March 2, 1943. J. L. FINCH 2,312,810

SIGNAL GENERATOR

Filed Feb. 24, 1940 3 Sheets-Sheet 1

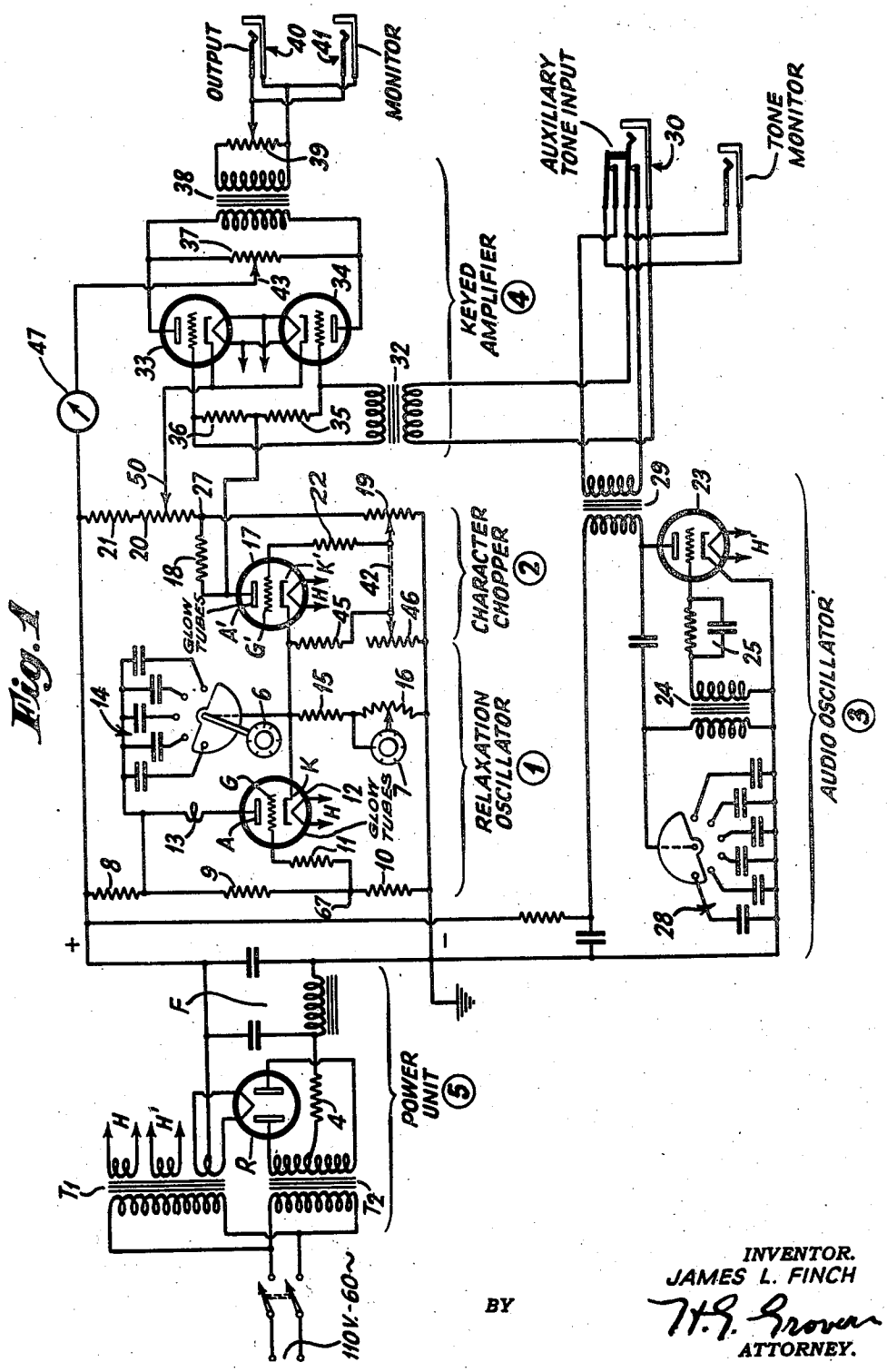


Fig. 1

INVENTOR.
JAMES L. FINCH

BY

ATTORNEY.

