

July 18, 1933.

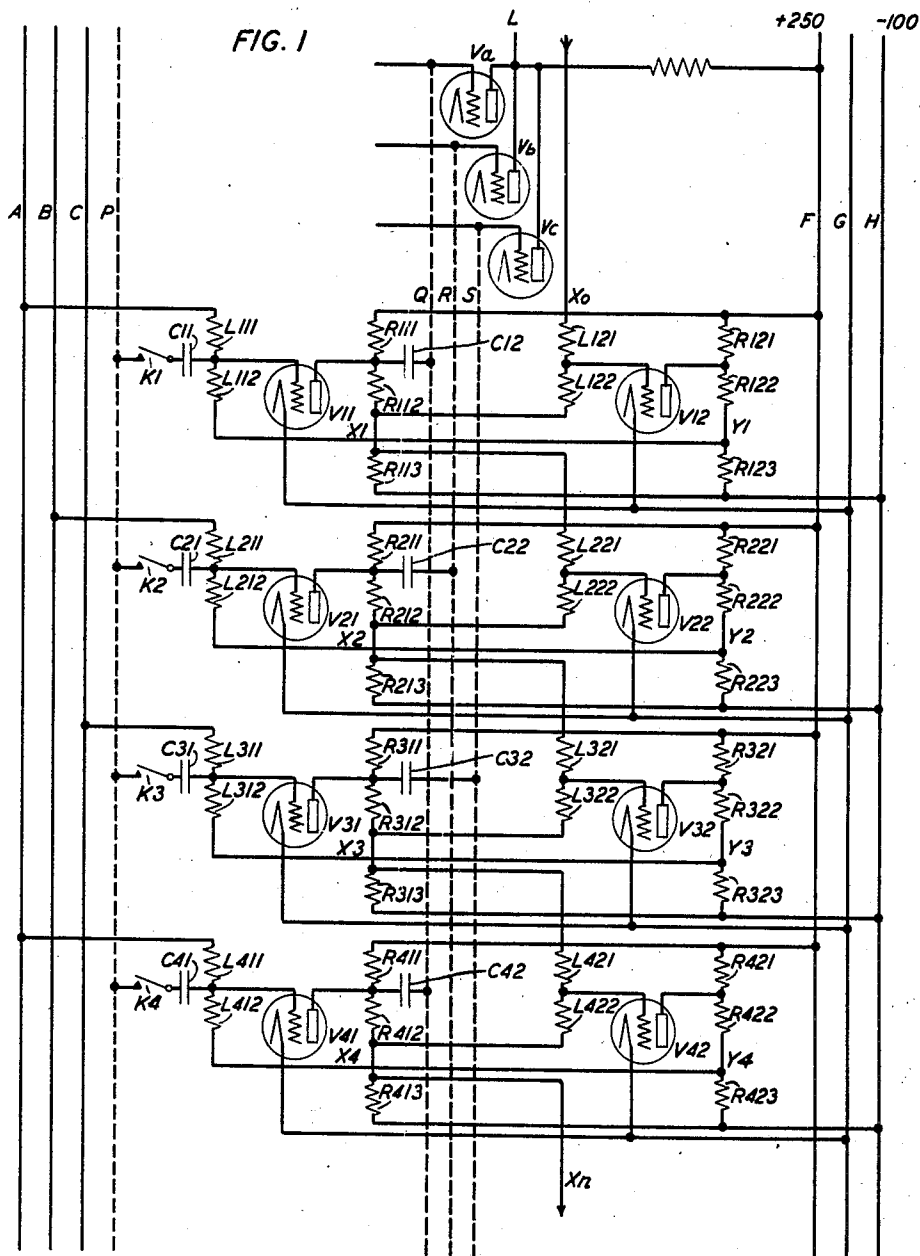
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1,918,252

