F. CUTTING AND B. WASHINGTON.

WIRELESS TELEGRAPHY.

APPLICATION FILED DEC. 4, 1916.

1,345,352. Patented July 6, 1920.

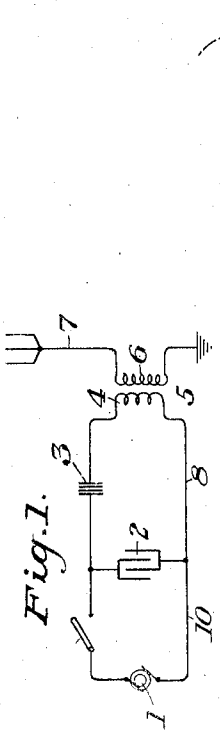


Fig. 1.

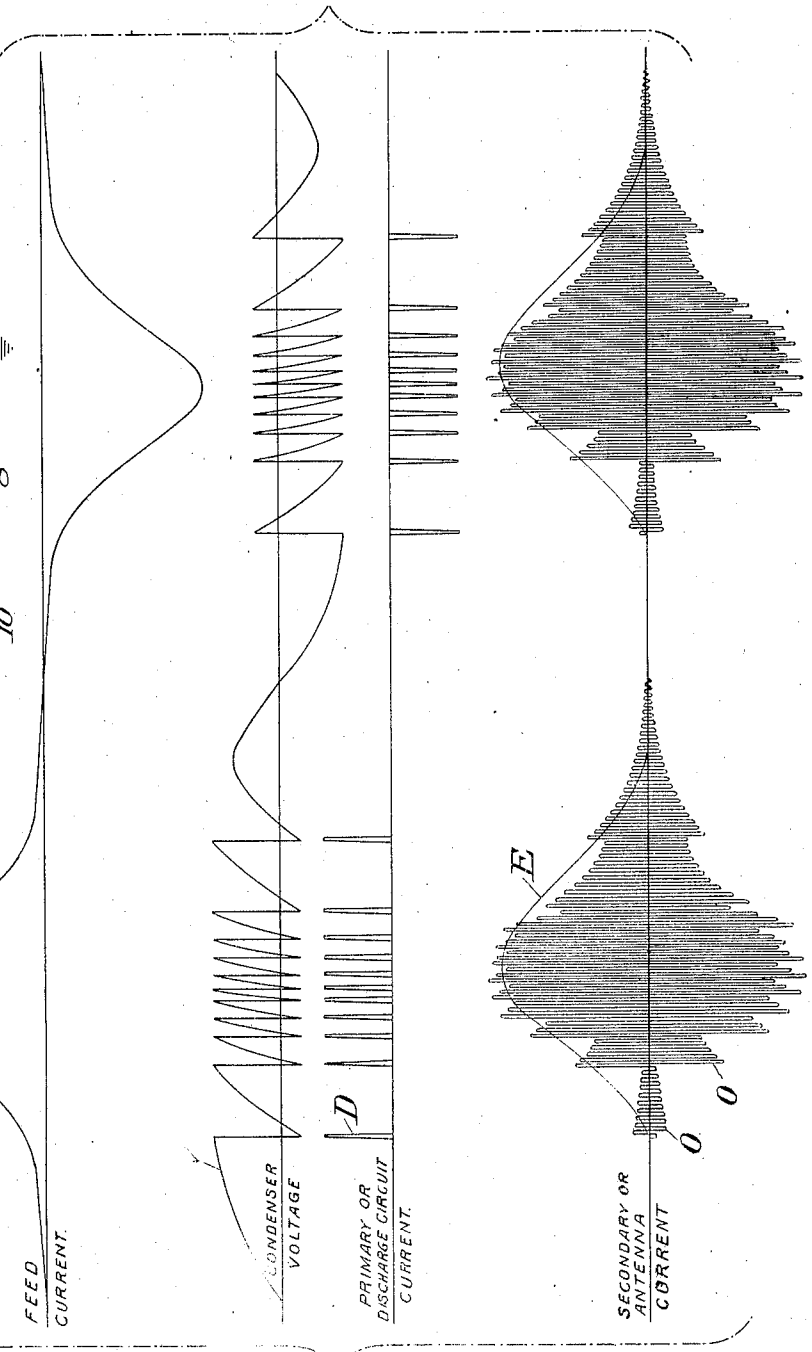


Fig. 2.

WITNESSES

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WIRELESS TELEGRAPHY.

