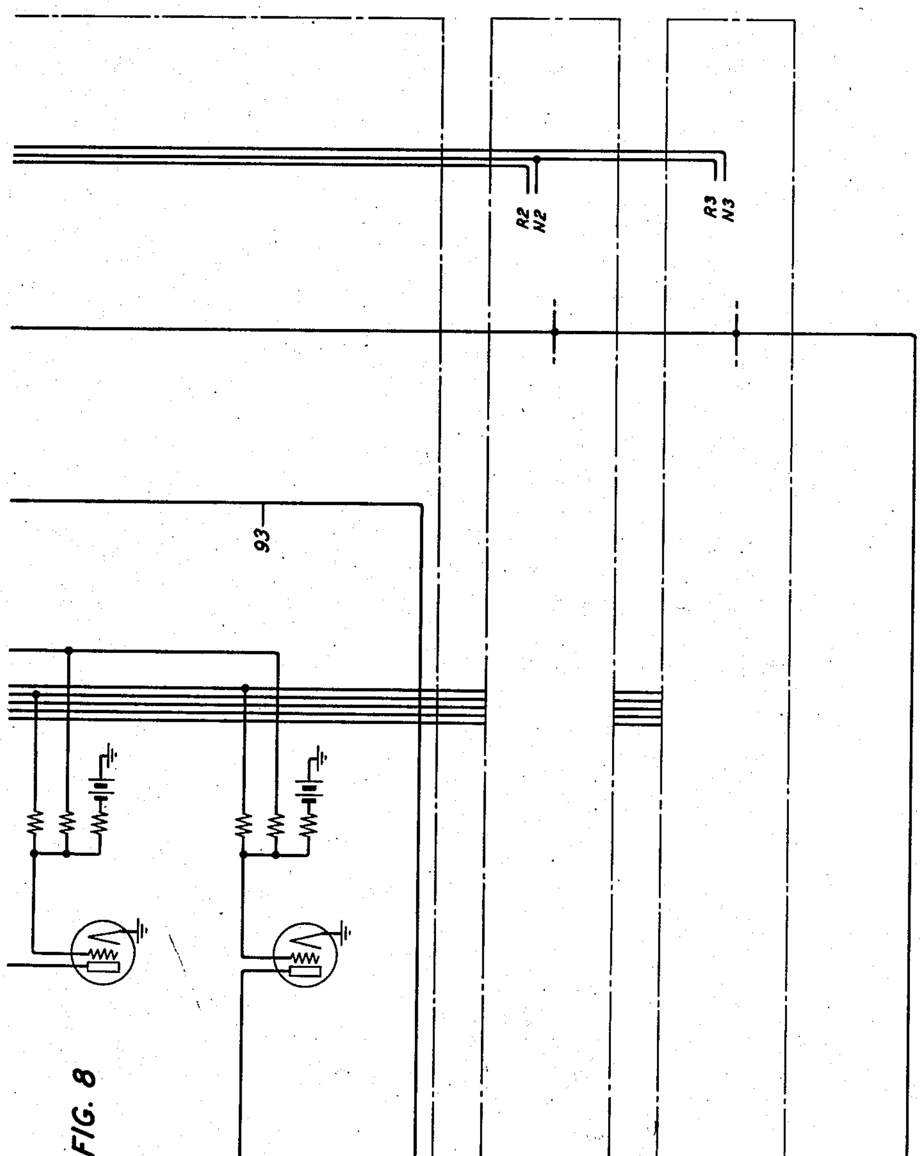

FIG. 8

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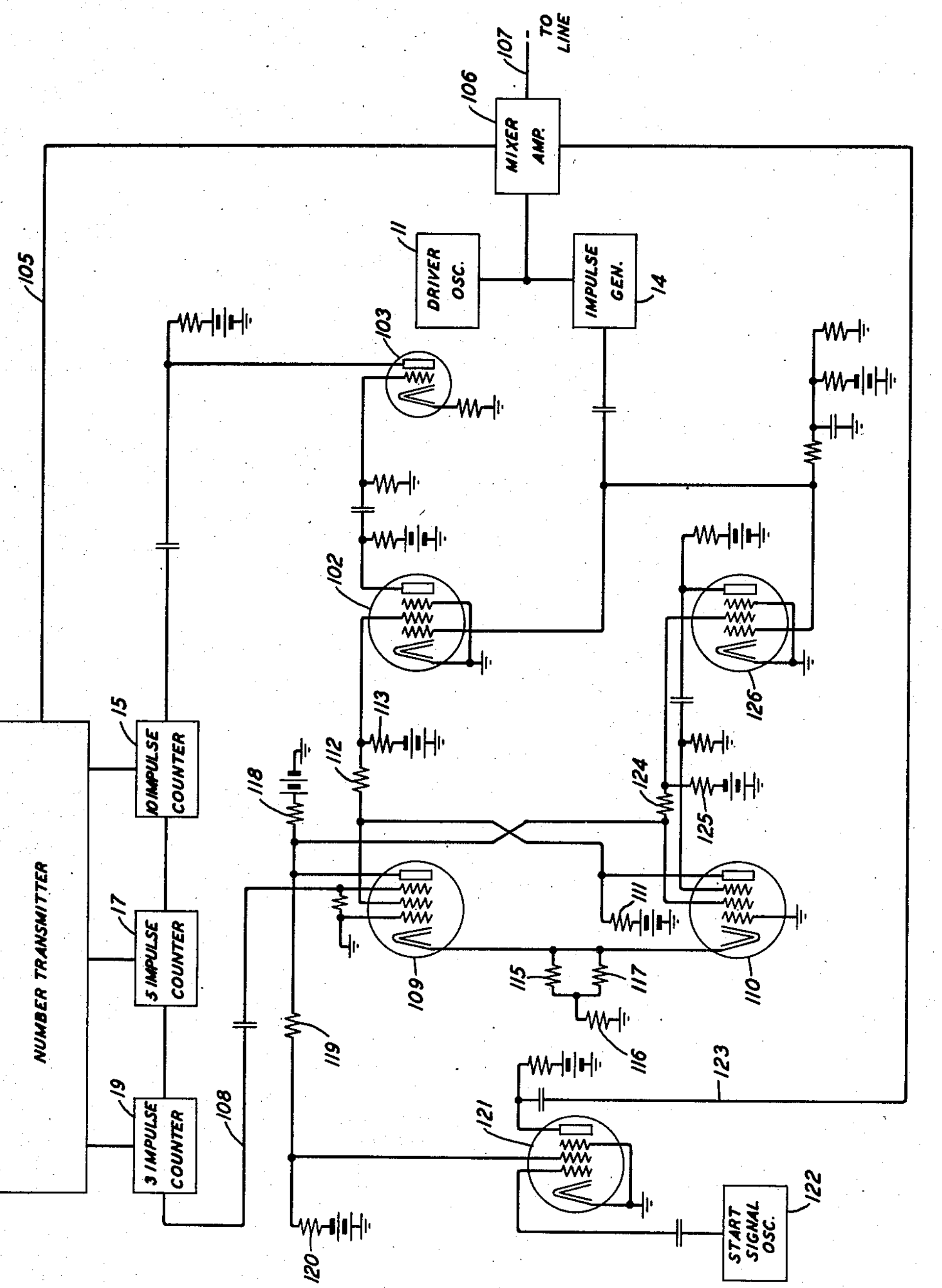
FIG. 9



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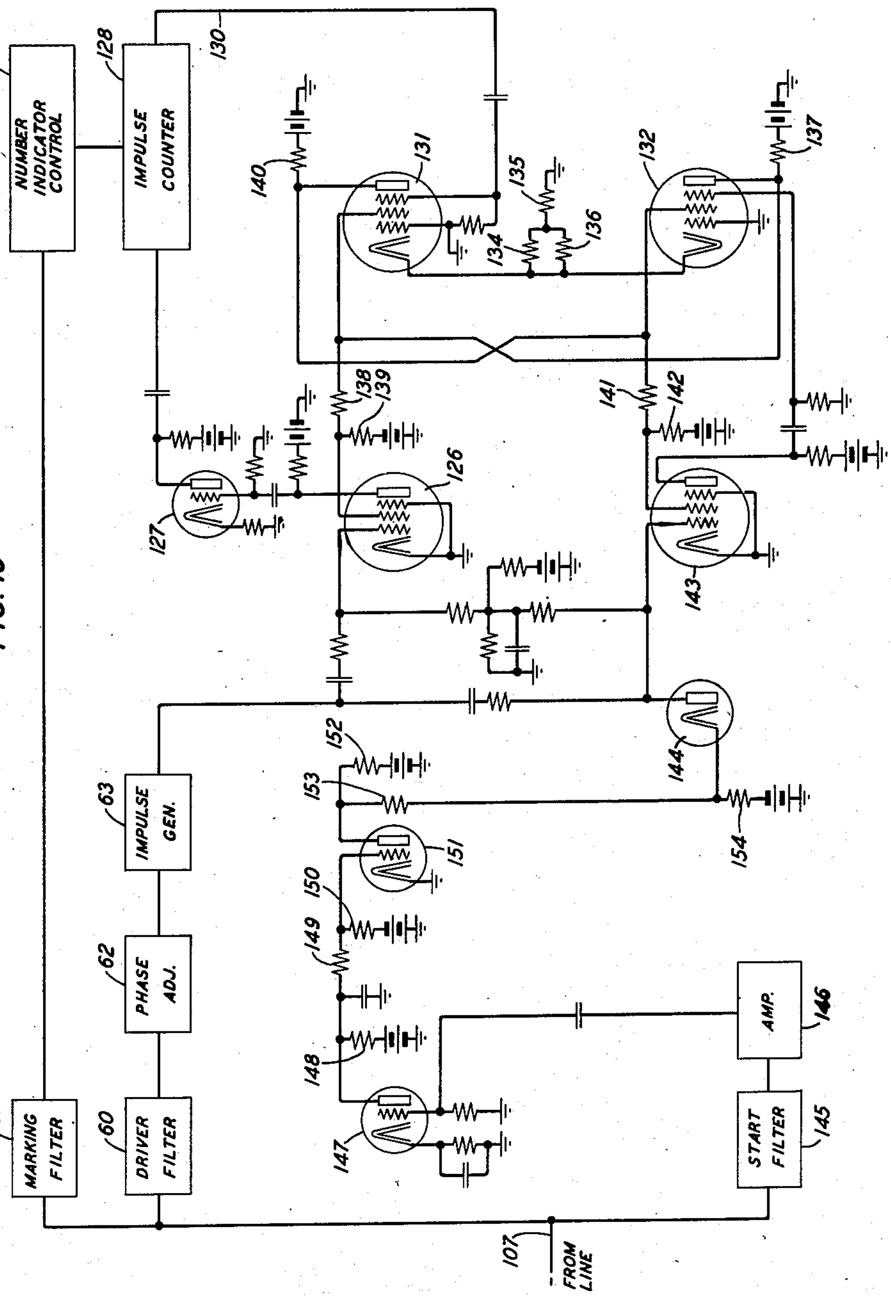