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Fig. 3

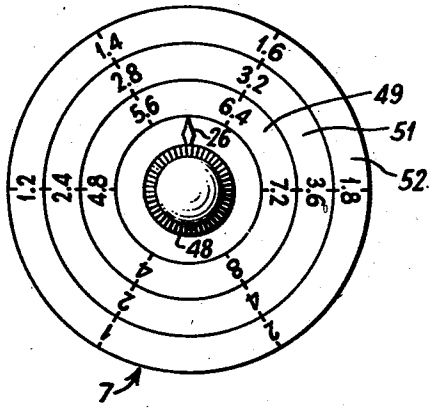
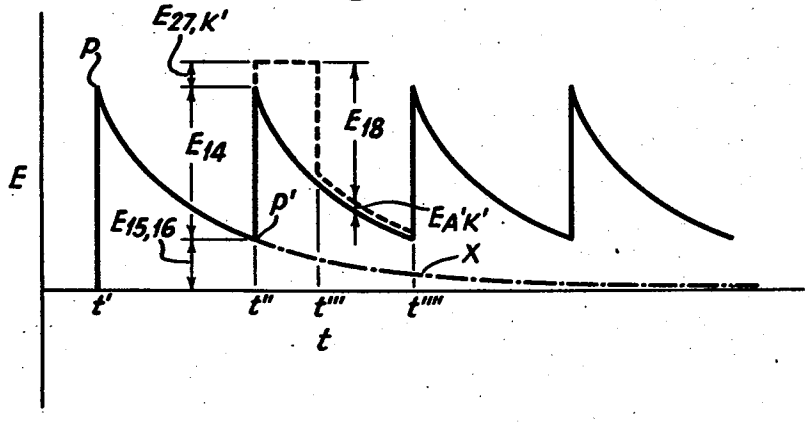


Fig. 2



INVENTOR.
JAMES L. FINCH

BY

ATTORNEY.

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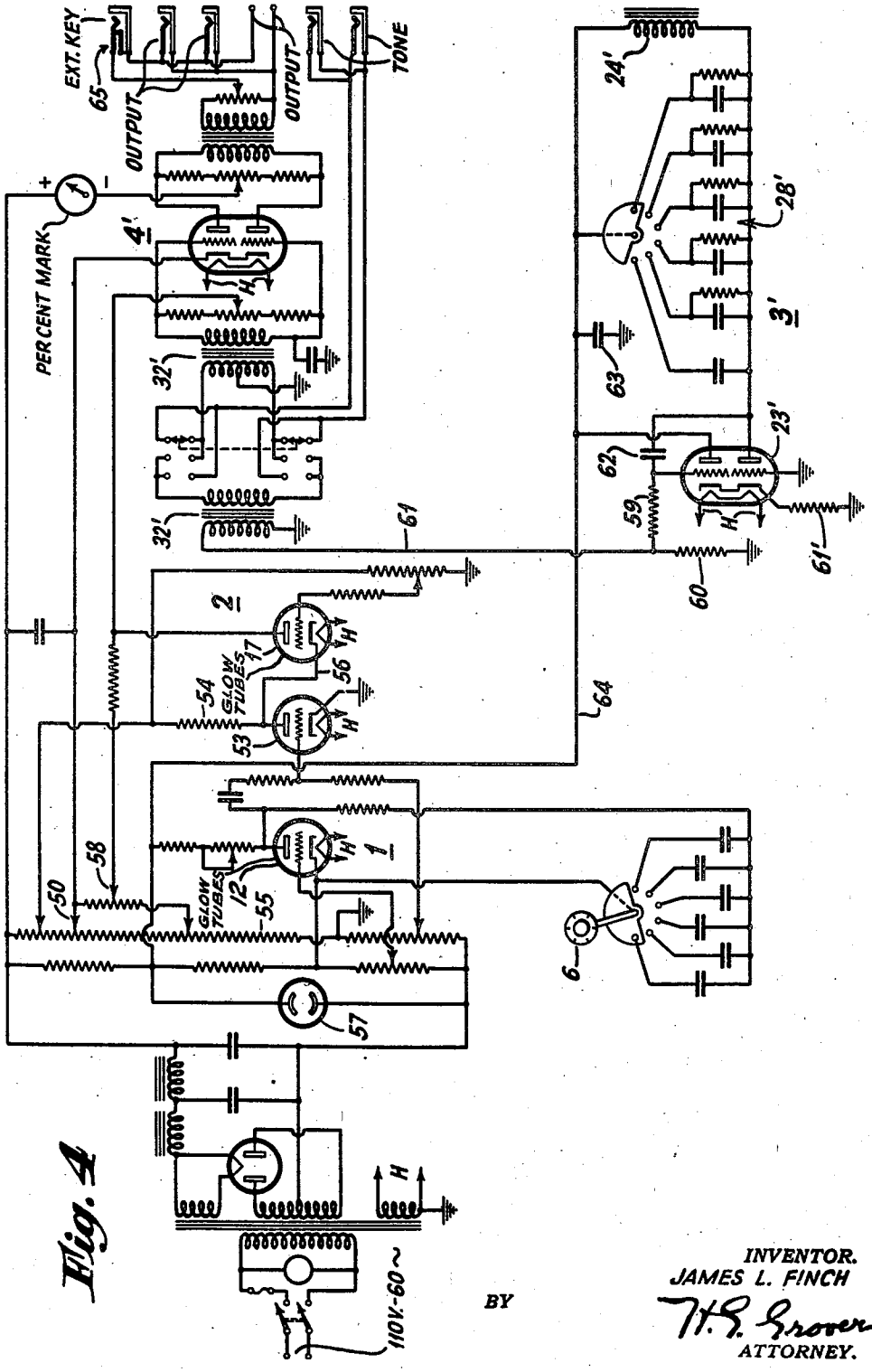


Fig. 4

BY

INVENTOR.
JAMES L. FINCH
H. B. Grover
ATTORNEY.