1,345,352. Specification of Letters Patent. **Patented July 6, 1920.**

Application filed December 4, 1916. Serial No. 134,812.

To all whom it may concern:

Be it known that we, FULTON CUTTING and BOWDEN WASHINGTON, both citizens of the United States, and residents, respectively, of Tuxedo Park, Orange county, New York, and Cambridge, Middlesex county, Massachusetts, have invented a new and useful Improvement in Wireless Telegraphy, of which the following is a full, clear, and exact description, reference being had to the accompanying drawings, forming part of this specification, in which—

Figure 1 is a conventional diagram showing one embodiment of the apparatus, and Fig. 2 is a diagrammatic illustration showing in a general way the relation between the various currents in the apparatus.

The present invention relates to wireless telegraphy, and more particularly to increasing the efficiency in the production of radiated wave trains of an audible frequency, and at the same time producing a clear audible note in the receiving station.

In the usual construction of quenched gap sets, it is well known that to have a clear note at the receiving station there should not be more than one spark per alternation or half cycle of the alternator. Five hundred cycle sets are usually built to spark once for each alternation, thus giving a thousand cycle note. It has been found that when such a set is operated to give two or three sparks per alternation, the note becomes bad. Consequently, the practice has been to so proportion the condenser and discharge gap to the feed current that but a single condenser discharge occurs for each alternation of the alternating current.

We have discovered, however, that a plurality of condenser discharges for each pulsation or alternation may be advantageously employed under certain conditions. If a suitable shaped feed current wave be employed, and the apparatus adjusted to give a sufficient number of condenser discharges per alternation, the condenser discharges will take place in separate or discrete groups, separated by periods of inactivity, and the general shape or outline of the radiated power wave will correspond approximately to the shape or outline of the feed current. Under these conditions a clear tone and maximum effect are obtained at the telephones of the receiving station. The note at the receiving station can be made as clear, if not clearer, than that obtained with the best five hundred cycle set operated with but a single discharge per current alternation. The wave of power acting on the telephone diaphragms of the receiver has approximately the duration of an alternation of the feed current and is much better suited to set the diaphragms into vibration than the single and much shorter power wave which is radiated from a sending station employing but a single spark per phase, and which has a duration of but a small fraction of an alternation of the feed current.

Referring to the drawings, there is illustrated in Fig. 1 a conventional diagram of one arrangement of circuits which may be employed to practice the present invention. In the illustrated arrangement, an alternator 1 supplies alternating current to a condenser 2 which discharges through a gap 3 indicated as a conventional quenched gap. The condenser discharges or impulses pass through the primary 4 of the transformer 5, the secondary 6 of which is included in an antenna or oscillation circuit 7. The circuit including the gap 3 and primary 4 may, for convenience, be designated as the discharge circuit 8, while the circuit including the alternator 1 and the sending switch 9 may be designated as a feed circuit 10.

The capacity of the condenser 2 and break-down voltage of the gap 3 are so proportioned with relation to the feed current that a plurality of discharges take place for each half cycle or alternation of the feed current. The number of discharges per alternation will vary depending upon the wave shape of the feed current and the type of the set. In using the usual commercial form of alternator supplied for five hundred cycle sets, we have found that from twenty to thirty discharges per alternation give good results on a one-half kilowatt five hundred cycle set. With the usual commercial type of alternator, the lower limit appears to be about eight condenser discharges per alternation, below which audible and undesirable harmonics begin to occur. However, if an alternator be employed having a wave shape such that the peaks of the waves are separated by periods of substantially no current flow, such, for example, as the wave shape indicated at F in Fig. 2 of the drawings, it is possible to reduce the number of condenser discharges per alternation below this

limit and to obtain a clear tone with four or five, or possibly less, condenser discharges per alternation. The generator wave indicated at F in Fig. 2, causes the condenser discharges to be closely spaced in well separated groups. Apparently the peaked wave causes the condenser discharges to be so closely spaced in the groups that during each group of discharges, the antenna current is not allowed to die down to any great extent between the condenser discharges and a power wave is radiated having a general outline or envelop like the wave shape of the feed current. The peaks or portions of the waves of sufficient voltage to excite the discharge gap are separated by periods of very low voltage and, consequently of substantially no current flow to the condenser, so that the resultant groups of condenser discharges and radiated oscillations are discrete, that is, separated by substantial intervals of inactivity from the next preceding and succeeding groups. This allows an opportunity for the diaphragm of the receiving telephone, which is energized by the received group of radiant oscillations, to swing back before it is again energized.