FIG. 10

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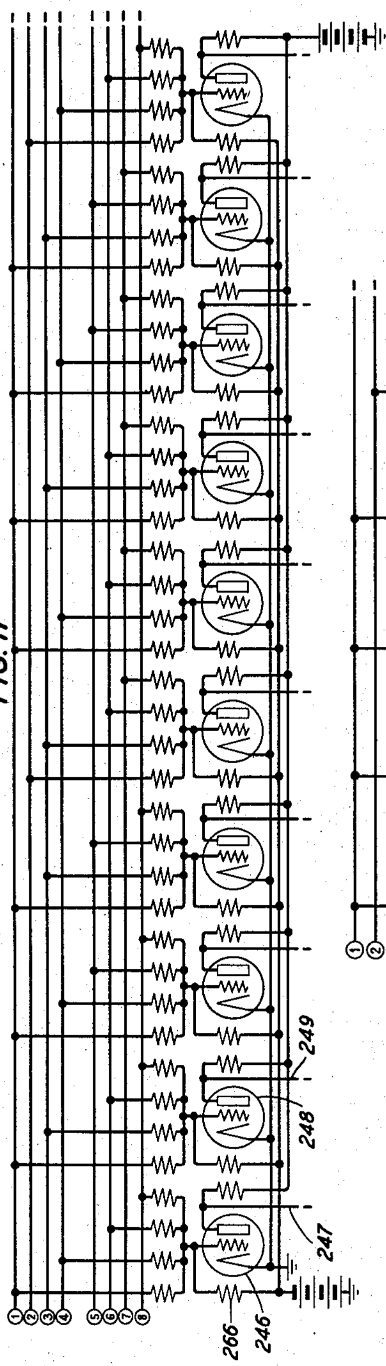

FIG. 11

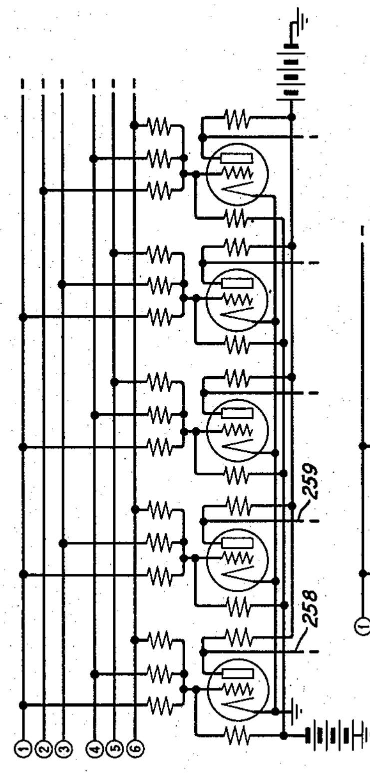

FIG. 12

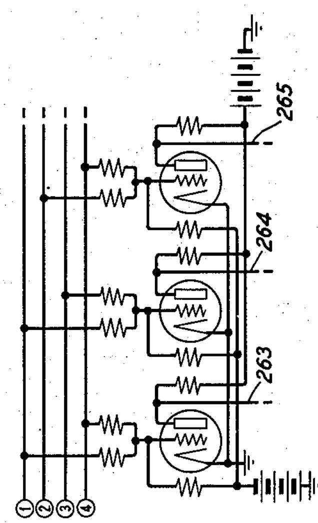

FIG. 13

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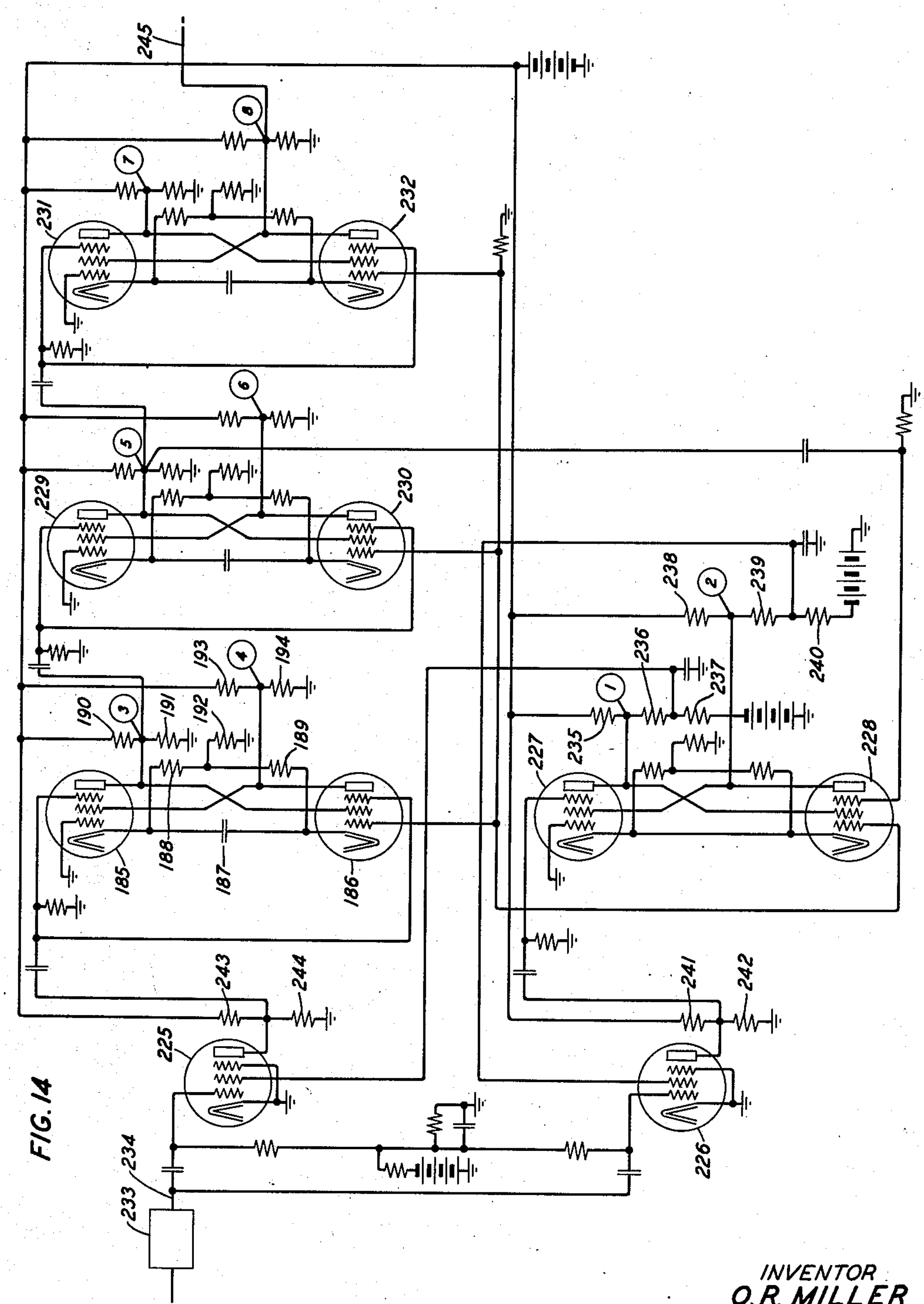