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UNITED STATES PATENT OFFICE

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SIGNAL GENERATOR

James L. Finch, Patchogue, N. Y., assignor to Radio Corporation of America, a corporation of Delaware

Application February 24, 1940, Serial No. 320,523

19 Claims. (Cl. 250—36)

This invention relates generally to a keying system, and more particularly to a signal generator for producing an audio frequency wave which is interrupted or chopped up into characters. The signal generator with which this invention is particularly concerned will hereinafter be referred to as a tone signal generator.

Heretofore, in checking or testing the performance of a locally situated transmission system it has been customary to transmit from a remote central office over a land line energy in the form of a tone or alternating current corresponding to certain signal characters. Such a system requires the use of terminal apparatus at the remote central office as well as a control channel extending from the central office to the local radio transmitting system. The terminal apparatus at the remote central office may consist of a facsimile machine or a high speed automatic transmitter, or other suitable apparatus. The procedure which has been followed in such known systems has required that information be relayed from the attendant or operator at the local transmitting system to the remotely situated central office to the effect that checking or testing of the transmitting system is necessary. Upon receipt of this information at the remotely located central office, the checking or testing equipment at this central office would be placed into operation.

The present invention eliminates the need for remotely situated character transmitting or checking apparatus for testing purposes and also eliminates the need for a control channel, by providing suitable means which can be used at the local transmission system for generating the desired signal characters.

One of the objects of the present invention is to provide a tone signal generator for producing an audio frequency wave interrupted or chopped up into characters, wherein the characters may have any desired weight and may employ any desired wave frequency within a wide range.

Another object of the present invention is to provide a source of continuously repeated signal characters consisting of marking characters and spacing characters, the marking characters being composed of any one of a group of selectable audio frequency waves.

A further object of the present invention is to provide a source of continuously repeated signal characters consisting of marking characters and spacing characters, the marking characters being adjustable in length or weight with respect to a complete cycle of operation composed of both a marking and a spacing character.

Other objects and their advantages will appear from a reading of the following description which is accompanied by drawings, wherein:

Fig. 1 illustrates a complete tone signal generator in accordance with one embodiment of the present invention;

Fig. 2 is a graphical representation given to aid in understanding the operation of the system of Fig. 1;

Fig. 3 shows a dial employed in connection with the relaxation oscillator of the tone signal generator of the invention; and

Fig. 4 is a preferred form of tone signal generator embodying the principles of the invention.

The tone signal generator of the invention shown in Fig. 1 includes a relaxation oscillator 1, a character chopper 2, an audio frequency oscillator 3, and a keyed amplifier 4, all coupled together in a manner more fully described hereinafter.

A suitable power unit 5 comprising a pair of transformers T_1 and T_2 whose primary windings are coupled to a source of 110 volt—60 cycle supply, a full wave rectifier R, and a low pass filter F for smoothing out the ripples from the rectifier, serves to supply suitable polarizing potentials and heating currents for the electrodes of the vacuum tube elements of the tone signal generator.

The relaxation oscillator 1 comprises a grid-controlled glow discharge tube 12, sometimes known as a "thyratron," having an indirectly heated cathode K, a grid G and an anode A. The grid, anode and cathode electrodes of the glow tube 12 are connected to suitable points on a voltage divider comprising resistors 8, 9 and 10 connected across the positive and negative terminals of the power unit 5, as shown. An adjustable condenser 14 composed of a plurality of selectable condenser units is connected across the cathode K and anode A of the glow tube for establishing the frequency of oscillation of the relaxation oscillator. Other elements for the establishment of the frequency of this relaxation oscillator are the serially connected resistors 15 and 16 which are connected between the cathode K and the grounded or negative side of the power unit. It will be appreciated that the relaxation oscillator operates at audio frequencies, and more specifically at character frequencies, i. e., keying frequencies, and produces saw-tooth waves. The adjustable condenser unit 14 is driven by a shaft to which is connected a dial 6 for indicating

which one of the several capacitors of the condenser 14 is connected in the circuit, thus indicating the range of audio frequencies within which the oscillator is operating. The resistor 16 is adjustable and is provided with a dial 7, shown in more detail in Fig. 3, for indicating the exact frequency of oscillation in the range selected by dial 6. An inductive reactor 13 is provided in series with the anode lead for limiting the instantaneous current through the tube 12 to a suitable value. Similarly, the resistor 11 is provided in the grid circuit to limit the grid current of the tube to a value which is not excessive. In parallel relation to resistors 15 and 16 there are provided a pair of serially connected resistors 45 and 46 for compensating for variations in the frequency of the relaxation frequency oscillator due to effects in the output of the chopper in the manner to be described later. The output of the relaxation oscillator 1, which in effect is the voltage across condenser 14, is impressed upon character chopper unit 2 of the tone signal generator.

