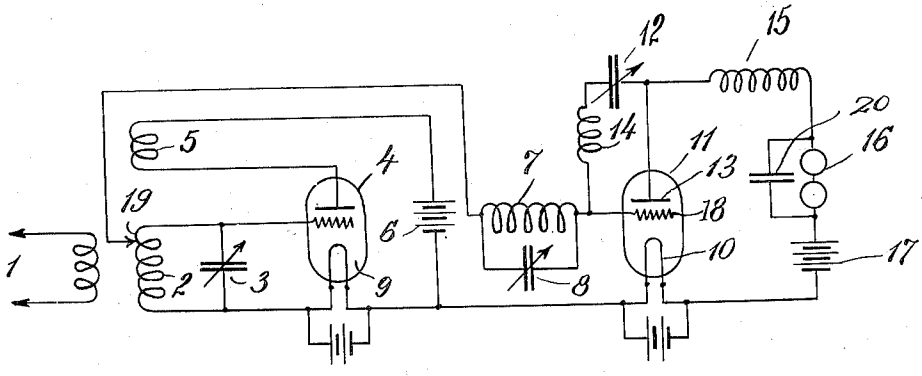
June 16, 1925. 1,541,780

E. H. ARMSTRONG

WAVE SIGNALING SYSTEM

Filed June 8, 1922



Edwin H. Armstrong INVENTOR

BY

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UNITED STATES PATENT OFFICE.

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WAVE SIGNALING SYSTEM.

Application filed June 8, 1922. Serial No. 566,681.

To all whom it may concern:

Be it known that I, EDWIN H. ARMSTRONG, residing at 1032 Warburton Avenue, Yonkers, in the county of Westchester, State of New York, have invented certain new and useful Improvements in Wave Signaling Systems; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

This invention relates to an electric regenerative system for amplifying varying electric currents, particularly radio or other high frequency signaling currents, wherein the varying potential of the current to be amplified is impressed on the system and the relation between the amount of regeneration and the degree of damping of the system is periodically varied to produce transient free oscillations proportional to the amplitude of the impressed potential and wherein the resulting free oscillations and the system are continuously maintained in this transient ordinarily unstable state to obtain super-regenerative amplification or action as described in my Patent 1,424,065 granted July 25, 1922, on a co-pending application, Serial No. 480,563 filed June 27, 1921.

The invention has for its particular object the provision of a form of circuit arrangement capable of producing super-regeneration whereby high amplifications may be obtained without introducing irregularities in operation resulting in distortion. To this end a regenerative system of any of the known forms may be used in conjunction with a specific form of oscillating feed-back circuit employing a vacuum tube in which the tuned grid circuit is maintained in the oscillating state by local energy supplied thru a small condenser connected between the grid and plate of the tube. This condenser may be the sole means for feeding back energy in the circuit. The feed-back oscillating circuit is adapted to supply an auxiliary frequency to the system which frequency may be low as compared to the frequency of the current to be amplified, and the circuit should be so associated with the high frequency regenerative amplifying system as to continuously and periodically vary the relation between the amount of regeneration and the degree of damping of the system, as described in my co-pending application mentioned above. This variation is accomplished in accordance with the present invention by the continuous periodic variation of the degree of damping, that is, the rate of dissipation of the energy of the system, with respect to the amount of regeneration, that is, the regenerative energy supplied to the circuit (the so-called negative resistance).

The particular form of circuit arrangement illustrated in the drawings is the preferred embodiment of the invention. It possesses marked advantages in enabling adjustment of the strength of the auxiliary frequency and the amount of regeneration to a point where extremely high amplification may be obtained without introducing irregularities in the operation of the system resulting in distortion, particularly when employed for the reception of radio telephone signals and other signals of like character.

Referring now to the drawing, the source 1, of the varying current to be amplified is associated with and is adapted to impress the varying potential of the current to be amplified, on a regenerative system, in this case, a feed-back circuit comprising the grid circuit 2, 3 of the vacuum tube 4 and the feed-back coil 5 in the plate circuit of the tube 4. There is also included in the plate circuit of the tube 4 a battery 6 adapted to supply energy to the system in the well known manner.

Associated with the regenerative system above referred to and effectively connected across the tuned circuit 2, 3 of the tube 4 is a second vacuum tube 11. The grid circuit of the tube 11 includes the tuned circuit 7, 8 and the grid circuit of the vacuum tube 4, the oscillating system including the tube 11, and the regenerative system including the tube 4, being associated by a direct connection between the filaments 9, 10 and a variable contact 19 on the inductance 2. It will, therefore, be understood that the degree of damping of the regenerative system is varied by the auxiliary frequency produced by the tube 11, which frequency in turn is controlled by the tuning of the circuit 7, 8. As pointed out above, the circuit 7, 8 is tuned and adjusted to the

desired auxiliary frequency at which the relation between the amount of regeneration and the degree of damping of the regenerative system is desired to be continuously and periodically varied to produce super-regenerative amplification. In this case the tube 11, producing the auxiliary frequency serves to vary the degree of damping of the system with respect to the amount of regeneration; the amount of regeneration being capable of being adjusted to some fixed value in a known manner, for example, by variation of the amount of coupling between the coil 5 and the inductance 2.