In Fig. 2 is illustrated diagrammatically what is believed to be the general relation between the feed current, the condenser voltage, the primary or discharge circuit current, and the secondary or antenna current. It is to be understood that these diagrams are not intended to be exact, but are presented for the purpose of more graphically presenting what we believe the current phenomena to be. These diagrams and their description are for the purpose of description, and they are not intended to limit the invention to the current relations therein shown.

The alternator 1 preferably produces a feed current F having the wave shape shown at the top of Fig. 2. It will be noted that this feed current has a peaked wave shape, the current decreasing substantially to zero after the peak and remaining there for a period, the duration of which is approximately the same as that of the current wave itself. As the condenser 2 is charged, the gap 3 breaks down whenever the condenser voltage reaches that of the break-down voltage of the gap. The condenser voltage is indicated diagrammatically by V in the second line of Fig. 2, in which condenser voltage is illustrated as gradually increasing until a discharge takes place, then increasing again until a second discharge takes place, and so on. The frequency of the condenser discharges, of course, varies, depending upon the feed current, the condenser being charged and discharged more rapidly when the feed current is at or near its maximum. The current in the discharge or primary circuit is in the form of discontinuous current impulses, indicated at D in the third line of Fig. 2. During the positive alternation or half cycle of the current these discharges will take place in one direction, while during the negative half cycle of the feed current the discharges D will take place in the opposite direction. Each discharge or current impulse D in the primary induces a train of oscillations in the secondary or antenna circuit, as indicated at O in the fourth or bottom line of Fig. 2. Each train of oscillations tends to die out. However, when the condenser discharges take place with increased frequency, as during the maximum of the discharge current F, the succeeding condenser discharges serve to boost the declining oscillations already in the oscillation circuit, and thereby increase them, provided, of course, that the primary discharge impulses occur with sufficient rapidity in proportion to the rate of decrement of the antenna oscillations. The line E indicates the general shape or smoothed-out contour or outline of the group of oscillation trains. This outline or envelop of the group has substantially the same shape as the envelop or outline of the wave of power produced in the oscillation circuit and radiated therefrom.

The current relations shown in Fig. 2 are those believed to exist in apparatus built by us as a modification of the Chaffee system shown in patent to Emory L. Chaffee, No. 1,189,791. The system built by us employed Chaffee's system of impulse excitation with substantially perfect quenching, and with the approximate one and seven tenths to one ratio between the natural period of the primary or feed current circuit and the natural period of the secondary or oscillation circuit, described in the Chaffee patent, but with a symmetrical discharge gap and an alternating instead of a direct feed current. In this system the secondary oscillations preferably overlap, the succeeding condenser discharges serving to boost and increase the oscillations already existing in the oscillation or antenna circuit.

Since the activity of the high frequency circuits is substantially proportional to the feed current, an antenna radiation is obtained the envelop or general outline of which is similar in shape to that of the alternating feed current rectified. Since the gap we employ is symmetrical, both the positive and negative alternations of the alternating feed current produce the same effect on the high frequency circuits. As the feed current increases from zero the condenser charges and discharges. At first this takes place slowly, but at an increasing rate as the feed current approaches and reaches its maximum. The frequency of occurrence of the primary impulses or discharges is therefore proportional to the feed current,

and if we consider the antenna current as approximately proportional to the square root of the frequency of the primary impulses or discharges, it can be seen that the antenna current is approximately proportional to the square root of the feed current, or the power in the antenna is approximately proportional to the feed current. This relation, while approximate, is not to be taken exactly, since the antenna current is continually dying down between the primary discharge impulses. In apparatus in which the secondary oscillations die down between the primary discharge impulses, instead of overlapping and boosting as shown in the illustrative diagram, similar results will be obtained, because the power radiated from the antenna will be approximately proportional to the frequency of the primary impulses, so that the power wave will have the general shape of the feed current wave. What the power wave is may, perhaps, be made clear by the following considerations: There are in the system three periodicities each different from the other. There is the generator frequency, the discharge frequency (which varies), and the antenna frequency. The antenna power may be viewed from all of these frequencies. From the point of view of the antenna frequency we have the actual instantaneous power varying at the same rate as the antenna oscillations. From point of view of the discharge frequency, we have a power function which increases rapidly during each condenser discharge, dies down between discharges and is renewed or boosted at the next discharge. The contour of such a wave is therefore saw-toothed. Lastly, if we neglect the saw-teeth of this power wave, we get a power wave which is similar in shape to the feed current wave. It is the values or ordinates of this power wave, (the smoothed-out contour of the saw-toothed wave) which are approximately proportional to the values or ordinates of the feed current taken at corresponding instants of time. This condition, it can be readily seen, can be obtained only by causing a large number of condenser discharges to take place per alternation or half cycle of the feed current.