The character chopper unit 2 includes a grid-controlled glow discharge device 17 having an indirectly heated cathode K', a grid G' and an anode A'. The cathode K' of this tube is directly connected to the cathode K of the relaxation oscillator, both cathodes being connected in parallel to the same point on resistor 15. The grid G' of character chopper 17 is connected through a resistor 22 to a slider on a potentiometer 19. Potentiometer 19 together with serially connected resistors 20 and 21 form a voltage divided which is connected across two sides of the power unit in a manner similar to voltage divider 8, 9 and 10. Tube 17 is similar to tube 12 and so arranged that the output of the relaxation oscillator is impressed during a portion of each cycle across resistor 18 in the anode circuit of the character chopper. The character chopper functions to key or control the keyed amplifier 4, from the latter of which characters of square formation are obtained in the output.

Keyed amplifier 4 is a push-pull amplifying system comprising a pair of indirectly-heated cathode vacuum tubes 33 and 34, whose cathodes are connected in parallel to a slider 50 on resistor 20 in the voltage divider system 19, 20 and 21. The grids of the amuplifier tubes are connected together through resistors 35 and 36 from which a connection is made to the anode A' of the character chopper tube 17. These same grids of the amplifier are also connected to one winding of an audio transformer 32 to whose other winding is supplied an audio frequency wave from the audio oscillator 3. In the output of the keyed amplifier there is provided a resistor or potentiometer 37 to which is connected a slider 43 which is adjustable over 37 to reduce to a minimum the transients in the output terminals due to the anode current of tubes 33 and 34. An instrument 47 is serially connected in the circuit from slider 43 to the positive side of the power unit to indicate the percentage of marking time to the total time. The output from the keyed amplifier is passed through an audio frequency transformer 38 to suitable jacks 40 and 41 from which connections extend through suitable apparatus to any desired type of utilization circuit; for example, a tone signal converter which, in turn, is used for keying a radio transmitter. Potentiometer 39 is employed for controlling the volume of the output of the keyed amplifier.

Audio oscillator 3 comprises an indirectly-heated cathode vacuum tube 23 having a tuned circuit comprising an adjustable condenser 28, adjustable by selecting any one of a plurality of individual condensers or groups of condensers in parallel relation to one winding of the audio frequency transformer 24. The other winding of transformer 24 is connected to the grid of the tube 23 through a grid leak condenser combination 25. Transformer 24 is preferably a specially designed transformer having large leakage reactance. The output of the audio oscillator 3 passes through audio frequency transformer 29 and through the normally made contacts of jack 30 before being impressed upon audio transformer 32. It will be evident that if desired a plug having an auxiliary audio tone may be inserted into jack 30, thus breaking the connection from the audio oscillator 3 to the keyed amplifier 4 and connecting the keyed amplifier 4 to the auxiliary tone input.

The operation of the system will now be described. Considering the relaxation oscillator, the voltage across resistors 9 and 10 is impressed across the circuit comprising condenser 14 and serially arranged resistors 15 and 16. Let us consider the start of the cycle to be the time when there is no charge on condenser 14. Charging current for condenser 14 will then flow through resistors 15 and 16 tending to charge the condenser 14 to the full voltage of the source. The gaseous grid-controlled glow tube or "thyratron" 12 has its anode A and cathode K connected across condenser 14 while its grid G is connected through resistor 11 to the junction point 67 between resistors 9 and 10. At the start of the cycle, the cathode K of tube 12 will be more positive than the grid G of this same tube. Consequently no current will flow through the glow tube. As the condenser 14 charges up, however, the voltage on the cathode K becomes more negative relative to the anode and the grid and eventually becomes negative with respect to the grid G. When a particular voltage relation between the cathode K and the grid G of the glow tube 12 is reached, the glow in the tube will strike and the cathode-anode circuit of tube 12 becomes highly conductive. This condition of the glow tube permits the condenser 14 to discharge through the tube 12 very quickly, after which the cycle of operations described above will repeat itself.

The frequency of oscillation of the relaxation oscillator 1 may be increased by decreasing the capacity of condenser 14 or by decreasing the resistance of resistor 16, while the frequency of oscillation can be reduced by increasing the capacity of condenser 14 or by increasing the resistance of resistor 16. The switch of condenser 14 is connected to the dial 6 which, as mentioned before, has an indicator which indicates the range of frequencies in which the relaxation oscillator is to operate. Resistor 16, on the other hand, is linked to dial 7 which is provided with a plurality of scales each scale indicating the exact frequency within the selected range of dial 6. Both dials 6 and 7 must be read together to obtain a correct indication of the frequency of the oscillator (note Fig. 3).

At the beginning of the cycle assumed above, the voltage relation between the cathode K' of the character chopper tube 17 and the point 27 between potentiometers 19 and 20 is such that the glow tube 17 is non-conducting. In this condition the cathode K' is positive with respect to the grid G'. As the voltage on the cathode K' be-

comes more negative relative to the anode A' of tube 17, it will be obvious that in effect the voltage on the anode A' becomes more positive relative to the cathode K'. Potentiometer 19, to which the grid G' of glow tube 17 is connected, is so set by means of the slider that at the start of the cycle the grid G' is more negative than the cathode K'. At some point in the cycle of operation the cathode K' will attain a voltage with respect to the grid G' such that the glow in the tube 17 will strike and the anode-cathode circuit will become conductive. This point in the cycle is variable and is determined by the position of the slider on the potentiometer 19. When the glow tube 17 becomes conductive, the output voltage of the relaxation oscillator, which is across condenser 14, is impressed upon resistor 18, except for the constant voltage drop of the glow tube 17 and except for the voltage difference across resistor 8 and resistors 20 and 21. This condition continues until condenser 14 discharges at the end of the cycle.