FIG. 14

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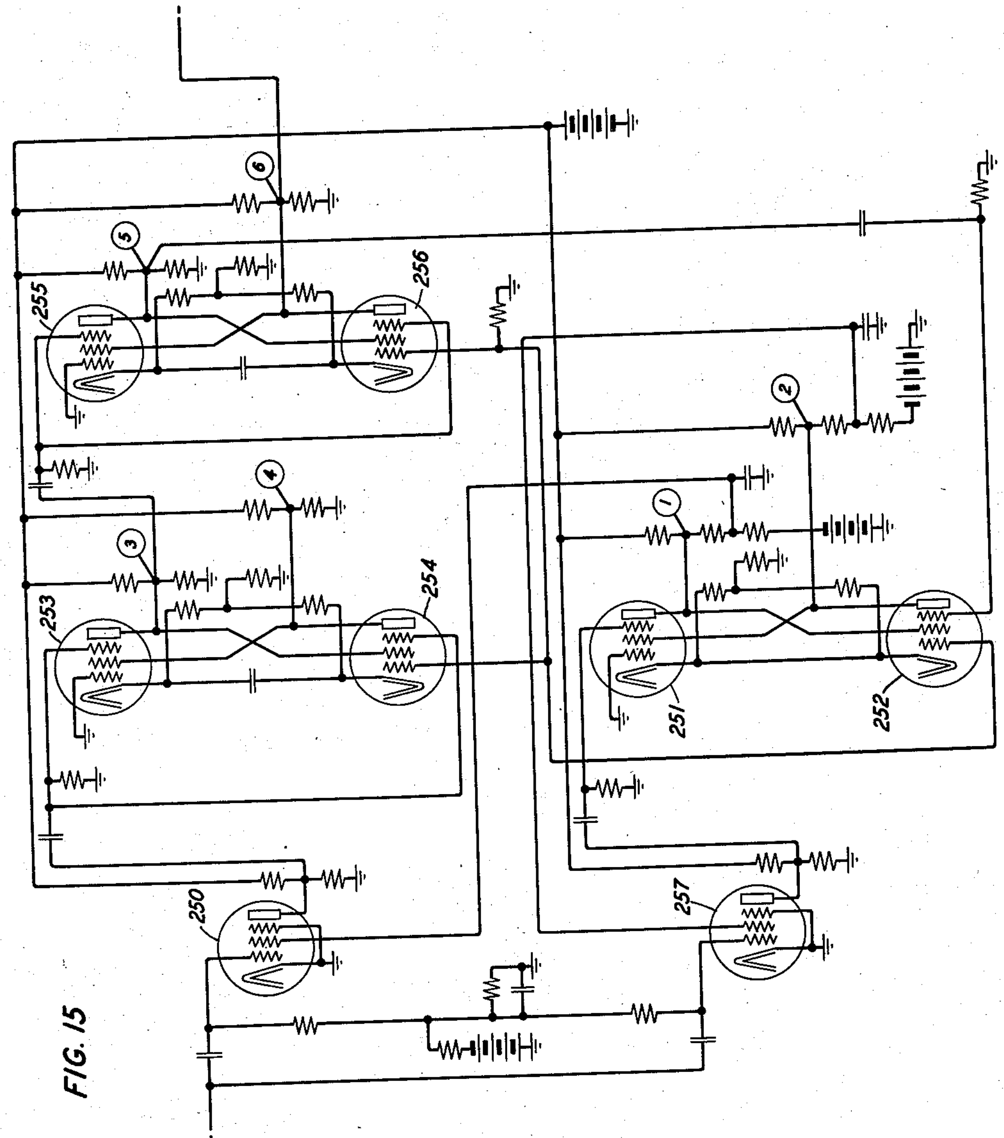

FIG. 15

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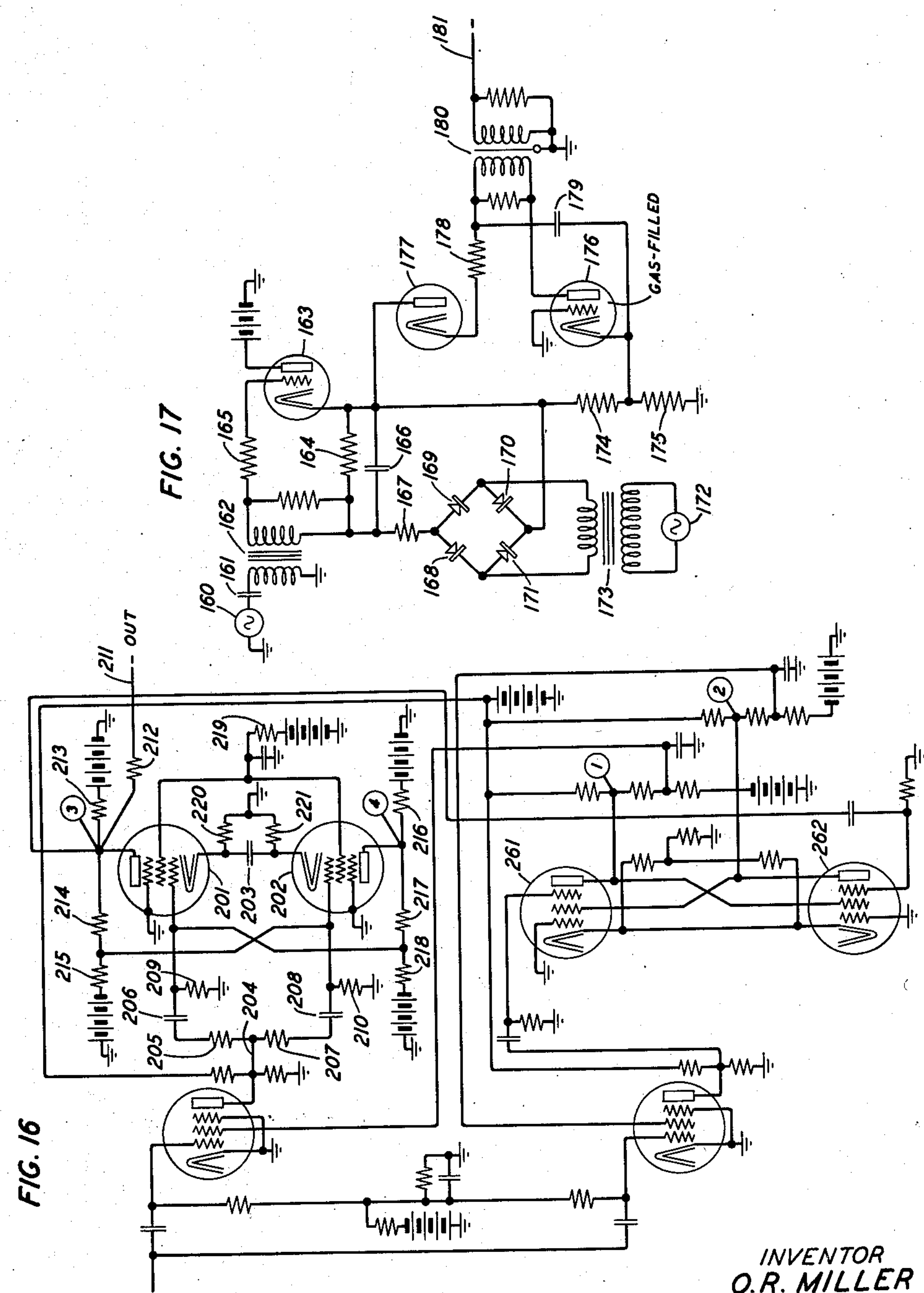

FIG. 17

FIG. 16

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Patented Aug. 14, 1945

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UNITED STATES PATENT OFFICE

2,381,920

TELEMETRIC DEVICE

Ohmer R. Miller, Morristown, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application February 17, 1944, Serial No. 522,713

3 Claims. (Cl. 177—337)

This invention relates to telemetric devices and particularly to number indicators, the object of the invention being to provide means controllable from some control point to continuously display at one or more distant points a plurality of numbers and to cause instant change in such displays when the controls at the central point are changed.

In accordance with this invention and as a specific example thereof it is desired to post at one or more remote locations three five-digit numbers and to cause instant change in such displays under control of an operator at a central location. The operation is carried out over a single conductor transmission channel by electronic devices similar in general principle to those devices known as cosmic ray counters, which are capable of very high speed operation. The apparatus employed may be termed an electronic commutator since the operation is similar in action to a pair of rotary distributors which simultaneously connects a transmitting circuit to a corresponding receiving circuit for a short interval of time and thus distributes the use of a single transmission channel over a large number of pairs of complementary terminal circuits. But unlike the conventional rotary distribution, the arrangement is very high speed and is limited only by the transmission characteristics of the channel. Thus the link between the two corresponding ends of a circuit, even where there are one hundred and fifty or more such complementary pairs may be completed a great many times per second.

Where circuit conditions can be rigidly controlled so that no unwanted disturbances will occur to throw the receiving arrangement out of synchronism with the transmitting arrangement a straight and permanent connection between the two ends may be made. However since these devices are extremely sensitive and responsive to very weak impulses and the system is likely to be used where great mechanical disturbances and vibrations which might result in unwanted electrical disturbances in the apparatus may occur, an arrangement somewhat analogous to the start-stop arrangements used in certain types of mechanical rotary distribution systems may be employed. Thus the transmitting arrangement as well as the receiving arrangement consists of an electronic counting device responsive to a continuous train of impulses and if one of the arrangements misses an impulse or responds to a stray impulse the synchronous action of the two arrangements will be disturbed. In such a case the response of the receiving device will be in error. Hence a synchronizing signal is transmitted periodically which has the effect of stopping the action of the receiving arrangement when it has gone through its cycle of operations and reached a normal position. The receiving arrangement is then rendered unresponsive to incoming signals until the transmitting arrangement reaches its corresponding normal position whereupon the two arrangements at the opposite ends of the transmission channel take up their synchronous operation.

In accordance with the specific embodiment of the invention disclosed herein the transmitting arrangement consists of three groups of counting tubes functioning to scan the electrical condition of the transmitting decade points to determine and transmit a signal for a particular digit for each of the three number designations in turn. For this purpose the first group of tubes has a complete cycle of ten different circuit conditions continuously responsive to a source of regularly recurring impulses, the second group of tubes has a complete cycle of five different circuit conditions continuously responsive to the recurring completion of its cycle by the first group and the third group of tubes has a complete cycle of three different circuit conditions continuously responsive to the recurring completion of its cycle by the second group.

At the receiving end a similar arrangement of tubes is employed to distribute the timed signals to operate corresponding indicators.