HIGH SPEED TELEGRAPHY

Filed May 25, 1931

5 Sheets-Sheet 1



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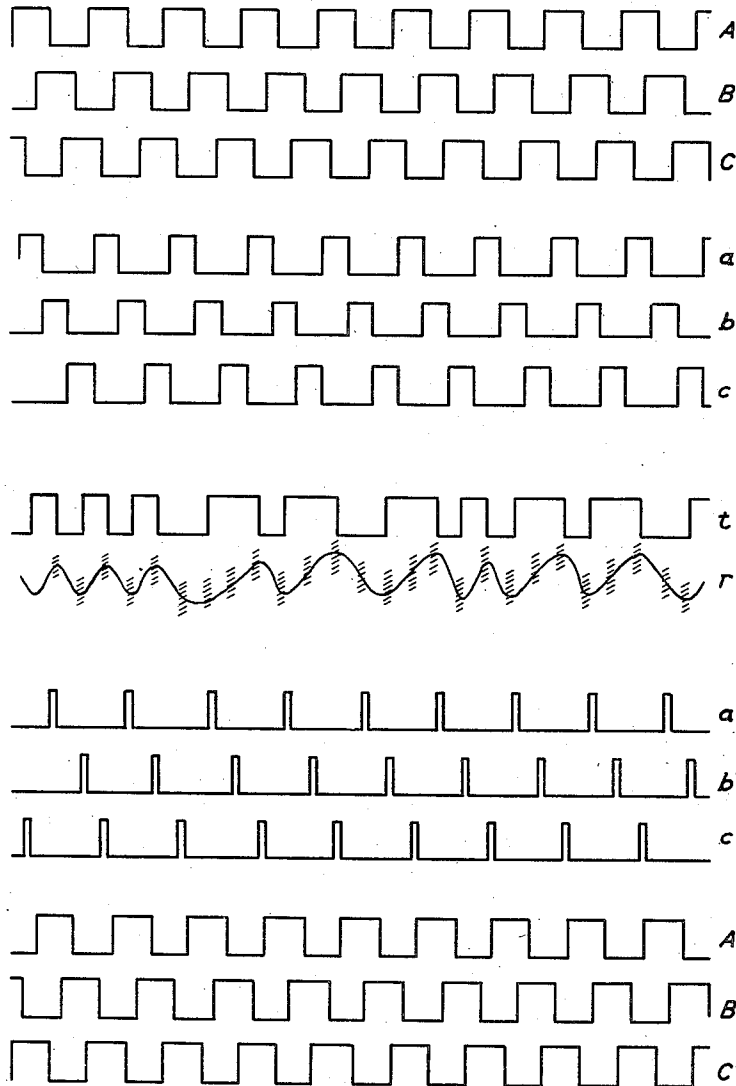
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Filed May 25, 1931

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FIG. 2



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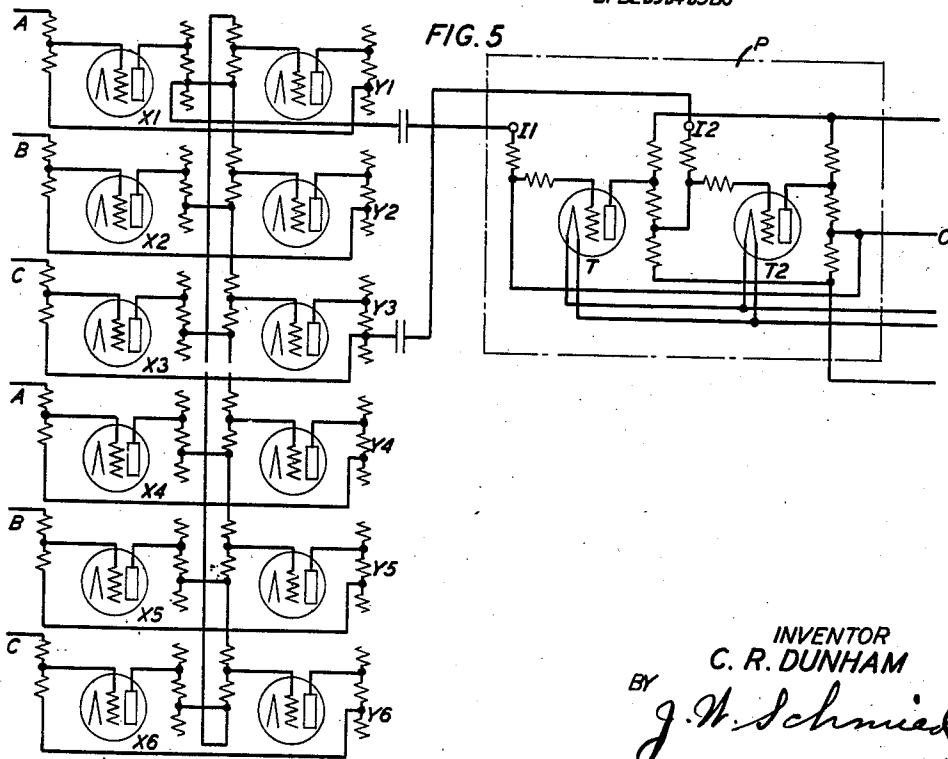
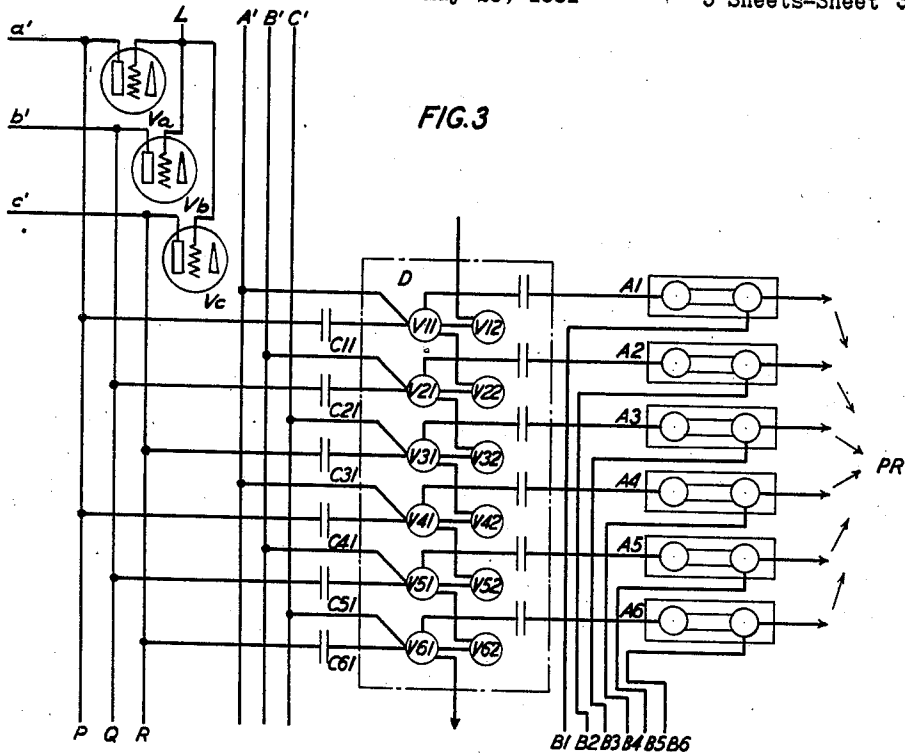
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Filed May 25, 1931