At this time it should be noted that in these circuits the glow tubes 12 and 17 of Fig. 1 differ in operation from grid-controlled glow discharge tubes in conventional circuits, in that in the present invention the circuits cause both the bias grid-cathode voltage and the anode-cathode voltage to change, while in the conventional circuit only the anode-cathode voltage changes while the bias grid-cathode voltage is constant.

The operation of the system, as so far described, will be more clearly understood by reference to Fig. 2 which graphically represents the wave form of the potential generated in the glow tubes 12 and 17. The ordinate represents the voltage E while the abscissa represents the time relation t. The start of the cycle when glow tube 12 is non-conducting is represented by point P at time t'. As the condenser 14 charges up, the cathode voltage becomes more negative relative to the anode and will tend to follow the logarithmic curve X, partly shown by the dot and dash line, which slopes gradually down to meet the abscissa axis t at some remote point. However, when the voltage on the cathode bears a predetermined relation with respect to the grid which will occur when the cathode is negative with respect to the grid or nearly zero with respect to the grid depending upon the characteristics of the tube employed, the glow in the tube 12 will strike at a point represented by P' on the curve X at time interval t''. At this point the voltage E_{14} from point P' to point P along the vertical axis represents the voltage on the condenser 14 while the voltage $E_{15, 16}$ from point P' on the vertical axis to the abscissa represents voltage across the resistors 15 and 16. In referring to this point P at this time it is assumed, of course, that point P now represents a horizontal voltage line at the distance P above the time axis. The discharge of the condenser 14 through the glow tube which occurs at point P' will cause the wave form to rise up again to a point on the P line, and the same cycle of operation will repeat itself. Considering the operation of character chopper 2, when the wave form of the glow tube 12 has reached point P, representing the start of the cycle, the voltage across the anode A' and cathode K' of tube 17 will be substantially the same as the voltage across the anode A and cathode K of tube 12. This voltage on the anode and cathode of tube 17 is represented by the line $E_{27, K'}$ and is shown to be slightly higher than the voltage on the same electrodes of tube 12 because of certain constants chosen in one particular embodiment of the invention, although it should be understood that the voltage on the anode-cathode electrodes of tube 17 may be the same or even less than the corresponding voltage on the glow tube 12. As the cathode voltage of the tube 12 becomes more negative with respect to the anode, the tube 17 will be non-conducting until time t''' is reached, at which time the relative voltage between cathode and grid of tube 17 is such that the glow in tube 17 strikes, after which the glow tube 17 will be conductive until time t'''' is reached. It should be noted that during the interval between t''' and t'''' the voltage across the anode and cathode of tube 17 is substantially constant and equal to the glow sustaining voltage in this same tube. This voltage is represented by $E_{A'K'}$. The voltage across resistor 18 resulting from the flow of current through resistor 18 and the anode-cathode circuit A', K' of tube 17 at any time is indicated by the vertical line E_{18}. The conductivity of glow tube 17 will cease immediately upon the complete discharge of condenser 14 through tube 12, a feature which the cycle of operations in both tubes 12 and 17 will repeat in the manner described above.

Currents flowing through the anode-cathode circuit of tube 17 will tend to influence the frequency of the relaxation oscillator. When these currents are varied with respect to their duration by varying the weight of the characters by means of potentiometer 19, this tends to change the frequency of the relaxation oscillator. To compensate for this change, resistor 46 is caused to vary by the same control means as that used to set the slider on potentiometer 19. This simultaneous variation is effected by unicontrol shaft 42, represented by dotted lines. Thus, when the frequency of the relaxation oscillator 1 tends to increase due to this cause, resistor 46 is increased and produces a counter tendency to decrease the frequency of the relaxation oscillator.

When the glow tube 17 is in a non-conducting condition during the time interval between t'' and t''' of Fig. 2, the bias on the grids of the keyed amplifier tubes 33 and 34 is determined by the position of the slider 50 on the potentiometer 20, at which time tubes 33 and 34 are conducting and passing audio frequency tone out to a suitable utilization circuit. However, when glow tube 17 becomes conducting during the time interval between t''' and t'''', this bias on vacuum tubes 33 and 34 of the keyed amplifier 4 is increased by the voltage which is impressed upon resistor 18 represented by E_{18} in Fig. 2. For all operating adjustments, this voltage impressed upon resistor 18 is sufficient to block vacuum tubes 33 and 34 as soon as tube 17 becomes conducting, thus preventing tone from going out over jacks 40 and 41. In this manner output current flows from the keyed amplifier 4 or, putting it another way, a marking character is formed during the interval between time t'' and t''', while a spacing character is formed during the time interval between t''' and t''''. These marking and spacing characters can be varied to take any desired percentage of time interval between t'' and t'''' by adjusting potentiometer 19.