The feed-back oscillating circuit including the tube 11, contains the condenser 12, connected between the grid 18 and the plate 13, and serves as a ready means for controlling the amount of feed-back and the oscillating condition of the circuit. The oscillating circuit also includes the plate inductance 15 and the small inductance 14, which acts as a choke for incoming signals and which also prevents an alteration of capacity produced by the variation of condenser 12 from effecting the tuning of the circuit 2, 3.

The vacuum tube 4 acts as a generator delivering currents of a frequency determined by the tuning of the circuit 2—3. Energy, for maintaining this oscillation, is supplied inductively by the coil 5 acting upon the coil 2 in the usual way. The tube 11 generates currents, the frequency of which is determined by the tuning of the circuit 7—8. The plate circuit of this tube includes the inductance 15 and the telephone 16 as well as the battery 17. Fluctuations upon the grid 18 cause corresponding fluctuations in the current in the plate circuit with a consequent change in voltage at the junction of the inductance 15 and the condenser 12. The changes in voltage upon the condenser 12 thus serves to impress energy upon the oscillating circuit 7—8 and, in this way, maintain the tube 11 in oscillation. The impedance of the connection 12—14 is regulated by adjusting the condenser 12. The quantity of energy fed to the circuit 7—8 is thus adjusted.

Each time that the grid 18 becomes positive (because of the alternating potential of the point in the circuit 7—8 to which the grid is connected) a conductive connection is established from the tap 19 through the condenser 8 and the space-current path 18—10 to the other side of the circuit 2—3. This connection is, in effect, a shunt between the grid and filament in tube 4. It thus affords an outlet for the energy of the oscillations in the circuit 2—3 and so increases the damping of said oscillations.

Each time the grid 18 becomes negative the shunt ceases to be conducting and the oscillations in circuit 2—3 build up to a maximum determined by the strength of the received signal. Negative potential of the grid means that the tube is working at the lower curved part of its characteristic curve. At the curved part of the characteristic, the tube has a detector action.

The oscillations of the circuit 2—3 cause changes in the negative potential of the grid 18 and the detector action of the tube 11 causes corresponding pulsations in the plate circuit including the telephone 16. During any one group of pulsations, a charge is built up on the condenser 20. During the space between two groups, the charge passes through the telephone 16. Group frequency being above audio frequency, these discharges through the telephone do not produce an audible sound. The degree to which the condenser 20 becomes charged depends on the amplitude of the pulsations. This amplitude varies at audio frequency. The discharges through the telephone, therefore, are modulated at audio frequency and this modulation is perceived as an audible signal.

It is to be understood that the present invention is adapted to receive radio signals, including radio telephone signals, when associated with an antenna, loop or other energy collecting device and to receive wired wireless signals (so-called wire carrier current transmission) when associated with the conductors of such signals. It should also be understood that modifications may be made in the specific circuit connections above described without departing from the spirit and scope of the invention.

I claim:

1. An electric regenerative system adapted to produce super-regenerative action, including a feed-back circuit having a certain degree of damping and means for periodically varying the relation between the amount of feed-back and the degree of damping of the system comprising a generator of electrical oscillations adapted to supply an auxiliary frequency to the regenerative system and a capacity in said generator for controlling and maintaining the oscillations in said oscillating system.

2. An electric regenerative system adapted to produce super-regenerative action, including a feed-back circuit having a certain degree of damping and means for periodically varying the relation between the amount of feed-back and the degree of damping of the system comprising a feed-back oscillating circuit having grid and plate elements and a variable capacity connected between said elements, said capacity being adapted to control and maintain the oscillations in said oscillating system.

3. Apparatus for amplifying varying electric currents comprising a feed-back circuit including a vacuum tube having a cer-

tain degree of damping and means for periodically altering the relation beween the amount of feed-back action and the degree of damping of the system whereby super-regenerative action is obtained, said means comprising a feed-back oscillating circuit including a vacuum tube having grid and plate elements and a variable capacity connecting said elements, said capacity being adapted to control and maintain the oscillations in said oscillating system.

4. An electric regenerative system adapted to produce super-regenerative action comprising a feed-back circuit having a certain degree of damping and including a vacuum tube having grid, filament and plate elements, a tuned circuit connected between said grid and filament elements and a feed-back coil connected between said plate and filament elements and associated with said tuned circuit, a second feed-back circuit adapted to be continuously maintained in the oscillating condition connected between the filament and grid of said first feed-back circuit for supplying an auxiliary frequency to the sysem to periodically vary the damping of the system with respect to the amount of regeneration, said second feed-back circuit including a second vacuum tube having grid and plate elements and a condenser connecting said elements, said condenser being adapted to control and maintain the oscillations in said feed-back oscillating system.

In testimony whereof I affix my signature.

EDWIN H. ARMSTRONG.