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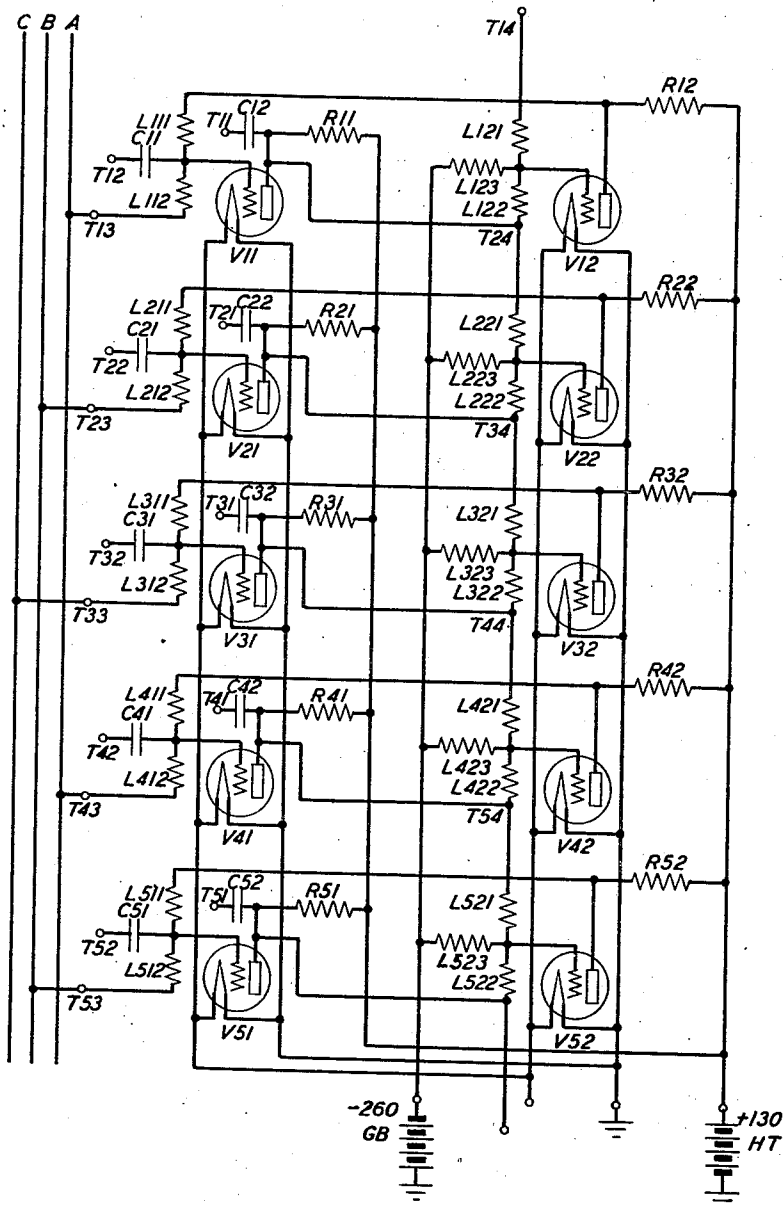
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HIGH SPEED TELEGRAPHY