In the operation of the tone signal generator as a whole, the adjustable condenser 28 of the audio oscillator 3 is set for the desired audio frequency and dial 6 and dial 7 are set to give the

relaxation frequency or frequency of repetition of the marking and space, while potentiometer 19 is set to give the desired weight or mark. By means of this adjustment of potentiometer 19, effected by movement of the slider due to movement of the unicontrol means 42, the weight (i. e., the length) of mark can be adjusted to be anywhere from say 5% to 95% of the character cycle, taking place during the time interval between t'' and t''''. For the purpose of calibration of the percentage marking instrument 47, the potentiometer 19 is first set at its lowest position so as to give an uninterrupted tone output from the signal generator, i. e., continuous mark. (This occurs when tube 17 will be continuously non-conducting.) Potentiometer 20 will now be adjusted until instrument 47, which is in the anode supply lead to the keyed amplifier 4, has a deflection mark of 100%, after which the unicontrol means 42 will be adjusted to vary the potentiometer 19 until the instrument 47 indicates the percentage which it is desired the marking time should bear to the total time of the character. After all this has been done, potentiometer 39 is adjusted to the desired output level.

Fig. 3 shows in detail one form of dial 7 which may be used in the relaxation oscillator circuit for resistor 16. There may be one such dial, as shown in this figure, for each setting of dial 6. This dial comprises a pointer 26 secured to a knob 48 which is movable over several stationary scales 49, 51 and 52, each of the latter having engraved thereon around the periphery different frequency markings. Where the switch on condenser 14 produces by movement thereof frequencies which are dissimilarly related to each other, then a single dial 7 (such as shown in Fig. 3) may be used for two or more settings of the dial 6, in which case it will only be necessary to multiply each of the markings on the stationary scale by ten or one hundred.

Fig. 4 shows a preferred form of the invention which is almost identical with the system of Fig. 1, except for a few minor changes which will appear hereinafter. The operation of this system of Fig. 4 is substantially the same as the operation of the system of Fig. 1, and the same reference numerals (some with prime designations) are employed in both of these figures to indicate equivalent parts. The main differences between the system of Fig. 4 and the system of Fig. 1 lies in the use of a buffer vacuum tube amplifier stage 53 placed between the output of the relaxation oscillator 1 and the character chopper 2. This buffer amplifier has its anode connected on the one hand through a resistor 54 to a voltage divider 55 and the same anode is connected on the other hand through a connection 56 to the cathode of the glow tube 17 of the character chopper 2. The relaxation oscillator shown in Fig. 4 is of the conventional type wherein the bias grid-cathode voltage is constant, the only voltage which changes being the anode-cathode voltage. A voltage regulator tube 57 ensures substantially constant supply voltage to the relaxation oscillator. The keyed amplifier 4' is here shown as a single evacuated vessel containing therein a pair of push-pull operated electrode structures, the cathodes being connected to the voltage divider by means of slider 50. In this case, however, the final bias adjustment for the keyed amplifier is obtained by means of slider 58. There is some further difference in the manner in which the audio oscillator 3' supplies audio frequency waves to the keyed amplifier, but inasmuch as this difference is somewhat conventional and apparent to anyone skilled in the art, it is not believed necessary to describe the same in any detail. The audio frequency oscillator 3' of Fig. 4 differs somewhat from the audio oscillator 3 of Fig. 1. In Fig. 4 this audio oscillator comprises a vacuum tube 23' having a pair of anodes, a pair of grids, and a pair of cathodes, and a tuned circuit consisting of reactor 24' in parallel relation to any one of the group of selectable condensers forming a condenser 28'. The tuned circuit 24', 28' is connected across both anodes of the vacuum tube 23'. One grid of this tube is directly connected to ground while the other tube is connected to ground through a pair of resistors 59 and 60. Both cathodes are directly connected together and to ground through a resistor 61'. The output voltage from the audio frequency oscillator 3' appears across resistor 60 and is taken off by means of connection 61 to be applied to one winding of transformer 32'. A condenser 62 connects the ungrounded grid to the anode directly associated with the other grid. Condenser 63 is a by-pass condenser for audio frequency energy connecting one of the anodes as well as one side of the tuned circuit to ground. A positive polarizing potential for the anodes is supplied by connection 64 which extends from the oscillator 3' to the power unit. A plurality of resistors are shown individually associated with different condenser units of the condenser 28' and serve for the purpose of reducing the power output level at different frequencies to substantially the same value. A jack 65 is provided in the output of the keyed amplifier and has short circuited contacts in series with the output of the keyed amplifier 4' for the purpose of enabling the attendant to key the system by hand in the event it is desired to communicate over the controlled transmission system with a remote receiving point. In such a case the tone signal generator will be adjusted for 100% mark, that is a continuous transmission of tone signal characters without any interruption, and the attendant, by means of a plug to be inserted in jack 65, can key the outgoing circuit, thus using this tone signal generator merely as a source of carrier tone.