The synchronizing means comprises an extra set of counting tubes at each end of the transmission channel which interrupts the flow of impulses into the principal counting arrangements for one pulse and thus effectively renders the complete cycle equal to one hundred and fifty-one impulses. During the interval between the one hundred and fiftieth impulse and the one hundred and fifty-first impulse a synchronizing signal is transmitted. At the receiving end, if the arrangements at the two ends are in synchronism, this synchronizing signal acts to continue uninterruptedly the operation of the receiving arrangement. If for some reason the receiving device has fallen one impulse period behind the transmitting arrangement then the action of the receiving arrangement is held up for the next one hundred and fifty impulses until the transmitting arrangement goes through an almost complete cycle of operations, the signals sent during this nearly complete cycle being ineffective at the receiving end. If for some reason the transmitting device has fallen one impulse period behind the receiving arrangement, then the action of the receiving arrangement is held up for only a single impulse period. In any case erroneous operation of the indicators at the receiving end can only take place during a small fraction of a second so that the effect will appear as a flicker (the indicators being in the form of glow lamps) persisting for too short a period to give erroneous information.

The transmission channel carries both the alternating current used to derive the driving impulses and the information signals. Since this alternating current is of comparatively low frequency and the information signals are of comparatively high frequency it is a simple matter to filter these currents out at the receiving end and to direct them each into the circuits in which they become useful.

A feature of the invention is the use of a pair of similar electronic counters to perform the functions of rotary distributors at either end of a transmission channel.

Another feature is the use of a single source of alternating current for driving the two electronic counters, the said alternating current being transmitted over the same channel simultaneously with the mark signals transmitted when the counters couple a marked transmitting termination with its corresponding receiving termination.

Another feature is a synchronizing arrangement for the counters consisting of electronic means in each for stopping the response thereof to the driving source at the end of each complete cycle of operations. At the transmitting end means is provided to send out a start signal and immediately recondition the counter so that invariably such counter is halted only for a single impulse. At the receiving end the incoming start signal will only be effective if the receiving counter has simultaneously reached a similar position. If as hereinbefore pointed out the receiving counter has fallen one or more steps behind the transmitting counter, then the receiving counter is held out of operation for nearly a complete cycle, until the transmitting counter again "catches up" with the receiving counter.

Another feature is the use of different frequency currents for driving the counters, for sending mark signals and for sending start signals with filtering means at the receiving end for diverting these different frequency currents each into its own useful channel.

Other features will appear hereinaftr.

The drawings consist of thirteen sheets having seventeen figures, as follows:

Fig. 1 shows how Figs. 3 to 8, inclusive, may be placed to form a complete circuit diagram;

Fig. 2 is a schematic circuit diagram to explain the theory of operation of the system shown in Figs. 3 to 8;

Fig. 3 is a circuit diagram, partly schematic, of the transmitting end of the system and showing in full the circuit of one number transmitter;

Fig. 4 is an extension of the circuits of Fig. 3, indicating by blocks the circuits of two other number transmitters and showing in full certain other common circuit details;

Fig. 5 is a circuit diagram, partly schematic, showing part of the receiving circuits at the distant end of the line, showing in full the circuits of the units indicator and indicating by blocks the tens, hundreds and thousands indicators;

Fig. 6 is an extension of Fig. 5 and shows in full the circuit of the ten thousands indicator, and indicates by blocks two other number indicators each having like units, tens, hundreds, thousands and ten thousands indicators, and in addition shows certain other common circuits in some detail;

Figs. 7 and 8 are extensions of Figs. 5 and 6, respectively, showing part of the details of the circuits of the units and ten thousands indicators of the first number indicator;

Figs. 9 and 10 when placed with Fig. 9 to the left of Fig. 10, show circuit details of a start-stop feature which may be employed to insure accuracy in the operation of the system, Fig. 9 showing circuit details at the transmitting end and Fig. 10 showing circuit details at the receiving end of the transmission line;

Figs. 11, 12 and 13, respectively, show circuit details of the common leads from the ten-impulse counter, the five-impulse counter and the three-impulse counter;

Fig. 14 shows the circuit details of a ten-impulse counter;

Fig. 15 shows the circuit details of a five-impulse counter;

Fig. 16 shows the circuit details of a three-impulse counter; and

Fig. 17 shows the circuit details of an impulse generator.

The operation of the system of the present invention may be readily understood by the following description of the theoretical circuit of Fig. 2. The system consists essentially of a pair of synchronous distributors connected by a transmission line 1. The transmitting distributor consists of an arm 2 driven continuously over a bank of one hundred and fifty-one contacts by the motor 3. The receiving distributor consists of a like arm 4 driven continuously over a bank of one hundred and fifty-one contacts by the motor 5. The motors 3 and 5 may be synchronous motors both driven from a common source 6 of alternating current, whereby the arms 2 and 4 may be rotated in synchronism.

If there is any possibility that the arms 2 and 4 may fall out of step with each other or for purposes of achieving synchronism between these arms, a start-stop feature may be added. This is indicated by the connections to the one hundred and fifty-first contact in each bank. At the transmitting end this will consist of a ground connection to the said contact and at the receiving end it will consist of a magnet 7 connected to the corresponding contact. Such magnet 7 is provided with an armature which in its normal position will stop the rotation of the arm 4. Therefore if the arms 2 and 4 are in synchronism with each other the magnet 7 will be energized once during each revolution of the arms 2 and 4 and the armature of magnet 7 will be moved to a point where the free movement of arm 4 is unhindered. If the arms 2 and 4 should fall out of step with each other then through the non-energization of the magnet 7, the arm 4 will come to rest on its one hundred and fifty-first contact and will remain there until the arm 2 is moved to a corresponding position, whereupon the magnet 7 will be energized and the arm 4 will be mechanically connected to the motor 5 and will thereafter rotate in synchronism with the arm 2. Arrangements of this nature are well known in the art. Other arrangements are known which allow faster rotating speeds but this is analogous to the hereinafter-described electronic commutator.

At the transmitting end the one hundred and fifty contacts over which the arm 2 travels are connected to corresponding contacts of fifteen switches each controlling the connection of battery to ten contacts and arranged so that three five-digit numbers may be set up on the said switches. Thus the switch arm 8 may be set on its seventh contact which is connected to the one hundred and thirty-seventh contact traversed by the distributor arm 2. The switch arm 8 is indicated in the drawings as controlling the thousands digit of the third number. An inspection of the other switch arms will show them to be set, by way of example, to transmit the numbers 31261, 59719 and 17921, respectively.

At the receiving end of the transmission line there are fifteen number indicators each consisting of a bank of ten indicators which may be lamps or other mechanical indicators having visual persistence or slow-releasing properties sufficient to give a constant indication when they are repeatedly energized once during each revolution of the arm 4. Thus the seventh indicator in the thousands group of the third number is shown connected to the one hundred and thirty-seventh contact traversed by the arm 4, so that once during each revolution of the arms 2 and 4 a circuit will be completed between battery, resistance 10, switch arm 8, distributor arm 2, transmission line 1, distributor arm 4, indicator 9 to ground. In this case only the seventh indicator in the thousands group in the third number will be energized, and likewise only one indicator in each of the other groups of indicators will be energized, whereby the numbers 31261, 59719 and 17921 will be displayed.

The switch arms such as 8 may be reset at any time and since the arms 2 and 4 travel at a relatively high speed the numbers displayed at the receiving end will appear to be instantly changed. Thus the display of numbers may be constantly in accordance with the setting of the tranmitting device.

It should be noted that a plurality of receiving devices may be connected in multiple so that the information set up by the switch arms such as 8 may be constantly transmitted to and displayed at a plurality of different locations.

The system of the present invention operates in the manner above set forth excepting that no mechanically moving parts are employed other than the manually controlled decade transmitting switches. As shown in Figs. 3 to 8, a source of alternating current 11 is used to energize certain counting tube combinations both at the transmitting end and the receiving end of the transmission line 12, being connected to the transmission line through a conventional driver amplifier 13 whereby current therefrom is transmitted over the transmission line simultaneously with the signaling impulses produced by the transmitter. In the transmitter circuit the current from the driver oscillator 11 operates an impulse generator 14 to produce a constant stream of impulses recurring at the frequency of the source 11 and suitable to operate a tube counter. These impulses are counted by a ten-impulse counter 15 repeatedly, this device energizing each of the ten conductors 16 in turn repeatedly. For each ten impulses counted by the device 15 one impulse is transmitted to the five-impulse counter 17 which in a similar manner energizes each of the five conductors 18. For each five impulses counted by the device 17 one impulse is transmitted to the three-impulse counter 19 which in a similar manner energizes each of the three conductors 20. Where, by way of example, a combination of three conductors is found simultaneously energized, as conductors 21, 22 and 23, then a signal is sent out over the transmission line 12. Since the five conductors in the group 18 are energized in turn then the tubes 24, 25, 26, 27 and 28 are in turn conditioned to be affected by the conditions found in the group 16 as determined by the setting of the decade switches 29, 30, 31, 32 and 33, respectively. Thus an impulse will be sent out somewhere within each group of ten impulses counted.

In a similar manner, since the three conductors in the group 20 are energized in turn, then the tube 35 in the first number transmitter and the corresponding tubes in the other two number transmitters will in turn be conditioned to be affected by the tube 34 and the corresponding tubes in the other number transmitters. Each time, therefore, that three such conductors as 21, 22 and 23 are simultaneously energized the tube 36 will be affected and the gate relay 37 will allow an impulse from the oscillator 38 to be transmitted through the marking amplifier 39 to the transmission line 12. Thus in a complete cycle the ten-impulse counter 15 will go through fifteen complete cycles, the five-impulse counter will go through five complete cycles and the three-impulse counter will go through one complete cycle and fifteen signals will be transmitted.