Filed May 25, 1931

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FIG. 4



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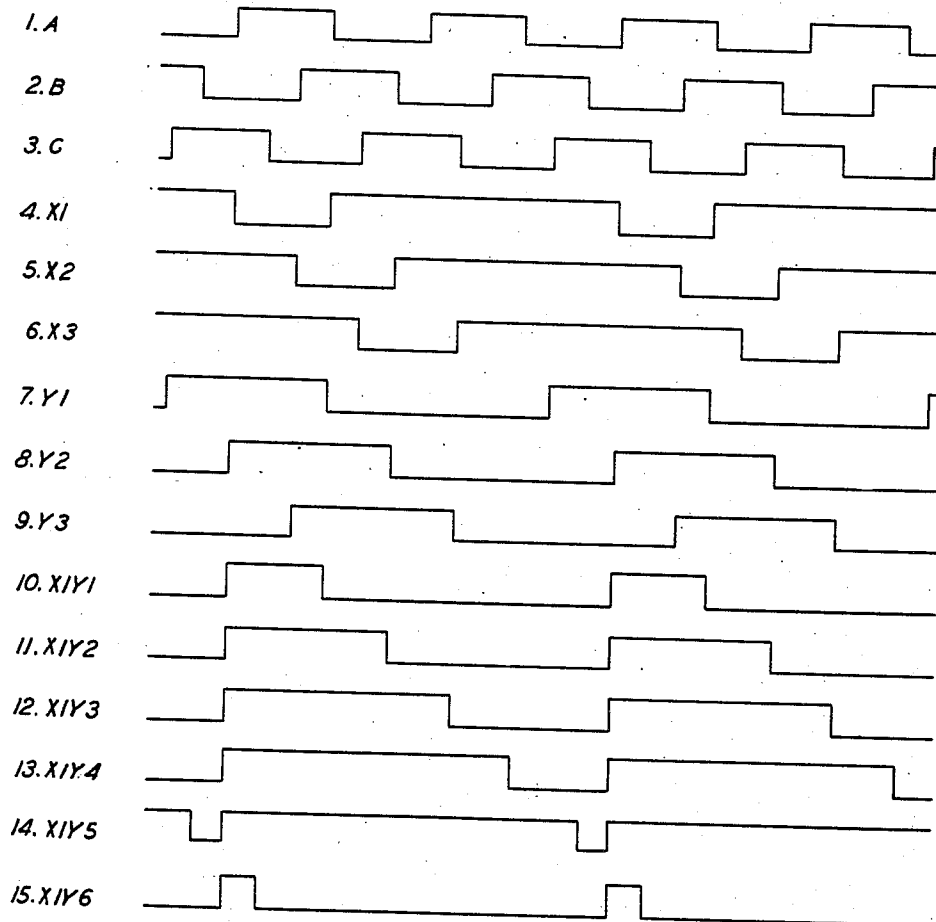
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Filed May 25, 1931

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FIG. 6



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HIGH SPEED TELEGRAPHY

Application filed May 25, 1931, Serial No. 539,687, and in Great Britain June 12, 1930.

This invention relates to electric circuits and provides an arrangement of energy translators such as three electron discharge devices which may have a variety of uses, but is particularly applicable for use as a distributor for high speed telegraphy.

One object of the invention is to provide a high speed telegraph distributor having no mechanical or moving parts.

Another object of the invention is to cause a series of current impulses of one frequency to produce another series of impulses of the same or different frequency with a definite control of the time relation at which the impulses occur.

According to a feature of the invention, a group of electrical energy translators is adapted to control the operation of an associated group throughout an assembly of such groups. An arrangement of this kind may comprise a plurality of valve circuits each of which is connected to the one following it in such a way that an impulse applied to any one of the valve circuits makes it operative for a short interval of time and an impulse is then passed on to the next valve circuit which is thereby made operative for an equal interval and so on through the remainder of the circuits in succession. A wave (preferably square) may be applied from an external origin to control the length of the interval during which each circuit is operative and hence the speed at which the operating condition passes down the line. This speed is therefore controllable and by coupling together the last and first row of valve circuits the system may be made cyclic in operation.

According to another feature of the invention the arrangement is such that a particular valve or valves in an assembly can operate as an amplifier only when all the valves of a certain set of one or more other valves are paralyzed.

According to another feature of the invention, a distributor which gives impulses for the purpose of operating external apparatus is so arranged that the impulses are given by units preceding the one for which the results of the operation of the external apparatus are intended, so that the time taken in the

operation of the external apparatus may be accounted for.

According to another feature of the invention an arrangement comprises a plurality of groups of valves, one valve in each group being subjected to an impressed pulse adapted to change its condition as from being operative or non-operative, and means are associated with the said valve, which due to said change, produce an opposite change in another valve of the same group which for a predetermined time maintains the changed condition of the first said valve. Other features of the invention will be disclosed in the following description having reference to the accompanying drawings, in which:

Fig. 1 is a schematic representation of an arrangement according to the present invention;

Fig. 2 gives a plurality of curves representing certain conditions in the circuit of Fig. 1 and is used to explain a principle of the invention;

Fig. 3 schematically shows the invention in the form of a receiving distributor for telegraphy or the like;

Fig. 4 illustrates a modification which may be made in the distributor of Fig. 1;

Fig. 5 illustrates a frequency divider according to the present invention; and

Fig. 6 is a set of curves used to describe the operation of the arrangement of Fig. 5.