It is found that a feed current wave of the same general form as that shown in Fig. 2 is most efficient for operating the telephones at the receiving station. A wave of this sort is a peaked wave which drops to substantially zero and remains at a substantially zero value for a period about equal in duration to that of the current wave itself (that is, neglecting small values insufficient to induce gap activity). With such a wave the periods of gap activity are about equal to the periods of inactivity. The resultant groups of radiated waves therefore have substantially the same shape and duration as the feed current wave rectified, the power gradually increasing to a maximum, then gradually decreasing to zero and remaining at zero for a period substantially equal to the length of the wave, and again increasing to a maximum and dropping to zero. While the antenna oscillations never actually cease, they are generally looked upon as having ceased or become zero when they have died down to an unimportant value, so that it will be understood that although the antenna oscillations do not absolutely cease during the periods of gap inactivity, yet, as a practical matter, they may be looked upon as having ceased. This relationship between the groups of wave trains, namely, that the duration of the groups of wave trains is about equal to the interval between the groups, is found to be of great advantage in the efficient operation of the telephones at the receiving station. With the apparatus of the present invention it has been found that four times greater audibility with a five hundred cycle set was obtained than when such set was operated with but a single spark per current alternation.

Other advantages obtained in the present system are, the low frequency power circuits are simpler and more advantageous, because lower voltages may be employed, no adjustment or resonant condition is needed between the capacity and inductances of the low frequency power circuits, the transformer usually employed between the generator and the condenser may be discarded if desired, the condenser losses due to the rapid charging of the condenser are much lower than when the condenser is charged for each alternation of the feed current, and the lower discharge voltage permits the use of a condenser with a much smaller quantity of dielectric than required with the higher discharge voltages necessary for but a single condenser discharge per alternation. Moreover, the purity of the tone at the receiving station is stable and is obtained inherently in the transmitting apparatus and without careful adjustment. A few condenser discharges more or less for each alternation does not disturb the purity of the tone, whereas with the ordinary five hundred cycle set if the number of condenser discharges increases beyond one per alternation the purity of the tone is destroyed. Greater audibility for the same power is produced at the receiving stations when the telephones are employed for receiving, due to the fact that the telephones work more efficiently under a weak sustained force than under a strong force of a short duration, and as above pointed out, the wave shape of the alternator may be so adjusted that the power radiated by the antenna, which is similar in

shape, will give the maximum effect on the receiving telephones.

By the expression "a plurality of condenser discharges" as employed herein, is meant a plurality or series of what are ordinarily termed condenser discharges. Such discharges occur when the condenser is charged to a voltage sufficient to break down the resistance of the discharge gap, and the individual discharges are separated by intervals of no gap activity, during which intervals the condenser is accumulating a new charge preparatory to another discharge. We are aware of the patent to McCaa No. 1,211,863, issued Jan. 9, 1917, and do not claim what is therein shown.

While we have illustrated and described one specific and preferred form of apparatus for carrying out the present invention, other forms and constructions of apparatus may be employed. For example, instead of the Chaffee gap, a quenched gap of the more usual construction may be employed. Also, instead of an alternator for supplying the pulsations which charge the condenser and which give the tone at the receiving station, other means for producing the pulsations may be used. It is to be understood therefore that the invention is not limited to its illustrated embodiment, but may be embodied in other apparatus anl methods within the scope of the following claims.

We claim:

1. Apparatus for producing electrical oscillations having an audible group frequency, comprising, an oscillation circuit, and means for producing oscillations therein comprising a discharge circuit coupled with the oscillation circuit and including a condenser and a discharge gap, and means for supplying a pulsating feed current to the condenser, the capacity of the condenser and the break-down voltage of the gap being so proportioned that a sufficient number of condenser discharges occur for each pulsation of the feed current to produce a radiated power wave having an envelop of substantially the same shape as that of the feed current pulsation, substantially as described.