As will be explained more in detail hereinafter, each of the conductors in the group 16 is normally held at a comparatively high positive potential, and likewise each of the conductors in the group 18 is normally held at a comparatively high positive potential. A negative battery is connected through a resistance 40 to the grid of tube 24 and since this grid is also connected through resistance 41 to some one of the conductors in group 16 and through resistance 42 to a particular one (22) of the conductors in group 18, the grid is thus connected to the potentiometer point at which the potential is such as to render the tube 24 normally conducting. Only when the potentials communicated through the resistances 41 and 42 are simultaneously at a comparatively low positive potential does the potential of the said potentiometer point, and hence the grid of tube 24, fall to such a value that tube 24 becomes non-conducting. The anode of tube 24 is connected to a potentiometer point between resistors 43 and 44 and hence when tube 24 becomes non-conducting the potential of this point is raised from a normal comparatively low positive potential. Consequently the potentiometer point between resistances 44 and 45 shows a rise in potential at this time so that tube 34 which is normally non-conducting now becomes conducting. This causes the potentiometer point between resistances 46 and 47 to fall and likewise the potentiometer point between resistances 47 and 48 to fall. However, it is not until the normally comparatively high positive potential of the conductor 21 in group 20 connected to resistance 48 also falls to a comparatively low positive potential, that the potential of the potentiometer point between resistances 48 and 47, which is connected to the grid of tube 35 will fall to a value sufficient to cause the tube 35 to become non-conducting. Thus when conductors 21, 22 and the conductor now connected to switch arm 29 simultaneously fall to a comparatively low positive potential, tube 35 will respond by becoming non-conducting.

Resistances 49, 50 and 51 constitute a potentiometer. When tube 35 is in a non-conducting state the potentiometer point between resistances 50 and 51 is at a comparatively high positive potential. Since the normal state of tube 35 and the corresponding tubes connected to resistances 52 and 53 is the same, the grid of the lower triode combination of tube 36 is at a comparatively low positive potential and this lower triode combination is in a non-conducting state. However, when any one of the tubes such as 35 becomes non-conducting then the grid 36 rises to a sufficiently high positive potential to render this lower triode combination conducting.

The grid of the upper triode combination of tube 36 is connected to a potentiometer point between resistances 54 and 55 and also to the anode of the lower triode combination. Consequently as the lower triode combination becomes conducting (on receipt of a signal) the grid of the upper triode combination falls to a comparatively low positive potential and the upper triode combination becomes non-conducting. Thus the lower and upper triode combinations are always opposed in state and the upper triode combination is non-conducting during the transmission of a signal.

The anode of the upper triode combination of tube 36 is connected to a potentiometer point between resistances 56 and 57 and the screen grid of tube 37 is connected to a potentiometer point between resistances 57 and 58. Consequently when a signal is to be transmitted the screen grid of gate tube 37 rises in potential and allows the output of the oscillator 38 to so affect the grid of this tube that a corresponding signal is produced in the anode circuit thereof. This signal is therefore in the form of a timed transmission of alternating current of the frequency of the source 38 transmitted to the marking amplifier 39 and thence out over the transmission line 12.

It is thus apparent how the signals corresponding to the digits 31261, 59719 and 17921 are sequentially transmitted.

At the receiving end of the transmission line 12 a pair of filters 60 and 61 are provided. Filter 60 is designed to pass current from the driver oscilator 11 and thus provide a source of current for operating the impulse generator 63. A phase adjusting circuit 62 is provided so that the impulses from the generator 63 may be brought into exact synchronism with the impulses from the transmitting generator 14. These impulses will then operate a ten-impulse counter 64 similar to the ten-impulse counter 15, a five-impulse counter 65 similar to the five-impulse counter 17 and a three-impulse counter 66 similar to the three-impulse counter 19. Similar to the arrangement at the transmitting end each conductor in the groups coming from the impulse counters will normally be at a comparatively high positive potential. In this case, however, the signal from the ten-impulse counter must be a positive pulse and so the conductors in the group 67 are held normally at a comparatively low positive potential by the use of an inverter tube placed in the lead from the ten-impulse counter. Thus the normally high potential (first left) lead from the ten-impulse counter 64 goes to the grid of tube 70 and holds this in a normally conducting state. Therefore the potential on conductor 71 is normally comparatively low, and hence the potentiometer point between resistors 72 and 73 is normally low so that the glow tube 75 is prevented from operating. Only when the potential on conductor 71 leading through resistance 72 and the potential on conductor 76 leading through resistance 74 are simultaneously comparatively high is the control electrode of tube 75 raised sufficiently to fire the tube and to make it glow for visual indicating purposes. Each of the leads from the ten-impulse counter 64 has an inverter tube such as 70 inserted betw en it and the corresponding conductor in the group 67 as indicated by the broken lines just below the ten-impulse counter 64.

The potential of conductor 76 is controlled from the five-impulse counter 65. Each of the conductors in group 68 is normally at a comparatively high positive potential so that the potentiometer point between resistances 77 and 79 (conductor 80 as will hereinafter appear also being normally at a comparatively high positive potential) will be sufficiently high to render the tube 81 conducting. With this tube conducting its anode is then at a compartively low potential. Therefore when conductors 82 and 80 simultaneously fall in potential tube 81 will become non-conducting and consequently conductor 76 will rise in potential. If during such a period conductor 71 also rises in potential, tube 75 will be triggered off and will glow, the tube thereby functioning as an indicator. A tube suitable for such a use is disclosed in Patent 2,271,685 issued to S. O. Ekstrand, February 3, 1942.

The potential of conductor 80 is controlled by tube 83, so that as tube 83 is in a conducting or non-conducting state its anode is at a comparatively low or comparatively high positive potential. Tube 83 is controlled by the condition of a conductor in group 69 and by the incoming signal which appears as a positive pulse on conductor 84. The normal condition of the three conductors coming from the three-pulse counter is a comparatively high positive potential whereby the tube 85 by way of example is rendered conducting thus holding its anode at a comparatively low positive potential. Thus through resistance 86 the grid of tube 83 is held normally low and tube 83 is rendered non-conducting to hold its anode and consequently conductor 80 normally high. Also, as will appear hereinafter, the potential of the grid of tube 83 is also held normally low by the potential of conductor 84 as connected to the grid of tube 83 by resistance 87.

Now it will be realized that one of the three conductors coming from the three-pulse counter is brought down to a low potential during the period when the corresponding number indicator is to be rendered active. Thus when the number indicator shown by the details of the units indicator and the broken line rectangles 88, 89 and 90 representing the tens, hundreds and thousands indicators, respectively, in Fig. 5 and the details of the ten thousands indicator in Fig. 6 are to be rendered active, the potential of the grid of tube 85 will be lowered and the other two conductors coming from the three-impulse counter 66 will rise in potential. Thus the potential of the grid of tube 83 is conditioned by a rise in potential through resistance 86 so that when a signal comes in over conductor 84 the tube 83 will become conducting, the potential of conductor 80 will be lowered and if the potential of conductor 82 is now lowered tube 81 will become non-conducting to pass the signal on as a rise in potential on conductor 76. Since at this time conductor 91 is at a comparatively low potential tube 92 will be non-conducting and the anode thereof will be at a comparatively high potential. Conductor 93 is connected to the upper electrodes of all the glow tubes such as 75 and hence during this period all such tubes of one number indicator are conditioned to operate when, as explained, the potentials supplied through resistances such as 72 and 74 become simultaneously high.

The incoming signal as hereinbefore explained is in the form of a short application of a particular frequency alternating current which is passed by the filter 61. This signal is then amplified by a conventional and appropriate amplifier 94 and passed to the grid of tube 95 which becomes conducting and consequently operates to lower the potential of its anode during the period of the reception of the signal. Tube 95 thus acts as a detector and translates a pulse consisting of a plurality of cycles of alternating current into a single impulse consisting of an interval during which the anode of tube 95 is lowered in potential. Tube 96 has its grid connected to a potentiometer point between resistances 97 and 98 controlled by the tube 95 and therefore it responds to this signal by becoming non-conducting, thus translating the signal to an impulse of comparatively high positive potential on conductor 84 with the results hereinbefore explained. Thus it will be seen how the sequentially arriving signals are translated into a display of the numbers 31261, 59719 and 17921. Since the frequency of the source 11 may be comparatively high the number of times the complete cycle of operations may be completed per second may be so high that the display of the numbers may be altered apparently as the switches 29 to 33 and so on are being altered, thus producing at one or more receiving stations a continuous and instantaneously adjustable display of certain information.

Attention is directed to the arrangement of the conductors in the group 69 coming from the three-impulse counter 66. These conductors are affected in rotation, that is, while the first (counting from the left) is at a comparatively high positive potential, the second and the third are at a comparatively low positive potential. Thus while the first number display circuit is enabled by the comparatively high positive potential supplied by way of resistor 86 the conductor 93 is rendered active by its connection through the tube 92 to the third conductor. Thus when one of the tubes such as 75 is triggered off it remains active as long as conductor 93 remains active. This is for the period of the setting of the first and the second number display indicators, for when the setting of the first is completed, although the first conductor of the group 69 changes from high to low potential and the second thereupon changes from low to high potential, there is no change in the third conductor until the third number indicator is to be rendered active. Thus a glow tube after being triggered off remains aglow for a period between one-third and two-thirds of the time taken for a complete cycle, depending on whether it was triggered off near the end or near the beginning of the count for the indicator in which it is situated. For this reason partly the display will appear to be continuous.

Corresponding connections to the three conductors of group 69 for the other number indicators will be seen in Fig. 8.