What is claimed is:

1. In combination, a relaxation oscillator, an amplifier, an audio frequency oscillator whose output is coupled to the input of said amplifier, an electric tube coupling said relaxation oscillator and said amplifier and responsive to the operation of said relaxation oscillator for periodically interrupting the output from said amplifier, whereby there are produced signal characters in accordance with said interruptions, and means for controlling the weight of said signal characters.

2. In combination, a relaxation oscillator, an amplifier, an audio frequency oscillator whose output is coupled to the input of said amplifier, an electric tube coupling said relaxation oscillator and said amplifier and responsive to the operation of said relaxation oscillator for periodically biasing said amplifier to cut-off, whereby there are produced tone signal characters in the output of said amplifier, and means in circuit with said electric tube for adjusting the weight of said tone signal characters.

3. In combination, a gaseous discharge tube relaxation oscillator having means for controlling the frequency of the produced oscillations, an amplifier, an audio frequency oscillator having

means for varying the frequency thereof, a connection from said audio oscillator to the input of said amplifier, and a non-oscillatory gaseous discharge tube circuit coupling said relaxation oscillator and said amplifier for periodically interrupting the conductivity of said amplifier during a predetermined portion of the cycle of operation of said relaxation oscillator.

4. In combination, a gaseous discharge tube relaxation oscillator having means for controlling the frequency of the produced oscillations, an amplifier, an audio frequency oscillator having means for varying the frequency thereof, a connection from said audio oscillator to the input of said amplifier, a non-oscillatory gaseous discharge tube circuit coupling said relaxation oscillator and said amplifier for periodically interrupting the conductivity of said amplifier during a predetermined portion of the cycle of operation of said relaxation oscillator, and a buffer amplifier between said relaxation oscillator and said non-oscillatory gaseous discharge tube.

5. In combination, a gaseous discharge tube relaxation oscillator having means for controlling the frequency of the produced oscillations, an amplifier, an audio frequency oscillator having means for varying the frequency thereof, a connection from said audio oscillator to the input of said amplifier, a non-oscillatory gaseous discharge tube circuit coupling said relaxation oscillator and said amplifier for periodically interrupting the conductivity of said amplifier during a predetermined portion of the cycle of operation of said relaxation oscillator, and a resistor coupled to the electrodes of both said gaseous discharge tubes for compensating for any tendency on the part of the relaxation oscillator to change its frequency due to reaction caused by said non-oscillatory discharge tube.

6. In combination, a gaseous discharge tube relaxation oscillator having means for controlling the frequency of the produced oscillations, a push-pull audio frequency amplifier, an audio frequency oscillator having means for varying the frequency thereof, connections between said audio oscillator and the input of said push-pull amplifier, and a non-oscillatory gaseous discharge tube circuit coupling said relaxation oscillator and said amplifier for periodically biasing said amplifier to cut-off in dependence upon the cycle of operations of said relaxation oscillator, said amplifier being biased to cut-off during the time said non-oscillatory gaseous tube is conductive and vice versa.

7. In combination, a gaseous discharge tube relaxation oscillator having means for controlling the frequency of the produced oscillations, an amplifier, an audio frequency oscillator having means for varying the frequency thereof, a connection from said audio oscillator to the input of said amplifier, a non-oscillatory gaseous discharge tube circuit coupling said relaxation oscilaltor and said amplifier for periodically interrupting the conductivity of said amplifier during a predetermined portion of the cycle of operation of said relaxation oscillator, and a potentiometer in the output of said amplifier for controlling the volume of the energy in said output.

8. In combination, a gaseous discharge tube relaxation oscillator having means for controlling the frequency of the produced oscillations, a push-pull audio frequency amplifier, an audio frequency oscillator having means for varying the frequency thereof, connections between said audio oscillator and the input of said push-pull amplifier, a non-oscillatory gaseous discharge tube circuit coupling said relaxation oscillator and said amplifier for periodically biasing said amplifier to cut-off in dependence upon the cycle of operations of said relaxation oscillator, said amplifier being biased to cut-off during the time said non-oscillatory gaseous tube is conductive and vice versa, means in the output of said push-pull amplifier for reducing to a minimum the transients due to currents in said amplifier, and means for controlling the volume of the output of said amplifier.

9. In combination, a relaxation oscillator comprising a gaseous discharge tube having across its anode and cathode an adjustable condenser composed of a plurality of selectable condenser units, an amplifier, an audio frequency oscillator having a tuned circuit composed of an inductive reactor and in shunt thereto an adjustable condenser comprised of a plurality of selectable condenser units, a connection from the output of said audio oscillator to the input of said amplifier, an electric tube coupling said relaxation oscillator and said amplifier and responsive to the operation of said relaxation oscillator for periodically interrupting the output from said amplifier, whereby there are produced signal characters in accordance with said interruptions, and means for controlling the weight of said signal characters.