The arrangement of Fig. 1 shows a plurality of groups or units each consisting of two valves such as V11 and V12. These units with their associated circuits are similar and therefore the description of one unit with its associated circuits will serve to explain the figure, except for the interaction of one unit upon another which is to be explained later. The unit consisting of valves V21 and V22 will be considered first. Assume that each valve V21 and V22 is such that for a grid voltage of -2 volts, the valve operates as a normal amplifier, taking a plate current of 1 milliampere, and that for a grid voltage of -6 volts or more, the valve is completely paralyzed and will pass no plate current.

The resistances R211, R212, and R213 form a potentiometer connected across points of a

battery F and H, which are at potential +250 volts and -100 volts with respect to the common filament potential of all valves. Plate current is supplied from the point F to the valve V21 via the resistance R211.

The values of the resistances R211, R212 and R213 are chosen such that, when the grid voltage of V21 is -6 volts or more negative, the potential at the junction X2 of R212 and R213 is -2 volts, and that when the grid voltage of V21 is -2 volts, the potential at the junction X2 of R212 and R213 is -10 volts. This change in voltage is obtained by virtue of the potential drop owing to the passage of the plate current through R211. In an exactly similar fashion there is associated with V22 a potentiometer of three resistances R221, R222 and R223. Grid leaks L211 and L212 of equal value connect the grid of V21 to the junction Y2 of resistances R222 and R223, and also to the point B, to which there is applied a square wave which has a voltage with respect to the filament voltage of -2 volts for half its cycle and of -10 volts for half its cycle. Thus the grid voltage of the valve V21 is the mean of the potentials at B and Y2, and therefore the valve V21 can operate only (as an amplifier) when the potentials at B and at Y2 are both -2 volts. That is the valve V21 can operate only when the square wave B is in the less negative half of its cycle and when the valve V22 is inoperative. It is to be noted in particular that if the valve V22 is operated, the valve V21 cannot become operative in any part of the cycle of the controlling wave.

The grid voltage of the valve V22 is the mean of the potentials at X2 and of X1 which is the corresponding point of the previous unit. Hence valve V22 is operative only when both V11 and V21 are inoperative.

In the remaining valve units the controlling waves for the 1st, 4th, 7th, 10th group, . . . are taken from points A, for the 2nd, 5th, 8th, 11th group, . . . from point B, and the 3rd, 6th, 9th, 12th, . . . from point C. The waves A, B and C are similar in form but B is retarded by 120° with regard to A, and C by 120° with regard to B. The other groups are composed of similar parts to these described and in order to show this in the drawings the reference letters which used throughout each group contain one numeral identifying the group, this group identification being given by the first numeral appearing after the reference letter.

Considering the operation of the system as a whole, it is seen that if the point X0 is given a potential -2 volts, a stable condition is attained when the left hand valve in each unit or group is inoperative, and the right hand valve operative; the points X1, X2, X3 . . . have potential -2 volts, the points Y1, Y2, Y3 . . . -10 volts. This

will be called the normal condition for each unit and for the system as a whole. If there be now applied to the point X0 an impulse of potential -10 volts, the valve V12 is made inoperative and the point Y1 becomes of potential -2 volts. When the point A has potential -2 volts (which it does in the less negative half of its cycle), the valve V11 becomes operative and the point X1 now has potential -10 volts. This locks the valve V12 in an unoperated condition and passes a working impulse to the valve V22 in the next unit. This action continues until the square wave applied to B gets in its less negative half cycle, when the valve V21 becomes operative. At a subsequent instant, the square wave applied to A falls to its negative half cycle, the valve V11 becomes inoperative, the valve V12 operative (I have assumed that the impulse applied to X0 has by this time been removed). Thus the unit comprising V11 and V12 is restored to normal condition and it remains so, until a further impulse is applied to X0. The impulse that this unit has applied to the valve V22 makes the second unit operative during the less negative half of the cycle of the wave B, passing a further impulse to the valve V32 in the third unit.

The train of operations continues, all the valve units in the system become operative in turn until the last unit is reached. If the point Xn in the last unit is joined to the point X0 a cyclic arrangement of units is produced (there being a multiple of three units), and the train of operations continues round the circle endlessly.