The system shown in Figs. 3 to 8, inclusive, and as above described operates without the start-stop feature. However, this feature may be incorporated in the system as indicated by the broken line rectangles 100 and 101 in Figs. 3 and 5, respectively, the one representing the circuits at the transmitting end and the other representing the circuits at the receiving end. In order to explain the start-stop feature, reference may be had to Figs. 9 and 10 placed end to end with Fig. 9 to the left of Fig. 10.

At the transmitting end, shown in Fig. 9, the driver oscillator 11 and the impulse generator shown in Fig. 3 are used. In this case the detail circuits show the apparatus indicated by the rectangle 100 of Fig. 3. Here the output of the impulse generator in the form of a stream of positive impulses feeds into the tube 102 which produces a stream of negative impulses and this in turn is changed by the inverter tube 103 into a stream of positive impulses feeding into the ten-impulse counter 15, the five-impulse counter 17 and the three-impulse counter 19. These function as hereinbefore described to operate the number transmitter here indicated by the rectangle 104 which in turn produces the marking signals which it transmits over the conductor 105 and thence through the mixer amplifier 106 to the transmission line 107. On the one hundred and fiftieth count the three-impulse counter 19 transmits a negative impulse over conductor 108 which will reverse the state of the tubes 109 and 110. Normally tube 109 is conducting and tube 110 is non-conducting whereby the potentiometer point between the resistances 111 and 112 is at a comparatively high positive potential and whereby the other potentiometer point between the resistances 112 and 113 is at a comparatively high positive potential, sufficient to render tube 102 conducting to pass the output of the generator 14 to the ten-impulse counter 15. When the negative impulse is transmitted to the suppressor grid of tube 109, this tube becomes non-conducting and since its anode is thereby raised to a comparatively high positive potential and since this anode is connected to the screen grid of tube 110, tube 110 now becomes conducting. As a result, the screen grid of tube 102 is lowered in potential to the point where it will no longer pass the impulses from the generator 14 to the ten-impulse counter 15 so that the one hundred and fifty-first impulse does not reach the counter 15 to be counted.

When the tube 109 becomes non-conducting the potential of its anode which is connected to a potentiometer point between the resistors 118 and 119 rises from a comparatively low to a comparatively high positive potential. The potentiometer point between the resistors 119 and 120 likewise rises and since this point is connected to the screen grid of tube 121, tube 121 becomes conducting and passes current from the source 122 to the conductor 123, which acts as a stop signal and is transmitted through the mixer amplifier 106 to the transmission line 107. It may be noted at this point that the current from the source 122 is of a different frequency from other signals being passed over the transmission line so that it may be properly filtered at the distant end and thereby directed in its proper channel for purposes which will be presently described.

When tube 109 becomes non-conducting and the negative impulse which produces this condition has terminated, tube 110 becomes conducting as described. The comparatively high positive potential of the anode of tube 109 now affects the potentiometer points between resistors 118 and 124 and between 124 and 125 as a consequence of which the potential of the screen grid of tube 126 rises and this tube becomes conducting. The next or one hundred and fifty-first impulse in the series transmitted from the generator 14, therefore, is conducted through tube 126 so that the potential of its anode suddenly drops thus producing a negative impulse to the suppressor grid of tube 110 which reduces this tube to a non-conducting state, which in turn activates tube 102 to pass the next, or first of a new series of impulses on to the counters. The movement of tube 110 to the non-conducting state also causes tube 109 to conduct whereby the tube 121 is rendered non-conducting and the transmission of current from the source 122 is stopped.

Thus by the arrangement shown in Fig. 9, each time after one hundred and fifty pulses have been counted by the counters 15, 17 and 19, the transmission of impulses from the generator 14 to the counters is stopped for the time of one impulse and during this period a start signal is transmitted over the line 107.

At the receiving end of the transmission line 107 there are provided the driver filter 60, the phase adjusting device 62 and the impulse generator 63. The impulses from this generator, in the form of a stream of positive pulses, are passed by the tube 126, when active, to the grid of inverter tube 127. Each impulse passed by the tube 127 appears as a sudden drop of potential on the anode of tube 126 and therefore constitutes a negative impulse on the grid of inverter tube 127. This renders the tube 127 non-conducting for an instant so that the consequent sudden rise of potential on its anode constitutes a positive pulse to the impulse counters here indicated by the rectangle 128 designated impulse counter. The impulse counter in conjunction with the number indicator control 129 also controlled through the marking filter 61 performs the functions hereinbefore described.

A conductor 130 leads from the impulse counter 128 and over this lead a negative impulse is transmitted on the one hundred and fiftieth count. Here tubes 131 and 132 are arranged as a pair, one of which is in a conducting state while the other is non-conducting. Normally tube 131 will be conducting so that the negative impulse transmitted over conductor 130 to the screen grid of tube 131 will reduce this tube to a non-conducting state. Thereupon, in a manner similar to that hereinbefore described, tube 132 which was heretofore non-conducting now becomes conducting. Therefore, the negative impulse over conductor 130 causes a reversal in the condition of tubes 131 and 132. Tube 132 has its anode connected to a potentiometer point between resistors 137 and 138 and therefore causes the normally comparatively high positive potential thereat to be reduced to a comparatively low positive potential whereby the potential at the potentiometer point between resistors 138 and 139 is lowered sufficiently to prevent the further passage of impulses through the tube 126. Therefore, tube 126 will not pass the one hundred and fifty-first impulse.

The anode of tube 131 is connected to a potentiometer point between resistors 140 and 141 and the screen grid of tube 143 is connected to a potentiometer point between resistors 141 and 142. Therefore when tube 131 changes from a conducting to a non-conducting state, tube 143 becomes conducting. This tube is now in condition to pass impulses so that a positive impulse from the generator (the one hundred and fifty-first impulse) will appear as a sudden drop in potential on the anode of tube 143. However the normal potential of the potentiometer point between resistances 153 and 154 is comparatively low so that the cathode of diode 144 is at a comparatively low potential whereby the grid of tube 143 is held down to a point where tube 143 will not be affected by a positive impulse from generator 63. However if the start signal is present from the one hundred and fiftieth to the one hundred and fifty-first impulse the potential, as will be hereinafter described, of the anode of tube 151 will be high which raises the potential of the anode of diode 144. Therefore the grid of tube 143 will be affected by the positive impulse from generator 63.

The incoming start impulse, in the form of a short application of a particular frequency alternating current, will pass through the start filter 145, be amplified by the amplifier 146 and will be detected by the tube 147 by which it will be translated into an interval of lowered plate potential. The anode of tube 147 is connected to a potentiometer point between resistors 148 and 149 and the grid of tube 151 is connected to another potentiometer point between resistors 149 and 150, so that as the potential of these potentiomer points falls during the reception of the start signal the normally active tube 151 becomes inactive. As a result the start signal appears as a positive potential on the cathode of the diode 144 and thus allows the one hundred and fifty-first (or any other positive) impulse from the generator 63 to effect tube 143. Therefore, if the start signal arrives simultaneously with the production of the one hundred and fifty-first impulse from the generator 63 the anode of tube 143 will produce a sufficiently powerful enough negative impulse on the suppressor grid of tube 132 to cause this tube to become non-conducting.

As tube 132 is reduced to the non-conducting state, its anode will rise in potential and enable the tube 126 to pass the next impulse from the generator through the tube 127 to the impulse counter 128. Thereafter, tubes 126, 131, 132 and 143 remain as they are now (126 and 131 conducting and 143 and 132 non-conducting) until another negative impulse is transmitted over the conductor 130 after the impulse counter has counted off one hundred and fifty impulses.

It may be noted that if the arrangement at the receiving end falls out of step with the arrangement at the transmitting end so that the start impulse does not arrive on the next pulse after tube 143 has become conducting, tubes 143 and 132 will remain active until such a start impulse is received, at which time a reversal will take place as described and tubes 126 and 131 will become active to enable the impulse counter 128. Thus the circuit ceases to operate when the impulse counter reaches the count of one hundred and fifty and remains inert until another start impulse is received. If, during one cycle, the impulse counter should fail to count every impulse and should lose one by way of example, that is if it should fall one step behind the transmitter, the start impulse would arrive as the receiver is counting the one hundred and fiftieth impulse but the start impulse at that time would be ineffective and so the receiver would wait without operating until the next start impulse is received. Thus the circuit will automatically be resynchronized within one full cycle which taking only a small part of a second will cause no noticeable disturbance in the display of the transmitted numbers.

The impulse generator shown in Fig. 17 is a device which produces a single sharply defined impulse from each cycle of alternating current fed thereinto. Through means provided, this single sharply defined pulse may be made to occur at any particular point in the cycle over a given range, as, for instance, just as the wave passes through zero from the positive half wave to the negative half wave. The source of alternating current 160 may be the driver oscillator 11 of Fig. 3. Alternating current from this source flows through condenser 161 and thence through the primary winding of transformer 162 to ground. The secondary winding of transformer 162 thus becomes a source of alternating current to affect the triode 163. The cathode grid circuit of this tube may be traced from the cathode through resistance 164, the secondary winding of the transformer 162, resistance 165 to the grid of tube 163. A condenser 166 is in parallel with both the resistance 164 and a source of negative biasing potential comprising the resistance 167 and the well-known network of rectifiers 168, 169, 170 and 171, energized by a source of alternating current 172 and an interposed transformer 173. The potential supplied by this network is sufficient to produce a given anode-cathode current flow in the tube 163 between the battery connected to the anode thereof and the resistances 174 and 175 to ground. Under these conditions, a given potential thus stands on the cathode of tube 163, this being a point on the potentiometer consisting of the internal resistance of the tube and the two resistances 174 and 175.