2. Apparatus for producing electrical oscillations having an audible group frequency, comprising, an oscillation circuit, and means for producing oscillations therein comprising a discharge circuit coupled with the oscillation circuit and including a condenser and a discharge gap, and means for supplying a pulsating feed current to the condenser, the capacity of the condenser and the break-down voltage of the gap being so proportioned that a plurality of discharges occur for each pulsation of the feed current, the discharge frequency varying and being substantially proportional to the feed current whereby the power in the oscillation circuit is approximately proportional to the feed current, substantially as described.

3. Apparatus for producing electrical oscillations having an adible group frequency, comprising, an oscillation circuit, and means for producing oscillations therein comprising a discharge circuit coupled with the oscillation circuit and including a condenser and a discharge gap, and means for supplying a pulsating feed current to the condenser, the capacity of the condenser and the break-down voltage of the gap being so proportioned that a plurality of discharges occur for each pulsation of the feed current and the envelop of the radiated power wave has substantially the same form and duration as the feed current pulsations, the feed current pulsations having such duration that the periods of gap activity are about equal to the periods of inactivity, whereby groups of wave trains are produced which will act efficiently on the telephones at the receiving station, substantially as described.

4. Apparatus for producing electrical oscillations having an audible group frequency, comprising, an oscillation circuit, and means for producing oscillations therein comprising a discharge circuit coupled with the oscillation circuit and including a condenser and a discharge gap, and an alternator for supplying an alternating feed current to the condenser, the capacity of the condenser and the break-down voltage of the gap being so proportioned that a sufficient number of condenser discharges occur for each alternation or half cycle of the feed current to produce a power wave in the oscillation circuit having an envelop of substantially the same shape as that of the alternating feed current, substantially as described.

5. Apparatus for producing electrical oscillations having an audible group frequency, comprising, an oscillation circuit, and means for producing oscillations therein comprising a discharge circuit coupled with the oscillation circuit and including a condenser and a discharge gap, an alternator for supplying an alternating current to the condenser, the capacity of the condenser and the break-down voltage of the gap being so proportioned that a plurality of condenser discharges occur for each alternation of the feed current and a power wave is generated having an envelop of substantially the same shape and duration as the feed current alternations or phases, the alternator having a peaked wave of such shape that the periods of gap activity are substantially equal to those of inactivity, substantially as described.

6. The method of producing electrical oscillations having an audible group frequency, comprising, charging a condenser with a pulsating current, discharging the con-

denser a plurality of times for each feed current pulsation, and causing the condenser discharges to produce trains of radiated waves or oscillations, the envelop of the power wave of each group of wave trains having approximately the shape and duration of the condenser charging current pulsations, substantially as described.

7. The method of producing electrical oscillations having an audible group frequency, comprising, charging a condenser with a pulsating current the wave shape of which increases to a maximum and then diminishes substantially to zero, discharging the condenser through a discharge circuit coupled with an oscillation circuit so as to produce a train of oscillations in the oscillation circuit for each condenser discharge, the discharge frequency of the condenser varying and increasing and decreasing according to the wave shape of the pulsation, whereby the power in the oscillation circuit increases to a maximum and then decreases to zero approximately the same as the feed current pulsation, substantially as described.

8. Apparatus for producing electrical oscillations having an audible group frequency, comprising an oscillation circuit, and means for producing oscillations therein comprising a discharge circuit including a condenser and a discharge gap, and means for supplying a pulsating feed current of an audible frequency to the condenser having its current pulsations separated by intervals of little, if any, current flow, said intervals being comparable in duration to the current pulsations, the capacity of the condenser and the break-down voltage of the gap being so proportioned that a plurality of condenser discharges occur for each pulsation of the feed current, said condenser discharges occurring in discrete groups separated by periods of substantially no gap activity, thereby causing the induced oscillations to be likewise divided into groups having an audible group frequency corresponding to the frequency of the feed current pulsations, substantially as described.

9. Apparatus for producing electrical oscillations, comprising an oscillation circuit, and means for producing oscillations therein comprising a discharge circuit including a condenser and a discharge gap, and an alternating current generator for supplying a feed current having peaks separated by periods of substantially no current activity, comparable in duration to the peaks of the current alternations, the capacity of the condenser and break-down voltage of the gap being so proportioned that a plurality of condenser discharges occur at each alternation of the feed current, said condenser discharges occurring in discrete groups corresponding to the peaks of the feed current and separated by periods of substantially no gap activity corresponding to the periods of substantially no feed current activity, substantially as described.