The manner in which the apparatus described above may be used as the transmitting distributor of a telegraph system will now be described. K1, K2, K3 . . . indicate contacts of the several transmitters that are desired to be connected to the line L in turn. Consider the circuit through the contact K1. During that part of the cycle in which the valve V11 is operative, high frequency current passes (or fails to pass, according to the position of the contact K1) from a source P, via the small condenser C11, valve V11, small condenser C12 to the valve Va and thence to the line L. Similarly when the second unit is in operation, high frequency current passes or does not pass by the contact K2, via the valve Vb to the line. The valve Va is interposed in the 1st, 4th, 7th, . . . group circuits, Vb in the 2nd, 5th, 8th, . . . group circuits, Vc in the 3rd, 6th, 9th, . . . , the function of these valves being to correct the length of the signal impulses applied to the line. This is necessary owing to the fact that impulses supplied from the distributor proper would otherwise overlap each other, and is accomplished by applying to the grids of the valves Va, Vb and Vc, three square waves a, b and c (see Fig. 2),

each of which has the positive portion of its cycle half as long as the negative. Thus the valves Va , Vb and Vc are each paralyzed through two-thirds of each cycle, and function through one-third of each cycle in turn as normal amplifiers passing the signals to the line so that they do not overlap. Fig. 2 shows the respective configurations of the six waves A , B , C , a , b , and c . It will be seen that all these waves have the same fundamental frequencies and can therefore be derived from the same oscillator.

In order to correlate the mechanical operations of the several transmitters with the electrical operations of the distributor, a lead from any one point X_0 , $X_1 \dots$ or Y_1 , $Y_2 \dots$ (or if necessary more than one) in the system may be taken and a positive or negative impulse once per complete cycle of the distributor may be obtained therefrom. This impulse may be used to work a relay train or perform any other desired function. It is clear that the time taken in the operation of the relays may be compensated for by using an impulse derived from a point X or Y more advanced in the cycle of the distributor than that instant at which the effect resulting from the operation of any particular relay is required. To operate an amplifier or vacuum tube device of a known kind which assumes and retains a certain condition when affected by an impulse until restored by a second impulse (usually of opposite sign) it is clear that a second impulse may be applied to it at a subsequent point of the cycle in order to restore the amplifier or device to its non-operated or original condition.

Fig. 3 is a symbolic diagram showing the arrangement at a receiving terminal. The high frequency current signaling impulses which are received over the line L may be considered as a succession of separate high frequency impulses; they are separated from each other by the three valves Va , Vb , Vc (which are made operative in turn by the three square waves a' , b' and c') and pass alternately to the leads P , Q and R . The distributor D (which is exactly similar to the transmitting distributor) controlled by the square waves A' , B' and C' distributes these impulses consecutively to the row of amplifiers A_1 , $A_2 \dots$ which in turn control the operation of the several printers PR . Leads B_1 , $B_2 \dots$ are shown connected to these amplifiers. These leads are connected to subsequent sections of the distributor and serve to restore the amplifiers (if they have been operated by the arrival of a high frequency impulse) in readiness for the next cycle of the distributor. The mechanical operation of the several printers may also be controlled by impulses taken from the distributor.

In Fig. 2 t shows a possible configuration of the envelope of the high frequency im-

pulses delivered by the transmitter, whereas r shows what might be expected at the receiving end after passage through the line (neglecting a probable phase displacement). a' , b' and c' show the configuration of the square top waves applied to the three separating valves at the receiving end, and A' , B' and C' are the square waves controlling the distributor. If the positive portions of the cycles of waves a' , b' and c' are made equal to half the negative portions, the whole of each impulse as received will be applied to the distributor. The impulses when received may be badly distorted; this distortion may lead to false operation of the printers. If the positive portions of the waves a' , b' and c' are made very short, only the central portions of each impulse will be applied to the distributor. These portions are shown shaded in r , and it is clear that they will lead to a truer operation of the printers than otherwise. It is clear that in a system consisting of a transmitting distributor and a receiving distributor, exact synchronism can be maintained if the controlling waves at both ends have the same frequency. This can be attained if the waves come fundamentally from the same source. For instance, an oscillator at the transmitting end may supply the waves required there, and the frequency transmitted over the line may be amplified to supply the waves required at the receiving end. Alternatively an oscillator may supply the waves required at the transmitting end; at the receiving end the waves required may be derived from a source whose frequency is controlled by the frequency of the telegraph impulses supplied over the line. In the above case, the frequency required for the controlling waves is two-thirds the dot frequency of the system.

The progressive distributor of Fig. 1 can be simplified by the arrangement as shown in Fig. 4 which shows the schematic diagram for a five-unit channel of such a distributor. The same scheme of reference designation is used here as in Fig. 1. Comparing this circuit to the one of Fig. 1 it is seen that fewer resistances are required. The plate of valve V_{21} is connected to the lower terminal of the leak resistance L_{222} . The plate is also connected over the resistance R_{21} to the high tension positive HT and over a condenser C_{22} to a terminal T_{21} . The grid of the tube V_{21} is connected over a condenser C_{21} to a terminal T_{22} . The carrier circuit is from terminal T_{12} to terminal T_{22} . The plate of the valve V_{22} is connected over a resistance L_{211} , to the grid of valve V_{21} . The said plate of the valve V_{22} is also connected over a resistance R_{22} to the high tension positive.