Now, as an alternating current wave in the secondary winding of transformer 162 rises from a zero value to an increasing positive potential, the grid of the tube 163 becomes less negative and as a consequence the anode-cathode current increases. Therefore, the potential of the cathode with respect to ground increases so that the potential between the resistances 174 and 175 in time rises to a point where tube 177 will function.

Normally the cathode of tube 163 is connected in a circuit with the elements of the diode 177, resistance 178, condenser 179, resistance 175 to ground, whereby the condenser 179 may be charged as the potential of tube 163 rises. Therefore on the rising part of the positive half wave condenser 179 will be charged, but not to the full extent possible because while its upper terminal is rising, its lower terminal is also rising. In time the rising part of the positive half wave will reach its limit and thereafter the potential of the cathode of tube 163 and likewise the potential of the potentiometer point between resistances 174 and 175 will decrease. The potential on the condenser 179 will remain at the highest point reached, due to the diode 177 but the lower terminal will decrease thus still further increasing the difference in potential set up on condenser 179. When the potential of the cathode of tube 176 falls so that the grid bias reaches a critical value then the gas-filled tube 176 will fire and cause condenser 179 to discharge through the primary of transformer 180. This produces a current in the secondary which appears on the output conductor 181 as a positive impulse.

Through the proper proportioning of the constants of this circuit this impulse may be made to appear with regularity at any point between near zero to maximum negative value in the incoming cycle from the source 160.

Fig. 14 shows a ten-impulse counter. This as well as the five and the three-impulse counter is based on the action of a plurality of pairs of counting tubes, only one of which will be described in detail herein. The tubes 185 and 186 form such a counting pair, one of which is always energized and in a conducting state. The principle of operation is fundamentally the same as that of the well-known Eccles and Jordan circuit, disclosed in British Patent 148,582. These tubes are, however, pentodes with the anode of each connected to the screen grid of the other. When a negative impulse is applied to the suppressor grid of both, the combination of the two tubes reaches an extremely unstable state as the conducting tube decreases to the non-conducting stage. This is caused by a charge on condenser 187 connected between the cathodes of the two tubes which is charged in one direction while tube 185 is active, and in the other direction while tube 186 is active. When the negative impulse is applied to the two suppressor grids, the discharge rate of condenser 187 through resistors 188 and 189 is slower than the rate of decrease of current through the conducting tube due to the sharp negative impulse so there is a slight residual charge left, the magnitude of which depends on the rate of change or sharpness of the said negative pulse. Without condenser 187 the inherent differences between the two tubes would determine which one was to become active on recovery, and generally there is enough difference between even the most carefully matched pair to dictate that a certain one would invariably become conducting at this time. However, with condenser 187 connected as shown there is sufficient influence to overcome the inherent differences in even a badly matched pair. Now the fact is that upon recovery and with condenser 187 still holding a small residual charge, tube 186 will become active if tube 185 had been active before or tube 185 will become active if tube 186 had been active before.

It has been pointed out hereinbefore that the cathode circuit of tube 185 may be traced through resistances 188 and 192. Therefore when this tube is active the current in its cathode circuit produces an IR drop in resistance 188 which places the cathode at a higher positive potential than the cathode of tube 186. Therefore in a normal state with tube 185 active and tube 186 inactive the condenser 187 becomes charged with a positive potential toward the active tube. As both tubes are reduced to a non-conducting state by an incoming negative impulse to their suppressor grids this difference of potential disappears and condenser 187 discharges through resistances 188 and 189. The constants of condenser 187 are such that this discharge does not become complete by the time the negative impulse to the suppressor grids of the tubes terminates so that there is still a slight residual charge on condenser 187 with the upper terminal thereof at a slightly higher positive potential. This means that the rate at which condenser 187 discharges is slower than the rate at which the anode and cathode currents of the tubes change when the potential of their suppressor grids is lowered from zero or ground potential to a negative value controlled by the incoming negative pulse. In their normal state both tubes are firmly locked into their conducting and non-conducting states, respectively, but as their anode and cathode potentials move toward equalization which may be attained when their suppressor grids are simultaneously reduced to a negative potential beyond a critical value they become very unstable with the slightest influence being effective to exercise a control. Without the condenser 187 the inherent characteristics of the tubes would control and in this case one of the tubes would be dominant and the two tubes would recover from the incoming negative pulse with such dominant tube always becoming conducting. But with the slight residual charge still left on condenser 187 a trigger action takes place since this slight positive potential toward the heretofore conducting tube now takes the place of and actually overcomes the inherent difference in the tubes with the result that the bias exerted by such slight potential causes the other tube to become slightly more conducting than that one which up to now had been conducting. The result is that at the termination of the incoming negative pulse when the tubes move toward recovery that one which has had the benefit of the negative side of the residual charge on condenser 187 and which has triggered over to the dominent state now tends to become conducting at a greater rate than the other so that as its anode potential drops accordingly the screen grid potential of the other drops also accordingly and prevents the movement of such other tube to the conducting state. As a result that tube which has the slightest advantage over the other becomes conducting. Thereafter the discharge of condenser 187 and its subsequent charge in the opposite direction is completed before another negative impulse is received on the suppressor grids to cause another reversal.

It will be noted that the anode of tube 185, and the screen grid of tube 186, are connected to a potentiometer point between resistances 190 and 191, resistance 190 being otherwise connected to a positive battery and resistance 191 being otherwise connected to ground. Therefore when the tube is active or conducting current will flow from positive battery through resistance 190, from the anode to the cathode of the tube, resistance 188 and resistance 192 to ground Therefore when the tube is non-conducting its anode will be at a comparatively high positive potential and when the tube is conducting its anode will be at a comparatively low positive potential. When, therefore, tube 185 is conducting and its anode is at a comparatively low positive potential the screen grid of the companion tube 186 will be at the same comparatively low positive potential. This will hold tube 186 in a non-conducting state. At the same time the screen grid of tube 185 which is connected to the anode of tube 186 and which is in a similar potentiometer circuit between the resistances 193 and 194 will be at a comparatively high positive potential which will render tube 185 conducting. Thus the tubes are in mutually controlling circuits.

Throughout the circuits to be described, a number of these counting pairs are employed, all of which operate in the same manner. Hence the detailed description of the operation of a single pair as above will be sufficient. In the ten-impulse counter there are five pairs of tubes shown, in the five-impulse counter there are four pairs of tubes shown and in the three-impulse counter there are three pairs of tubes shown. At normal, the upper tube of each pair is active or conducting and the lower tube of each pair is inactive or non-conducting. In the case of tubes 185 and 186 the tube 185 is conducting when the ten-impulse counter is in its normal or zero state.

Before going on with the description of the operation of Fig. 14, reference will be made to Fig. 16 where an alternative counting pair circuit is shown. The over-all operation of the two tubes 201 and 202 is respectively the same as the tubes 185 and 186 but these tubes being designed as video beam power amplifier tubes having an exceedingly high value of transconductance and high anode-cathode current carrying capabilities have certain practical advantages for this service. In this case the incoming negative pulse is applied over conductor 204, over resistance 205 and condenser 206 to the control grid of tube 201 and likewise over resistance 207 and condenser 208 to the control grid of tube 202. By reason of the resistances 209 and 210 the sudden lowering of the potential on the line side of the condensers 206 and 208, respectively, induces a corresponding sudden lowering of the potentials on the control grids of tubes 201 and 202, respectively.

Now it may be assumed that tube 201 is normally conducting whereby the output conductor 211 is at a comparatively low positive potential since it is connected through resistance 212 to the anode of tube 201, and this in turn is connected to a potentiometer point between resistances 213 and 214. With resistances 213, 214 and 215 being connected between a source of positive and a source of negative potential, the anode of tube 201 will be at a comparatively high positive potential while the tube is non-conducting and at a comparatively low positive potential when the tube is conducting. By the same token the potential of the potentiometer point between resistances 214 and 215 moves up as the tube goes from a conducting to a non-conducting state and down as the tube moves from a non-conducting to a conducting state. The anode of tube 202 is in a similar circuit with like resistances 216, 217 and 218. In this case the suppressor grids are both held at ground or zero potential and the screen grids connected to a source of high positive potential through the resistance 219. The control grid of one tube is effectively connected to the anode of the other so that as the potential of the anode of tube 201, for instance, is held at a comparatively low positive potential, the control grid of tube 202 is held at a correspondingly comparatively low positive potential which will lock the tube 202 in a non-conducting state.

Upon the arrival of a negative pulse the control grid of the conducting tube will be forced down to the point where tube 201 now becomes non-conducting so that at the termination of this negative pulse both control grids tend to go up to a comparatively high positive potential and there tends to be a race between the tubes to determine which of the two will become conducting. Without a definite means to provide a determining influence, the inherent difference in the characteristics of the two tubes might dictate that one would always win such a race. However, as before, a small condenser 203 is connected between the cathodes of the two tubes and which becomes charged in one direction or the other during a period between operating movements. As tube 201, for instance, is reduced to a non-conducting state upon the arrival of a negative pulse over the incoming conductor 204, condenser 203 discharges through resistances 220 and 221 but as this operation is not completed at the termination of the impulse the residual charge on condenser 203, positive toward tube 201, causes tube 202 to now become dominant and therefore to succeed in becoming conducting to the exclusion of tube 201.