10. Apparatus for producing electrical oscillations, comprising an oscillation circuit, and means for producing oscillations therein, comprising a discharge circuit including a condenser and a discharge gap, and means for supplying to the condenser a pulsation feed current having its pulsations separated by intervals of little, if any, current flow, the duration of such current pulsations and intervals being of the same order of magnitude, the capacity of the condenser and the break-down voltage of the gap being so proportioned that a plurality of condenser discharges occur for each pulsation of the feed current, whereby the condenser discharges occur in discrete groups having substantially the duration of the feed current pulsations and separated by intervals having substantially the duration of the intervals of little, if any, feed current flow, substantially as described.

11. Apparatus for producing electrical oscillations having an audible group frequency, comprising an oscillation circuit and means for producing oscillations therein comprising a discharge circuit including a condenser and a discharge gap, and means for supplying to the condenser a pulsating feed current having its pulsations separated by periods in which the current flow, if any, is insufficient to cause any material activity at the discharge gap, the capacity of the condenser and break-down voltage of the gap being so proportioned with relation to the feed current that a plurality of condenser discharges occur for each pulsation of the feed current separated into discrete groups by periods of substantially no gap activity, substantially as described.

12. Apparatus for producing electrical oscillations, comprising an oscillation circuit, and means for producing oscillations therein comprising a discharge circuit including a condenser and a discharge gap, and means for supplying to the condenser a pulsating feed current of such a wave shape and of such strength with relation to the capacity and break-down voltage of the gap that a plurality of closely spaced condenser discharges occur at each wave peak forming groups separated by periods of substantially no gap activity between the wave peaks, substantially as described.

13. Apparatus for producing and radiating electrical oscillations having an audible group frequency, comprising a radiating circuit and means for producing oscillations therein including a circuit having a condenser and a discharge gap, and means for supplying to the condenser a pul-

sating feed current having its pulsations of such strength with relation to the capacity of the condenser and break-down voltage of the gap and occurring at such timed intervals that the condenser discharges form discrete groups of a plurality of condenser discharges each, separated by periods of substantially no gap activity, each group having a sufficient number of discharges to produce a clear tone in the telephones of a receiving station, substantially as described.

14. Apparatus for producing and radiating electrical oscillations having an audible group frequency, comprising a radiating circuit and means for producing oscillations therein, including a circuit having a condenser and a discharge gap, and an alternating current generator for supplying to the condenser an alternating feed current having such wave shape that the condenser discharges occur in discrete groups separated by periods of substantially no gap activity, the capacity of the condenser and the break-down voltage of the gap being so proportioned with relation to the feed current that a sufficient number of discharges occur for each alternation of the feed current to produce a clear tone of double the generator frequency in the telephones at a receiving station, substantially as described.

15. Apparatus for producing and radiating electrical current having an audible group frequency comprising an oscillation circuit and means for producing oscillations therein including a circuit having a condenser and a discharge gap, and means for supplying to the condenser a pulsating feed current of audible frequency having its current pulsations separated by intervals comparable in duration to the current pulsations during which intervals the current flow, if any, is insufficient to cause any material activity at the discharge gap, the capacity of the condenser and break-down voltage of the gap being so proportioned with relation to the feed current that a sufficient number of discharges per pulsation occur to produce a clear tone in the telephones at a receiving station, substantially as described.

16. The method of producing electrical oscillations, comprising charging a condenser with a pulsating feed current having its current pulsations separated by intervals of substantially no current flow comparable in duration to the current pulsations, and permitting the condenser to discharge a plurality of times during each pulsation of its feed current, whereby the condenser discharges occur in discrete groups corresponding to the feed current pulsations, the groups being separated by intervals corresponding to the intervals of substantially no feed current flow, substantially as described.

17. The method of producing electrical oscillations having an audible group frequency, comprising charging a condenser with a pulsating feed current having its pulsations recurring with an audible frequency and separated by intervals of substantially no current flow, such intervals being of approximately the same order of magnitude as the duration of the current pulsations, and permitting the condenser to discharge a plurality of times during each pulsation of its feed current whereby the condenser discharges occur in discrete groups corresponding to the feed current pulsations and separated from preceding and succeeding groups by inactive periods, substantially as described.

In testimony whereof, we have hereunto set our hands.

FULTON CUTTING.
BOWDEN WASHINGTON.

Witnesses:
M. E. REID,
F. E. DANIELS.