The grid of the valve V_{21} is connected through a resistance L_{212} to a terminal T_{23} which is connected to a source of square

waves B. The terminal T24 is connected over a resistance L221 to the grid of the valve V22 and the impulse for initiating the operation of the distributor unit is impressed at T24 from the plate of the valve V11 in the previous unit. The arrangements connected to valve V11 and valve V31 are similar to those connected to valve V21 except that the square wave is from A and C respectively and is displaced in phase as in the case of Fig. 1. A permanent grid bias for the tubes V12, V22, etc., is obtained through resistances L123, L223, etc., from grid bias battery GB.

A unit or group (e. g. that comprising valves V21 and V22 whose characteristics I will assume to be as described in connection with Fig. 1) has grid leaks L212, L211, L222, L221 and L223 (each 0.5 megohms) and grid biasing battery GB which may be of, say -260 volts if the plate voltage H. T. be 130 volts, the low tension positive terminal L. T. + being considered to be at zero potential. Resistances R21 and R22 are 60000 ohms.

In the arrangement shown, if valve V21 be inoperative, the voltage at the point T34 of L222 will be +130 volts with respect to the grounded filament, if V11 be inoperative, the voltage at T24 will be +130 volts with respect to the grounded filament and therefore the bias on the grid of valve V22 will be zero with respect to the plate of V22; and hence V22 is operative. If V11 becomes operative the potential at T24 falls to 70 volts because of the drop of potential in R11 and the valve V22 is made inoperative by the bias of -20 volts on its grid. This value of -20 volts follows from the facts that GB is at -260 volts, H. T. at +130 volts, and from the potential drops in the resistances L221, L222 and L223 with respect to the filament of V22. The voltage drop across R22 therefore ceases and the upper terminal of L211 has its potential raised to 130 volts, i. e. that of H. T. This raising of the voltage at the terminal of L211 makes the grid of the valve V21 have a bias of zero so that V21 is inoperative if the square wave B is in its less negative half cycle (when its potential is -130 volts), and being operative there is a potential drop across R21 which reduces the potential of the lower terminal of L222, thereby maintaining the bias of -20 on the grid of valve V22 even after the cessation of the pulse impressed on T24 which caused the original change in the circuit. If the square wave B be in its more negative half cycle (potential -170 volts), V21 does not operate. The operation of the distributor units in sequence is therefore as described with reference to Fig. 1.

In Fig. 5 is shown how the circuit arrangement according to the present invention may be used for frequency division. The points

X1, X2, etc. and Y1, Y2, etc. correspond with the similar identified points in Fig. 1 and the square waves as in Fig. 1 are impressed at A, B and C. In the figure X1 is shown connected over a condenser to a terminal I1 and Y3 over another condenser to I2, of a "flip-flop" device P. This device has two stable conditions, one producing one potential at the terminal O, and the other a different potential at that terminal. In the figure, when X1 gives its negative impulse, the valve T2 becomes operative while when the point Y3 gives its negative impulse the valve T becomes operative. With either T or T2 operative and the other valve non-operative the device P is in a stable condition. Thus the output O of the flip-flop device P gives a square wave of frequency equal to the frequency of the cycle of the distributor, which may be for example half the frequency of the controlling square wave.

Fig. 6 shows, in 1, 2 and 3, the three phases of the controlling waves, in 4, 5 and 6 impulses given by X1, X2 and X3, in 7, 8 and 9 impulses given by Y1, Y2 and Y3. 10 shows the output of the flip-flop when its grids are connected to X1 and Y1, 11 shows the output when connected to X1 and Y2, and so on. It is clear that square waves of a variety of phases and ratios of crest to trough can be obtained by choosing suitable X and Y points to connect to the flip-flop device.

If a distributor of groups or 9 units (for a 3-phase controlling wave) is used, division of frequency by three may be obtained. If one of the grids of the flip-flop device be connected (by high resistances and condensers) to two different X points, and the other grid to two Y points, the output of the flip-flop device will have two crests and two troughs per cycle of the distributor. It will not in this case be possible to make the crests appear at equal intervals, so that strictly speaking the output frequency cannot be said to be twice the frequency of the distributor cycle and two-thirds that of the controlling waves. However, if a 4-phased controlling wave be used employing a distributor of 12 units, it will be possible to make the output wave double the frequency of the distributor cycle, and therefore two-thirds the frequency of the controlling waves. By similar means it is possible to provide frequency dividers for square waves giving all simple ratios such as $\frac{1}{2}$, $\frac{1}{3}$, $\frac{2}{3}$, $\frac{1}{4}$, $\frac{3}{4}$, $\frac{1}{8}$ etc.; in order to obtain a division by 2, four square waves would be employed with eight valve units and the points X1 and Y3 would be connected to the flip-flop device. Generalizing, the frequency of the changes or kicks in the device

$$P = \frac{\text{frequency of the square wave}}{\text{the number of valve units}} \times$$

the number of square waves.