Going back now to Fig. 14 for a description of the complete operation of the ten-impulse counter, it may again be noted that the upper tube of each pair is in a conducting state at the start of a circuit cycle. Thus tubes 227, 185, 229 and 231 are now assumed to be conducting and tubes 228, 186, 230 and 232 are assumed to be non-conducting. If the rectangle 233 represents an impulse generator, then a steady stream of positive impulses will be applied to conductor 234. The tube 227 being now in a conducting state its potentiometer point 1, between resistances 235 and 236 and the potentiometer point between resistances 236 and 237 will be at comparatively low positive potentials so that the screen grid of tube 225 will be at such a comparatively low positive potential that tube 225 is rendered inactive and incapable of passing impulses from conductor 234. By the same token tube 228 being in a non-conducting state, its potentiometer point 2 between resistances 238 and 239 and the potentiometer point between resistances 239 and 240 will be at comparatively high positive potentials so that the screen grid of tube 226 being at a comparatively high positive potential this tube 226 is active and capable of passing impulses from conductor 234. The first positive impulse applied to conductor 234 therefore causes a sudden increase in the anode-cathode current of tube 226 whereby the potentiometer point between resistances 241 and 242 suddenly drops in value thus applying a negative impulse to the suppressor grid of tube 227 and reducing it to a non-conducting state. This causes tube 228 to become conducting and tube 227 to become non-conducting with the further result that tube 226 now becomes incapable of passing impulses from conductor 234 and tube 225 is enabled to pass on such impulses. The result of the first impulse therefore is a reversal of the state of tubes 227 and 228 with their potentiometer points 1 and 2, respectively, going from low to high and from high to low, respectively.

The second impulse is passed by tube 225 and results in a sudden drop of the potential of the potentiometer point between resistances 243 and 244, which constitutes a negative impulse to the suppressor grids of tubes 185 and 186, resulting in the reversal of the condition of this pair of tubes. Therefore the potentiometer point 3 goes from low to high and the potentiometer point 4 goes from high to low. Potentiometer points 1 and 2 are not affected by this second impulse.

The third impulse again reverses the condition of tubes 185 and 186 so that potentiometer point 3 goes from high to low and potentiometer point 4 goes from low to high. The movement of the potentiometer point 3 from high to low constitutes a negative impulse to the pair of tubes 229 and 230 whereupon the potentiometer point 5 goes from low to high and the potentiometer point 6 goes from high to low. Potentiometer points 1 and 2 remain unchanged.

The fourth impulse again reverses the condition of tubes 185 and 186 so that the potentiometer point 3 goes from low to high and potentiometer point 4 goes from high to low. Potentiometer points 1, 2, 5 and 6 remain unchanged.

The fifth impulse again reverses the condition of tubes 185 and 186 so that potentiometer point 3 goes from high to low and potentiometer point 4 goes from low to high. The movement of the potentiometer point 3 from high to low constitutes another negative impulse to the pair of tubes 229 and 230 whereupon the potentiometer point 5 goes from high to low and the potentiometer point 6 goes from low to high. The movement of the potentiometer point 5 from high to low constitutes a negative impulse to the pair of tubes 231 and 232 whereupon the potentiometer point 7 goes from low to high and the potentiometer point 8 goes from high to low. The movement of the potentiometer point 5 from high to low also constitutes a negative impulse to the suppressor grid of tube 228 whereupon the potentiometer point 1 goes from high to low and the potentiometer point 2 goes from low to high. The movement of the potentiometer points 1 and 2 reverses the condition of tubes 225 and 226 so that after this fifth impulse the circuit is now in its normal condition except that the state of the pair of tubes 231 and 232 is reversed.

The sixth impulse brings about the same changes as the first impulse and therefore leaves tube 228 conducting, 227 non-conducting, 226 incapable of passing signals and tube 225 capable of passing signals. The state of the potentiometer points is therefore the same as after the first impulse with the exception that the state of the potentiometer points 7 and 8 is reversed.

The seventh impulse brings about the same changes as the second impulse so that the state of the potentiometer points is the same as after the second impulse with the exception that the state of the potentiometer points 7 and 8 is reversed.

The eighth impulse brings about the same changes as the third impulse so that the state of the potentiometer points is the same as after the third impulse with the exception that the state of the potentiometer points 7 and 8 is reversed.

The ninth impulse brings about the same changes as the fourth impulse so that the state of the potentiometer points is the same as after the fourth impulse with the exception that the state of the potentiometer points 7 and 8 is reversed.

The tenth impulse brings about the same changes as the fifth impulse. This again affects the pair of tubes 231 and 232 so that after this impulse the circuit is returned to normal exactly as it was before the first impulse. As a result of this tenth impulse the potentiometer point 8 goes from a low to a high potential and this being connected to the outgoing signal conductor 245 constitutes a positve impulse which may be applied to the five-impulse counter.

Throughout the above description the change in the condition of the potentiometer points 1 to 8 has been described. Each of the tubes has such a potentiometer point marked with the appropriate numeral in a circle. These eight potentiometer points may be connected to eight bus wires and thence to a network of resistances as shown in Fig. 11. Each such network comprises four resistors connected according to a permutation code to these eight bus wires and joined to a resistance such as 266, thus forming a potentiometer point connected to the grid of a triode such as 246. Due to the permutation code arrangement it will be found that at any one time there will be only one triode whose grid is at a sufficiently high positive potential, because the four bus-wires to which it is connected are at this time simultaneously at comparatively high potentials, to affect its plate lead. Hence only one of the ten plate leads from the triodes will be affected at a time. Thus the normal state of a tube such as 246 is non-conducting and its anode (properly connected to a source of positive potential) will be at a comparatively high positive potential. However, after the first impulse when potentiometer points 1, 4, 6 and 8 are each at a high level the grid of tube 248 will then be sufficiently high to render the tube 246 conducting. Examination will show that no other one of the ten like tubes is connected through its grid resistors to four bus-wires each of which is at as high a potential, in other words at least one connection to each of the remaining nine grids is to a low potential point so that only tube 246 is at this time conducting and therefore only conductor 247 is at a comparatively low potential. After the second impulse tube 248 will be the only conducting tube in the group and only conductor 249 will be at a low potential. Thus the ten conductors of which 247 and 249 are two are affected in sequence as the incoming impulses are counted by the ten-impulse counter of Fig. 14.

The five-impulse counter of Fig. 15 is the same as the ten-impulse counter of Fig. 14 with the tubes 231 and 232 controlling the seventh and eighth potentiometer points left off. Tubes 251 to 256 control the first to the sixth potentiometer points respectively and these points connected to the correspondingly designated bus-wires in Fig. 12 will control the five leads 258, 259 and so on.

The three-impulse counter of Fig. 16, hereinbefore partly described, is the same in its principle of operation as the five-impulse counter of Fig. 15 with the last pair of tubes 255 and 256 left off. Tubes 261, 262, 201 and 202 control the potentiometer points 1, 2, 3 and 4, respectively, and these points connected to the correspondingly designated bus-wires in Fig. 13 will control the three leads 263, 264 and 265 for the purposes hereinbefore set forth. The output lead 266 may be used for the operation of the start-stop feature hereinbefore described.

What is claimed is:

1. In a telemetric system, a plurality of transmitting circuit terminations, means for selectively marking said terminations, a corresponding plurality of receiving circuit terminations, an indicator individual to each said receiving termination, a transmission channel between said transmitting and said receiving terminations, electronic means for successively effectively interconnecting corresponding terminations over said channel, said electronic means comprising at each end of said channel a similar arrangement of counting tubes, each said arrangement consisting of a plurality of groups of said tubes in tandem, means whereby the first said group responds in repeated cycles to a series of input impulses, means whereby the first group produces a series of output impulses, one impulse for each of its repeated cycles, means whereby a second group responds in repeated cycles to the output impulse series of the first group and in turn produces a series of output impulses, one for each of its repeated cycles, means whereby a third group responds to the output impulses of the second group, means whereby the individual groups at one end of the channel cooperate to successively effectively connect for each count the circuit terminations thereat to the channel, means whereby the individual groups at the other end of the channel cooperate to successively effectively connect for each count the circuit terminations thereat to the channel and a source of synchronizing impulses serving as the common input impulse series for the first group of each of the similar arrangements of counting tubes.

2. In a telemetric system, a plurality of transmitting circuit terminations, means for selectively marking said terminations, a corresponding plurality of receiving circuit terminations, an indicator individual to each said receiving termination, a transmission channel between said transmitting and said receiving terminations, counters comprising electronic means for successively effectively interconnecting corresponding terminations over said channel, said electronic means comprising at each end of said channel a similar arrangement of counting tubes adapted to respond to a series of impulses recurrently in a complete cycle for every count of a predetermined number of said impulses, means at the transmitting end of said channel responsive to the completion of said counting cycle for sending a start signal over said channel, means at the receiving end of said channel for rendering said counter thereat unresponsive to impulses responsive to the completion of said counting cycle, means responsive to the receipt of said start signal as or after said receiving counter reaches or has reached said unresponsive state for reconditioning said receiving counter for response to impulses, and a source of impulses for driving said counters.

3. In a telemetric system, a plurality of transmitting circuit terminations, means for selectively marking said terminations, a corresponding plurality of receiving circuit terminations, an indicator individual to each said receiving termination, a transmission channel between said transmitting and said receiving terminations, counters comprising electronic means for successively effectively interconnecting corresponding terminations over said channel, said electronic means comprising at each end of said channel a similar arrangement of counting tubes adapted to respond to a series of impulses recurrently in a complete cycle for every count of a predetermined number of said impulses, means at the transmitting end of said channel responsive to the completion of said counting cycle for sending a start signal over said channel to start said receiving counter on a new cycle of counting operations, a source of alternating current of frequency f for supplying start signal current, a source of alternating current of frequency f_1 for supplying mark signal current for transmitting mark signals when a marked transmitting termination is coupled with its corresponding receiving termination, a source of alternating current of frequency f_2 for driving said counters, and filtering means at the receiving end of said channel for diverting said different frequency alternating currents each into its own useful path in the circuits thereat.

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