10. In combination, a relaxation oscillator comprising a gaseous discharge tube having across its anode and cathode an adjustable condenser composed of a plurality of selectable condenser units, an amplifier, an audio frequency oscillator having a tuned circuit composed of an inductive reactor and in shunt thereto an adjustable condenser comprised of a plurality of selectable condenser units, a connection from the output of said audio oscillator to the input of said amplifier, a grid-controlled gaseous electric tube coupling said relaxation oscillator and said amplifier and responsive to the operation of said relaxation oscillator for periodically interrupting the output from said amplifier, whereby there are produced signal characters in accordance with said interruptions, and a potentiometer coupled to the grid electrode of said electric tube for controlling the time of striking of the glow therein with a consequent control of the weight of said signal characters.

11. In combination, a relaxation oscillator comprising a gaseous discharge tube having across its anode and cathode an adjustable condenser composed of a plurality of selectable condenser units, a source of direct current voltage having one side connected to one terminal of said adjustable condenser and the other side connected through an adjustable resistor to the other terminal of said adjustable condenser, whereby both said adjustable resistor and said adjustable condenser establish the frequency of oscillation of said relaxation oscillator, a dial linked to said adjustable condenser for indicating the range of frequencies within which said relaxation oscillator is operating, and a dial linked to said adjustable resistor for indicating the exact frequency of oscillation in the range selected by said first dial, an amplifier, an audio frequency oscillator whose output is coupled to the input of said amplifier, an electric tube coupling said relaxation oscillator and said amplifier and responsive to the operation of said relaxation

oscillator for periodically interrupting the output from said amplifier, whereby there are produced signal characters in accordance with said interruptions, and means for controlling the weight of said signal characters.

12. In combination, a saw-tooth wave generator, an amplifier, means coupling said generator and the input of said amplifier for controlling the conductivity of said amplifier over substantially any desired portion of each cycle of operation of said generator, said means comprising a gaseous discharge device having an anode, a grid and a cathode, a source of unidirectional potential, a voltage divider connected across said source of unidirectional potential, connections from said anode and grid to different points on said voltage divider, and a connection from said cathode to said voltage divider.

13. In combination, a saw-tooth wave generator, an amplifier, means coupling said generator and the input of said amplifier for controlling the conductivity of said amplifier over substantially any desired portion of each cycle of operation of said generator, said means comprising a gaseous discharge device having an anode, a grid and a cathode, a source of unidirectional potential, a voltage divider connected across said source of unidirectional potential, connections from said anode and grid to different points on said voltage divider, and a connection from said cathode to said voltage divider, the connection from said grid to said voltage divider being adjustable over said voltage divider for determining the exact point in said cycle of operation at which the glow in said gaseous discharge device will strike.

14. In combination, a wave form generator, an amplifier, a character chopper coupling said generator and said amplifier for controlling the conductivity of said amplifier over substantially any desired portion of each cycle of operation of said generator, said chopper comprising a gaseous discharge device having an anode, a grid and a cathode, a source of unidirectional potential, a voltage divider connected across said source of unidirectional potential, connections from said anode and grid to different points on said voltage divider, and a connection from said cathode to said voltage divider, and an instrument in circuit with the output of said amplifier for indicating the percentage length or weight of the marking characters produced in the system.

15. In combination, a relaxation oscillator, an amplifier, an oscillator whose output is coupled to the input of said amplifier, an electric tube coupling said relaxation oscillator and said amplifier and responsive to the operation of said relaxation oscillator for periodically interrupting the output from said amplifier, whereby there are produced signal characters in accordance with said interruptions, and means for controlling the weight of said signal characters.

16. In combination, a wave form generator, an impedance, means including a glow discharge device for impressing any desired portion of the voltage wave of said generator upon said impedance, an amplifier, an oscillator having its output coupled to the input of said amplifier, and a connection from said amplifier to said impedance, whereby the conductivity of said amplifier is controlled by the voltage impressed on said impedance.

17. In combination, a pulse generator producing pulses of equal length, an impedance, means for impressing the voltage wave of said generator upon said impedance, an amplifier, an audio frequency oscillator coupled through a circuit of low impedance to energy of the oscillator frequency to the input circuit of said amplifier, and a connection from the input circuit of said amplifier to said impedance, whereby the conductivity of said amplifier is controlled by the voltage impressed on said impedance and there are produced signal characters in the output of said amplifier, and means for controlling the weight of the signal characters.

18. In combination, a relaxation oscillator, an amplifier, and a glow discharge tube coupling said oscillator and said amplifier and responsive to the operation of said generator for periodically rendering said amplifier non-conductive, and a potentiometer in circuit with said glow discharge tube for determining the duration of the conductive periods of said amplifier.

19. In combination, a pulse generator, an amplifier, an audio frequency oscillator whose output is coupled to the input of said amplifier, an electric tube coupling said pulse generator and said amplifier and responsive to the operation of said pulse generator for periodically interrupting the output from said amplifier, whereby there are produced signal characters in accordance with said interruptions, and means for controlling the weight of said signal characters.

JAMES L. FINCH.