It is clear that one distributor may be used to work two or more flip-flop devices at the same time so that a plurality of square waves of various shapes, phases and frequency may be obtained from one and the same distributor. The distributor may at the same time be used for another purpose, such as for instance a telegraph transmitting or receiving distributor.

The device substantially as shown in Fig. 1 or 5 may also be used as a timing circuit, and this in the following manner:

Suppose there are a number of units of a distributor connected together as usual, but without the last connected to the first so that they are in a row instead of in a cycle. Under the influence of the controlling waves, this row will remain in a normal state with all selecting valves paralyzed, but if an impulse be applied, it will be transmitted down the row at a definite rate and will emerge at the last unit after a fixed time where it may be made to serve some useful purpose either directly or by the aid of a flip-flop device. Thus the arrangement is a timing circuit, which will act at a definite interval after any given action. Moreover its delay is adjustable and exact. Such a system could be made to give a series of impulses in sequence after regular or irregular intervals. In such a system it might be convenient to divide the distributor into classes of units, some of which were controlled by square waves of one frequency and some by square waves of another frequency.

Although the description has been restricted to specific circuit arrangements, the principles involved in the invention are capable of application in a variety of specific forms to perform a variety of functions.

What is claimed is:

1. A circuit arrangement comprising a plurality of groups of mechanically static electric energy translators, such as thermionic valves of which each comprises a grid, a cathode and an anode, means for applying a potential to the grid of one of said valves, said potential depending on the anode current of another valve in the arrangement.

2. A circuit arrangement comprising a plurality of valves forming a closed group in which each valve has its grid bias controlled by another tube of the group, each tube in turn performing a function of grid bias controller.

3. A circuit comprising a plurality of groups of valves arranged in groups, one valve being subjected to an impressed pulse adapted to change its condition as from being operative or non-operative, and resistance elements associated with the said valve which due to said change produces an opposite change in another valve of the same group which for a predetermined time maintains

the changed condition of the first said valve.

4. Circuit as defined in claim 3 characterized in that at least one resistance element is provided in the output circuit of said valve whereby input current is supplied to the other of said valves by virtue of the potential drop in said resistance.

5. A circuit arrangement comprising thermionic valves in which a valve is adapted to operate as an amplifier only when another valve in the arrangement is paralyzed and when voltage of a synchronizing wave applied to the grid of said first mentioned valve lies within certain limits.

6. A circuit arrangement according to claim 5 comprising means whereby the grid voltage of the first mentioned valve causes the valve to operate normally as an amplifier while said other valve is paralyzed and in which the condition of the grids of the two valves is reversed on the application of an impulse to the circuit, said means comprising a potentiometer arrangement of resistances.

7. A plurality of circuit arrangements according to claim 5 connected in sequence such that the application of an impulse to the first arrangement causes the reversal of the conditions of the grid potentials of two valves therein and also causes an impulse to be passed to the second arrangement causing the reversal of valve conditions therein and the generation of a further pulse and so on in sequence.

8. An arrangement according to claim 1 in which at least one valve of a group is adapted to be used as a normal amplifier during the time in which it is not paralyzed.

9. A high speed telegraph distributor comprising a plurality of space discharge tubes connected in pairs and having input and output circuits, resistance elements in said circuits, said elements being so dimensioned that the input voltage of the second of said devices is the mean of the potentials at two points of which one point is located in the output circuit of the second space discharge device and the other point is located at the junction point of said input circuit with the point of application of a square wave which has a voltage smaller than the filament voltage of said discharge devices.

10. A thermionic repeater comprising at least two space discharge devices each having an anode, a cathode and a control electrode, circuits connected to said electrodes, a source of high frequency signals connected to the input circuit of one of said devices, a line connected to the output circuit of said device, the output circuits of both of said devices being connected effectively in parallel and the anode circuit of the first mentioned device being connected to the grid circuit of the succeeding device through a resistance element, and means connected to the anode

circuit of the first mentioned device for correcting the length of the signal impulses transmitted to said line.

11. A distributor comprising a plurality of valves interconnected through a plurality of resistance elements for biasing the grids of said valves whereby said valves in turn open and close a path for signal currents, and means for providing impulses which may be used to operate an external apparatus.

12. A distributor adapted to transmit or receive electric signal impulses to or from a transmission medium, said distributor comprising means including a space discharge device which when said impulses would unduly over-lap in time corrects the length of the impulses, said means being operative only during the length of time desired for the impulses.

13. A distributor according to claim 12 comprising a plurality of signal distributing paths to which the signals are distributed, each of said paths containing a corrector valve.

14. A circuit arrangement according to claim 1 comprising means for supplying simple frequency multiplication or division of an input frequency wave, said means comprising two space discharge devices having input and output circuits, the output circuit of one of said devices being connected to the input circuit of the other device through at least one resistance element and the output circuits of said devices being connected effectively in parallel.

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30	95
35	100
40	105
45	110
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55	120
60	125
65	130