

UNITED STATES PATENT OFFICE

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SIGNALING SYSTEM

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This invention relates to signaling systems and particularly to signal transmission for telephone systems.

An object of the invention is to improve the efficiency and decrease the cost of signal transmitting systems employing signal currents within the voice frequency range.

Heretofore, impulses consisting of damped trains of oscillations have been employed as signals. Such trains of oscillations were generated by alternately connecting direct current battery to and disconnecting it from a tuned circuit including inductance and capacity.

A feature of this invention is a system comprising two differently tuned circuits of this type having different damping characteristics and so coupled that the output waves or trains of oscillations of one circuit having the desired frequency are sustained for the required interval by the other circuit which has a lower damping factor. Signals may be produced in this manner having such fundamental duration, amplitude characteristics and frequency as to make them suitable for transmission as dialing impulses to control automatic switches or as supervisory signals over long lines.

Another feature is a circuit arrangement in which the signals are automatically varied in duration and in rate of transmission.

Another feature is an arrangement whereby the duration of the signals is changed with the rate of transmission, that is, each rate of transmission corresponds to a certain duration period of the individual signals transmitted at said rate.

The invention has been illustrated in the accompanying drawing in which two tuned circuits are arranged to be controlled by a dial or a low frequency source, for production of dial pulses or supervisory impulses respectively.

The dial 1 is arranged with its contacts in a circuit including the winding of relay 2 and resistance 3 connected to a source of direct current. A relay 5 is provided to change this circuit to exclude the dial contacts and include connections to ground and alternating current source 6. The first tuned

circuit which comprises a capacity 7 and inductance 8 extends through the armature and front contact of relay 2. This tuned circuit is coupled through the condensers 9 and 10 to the second tuned circuit. The second tuned circuit comprises a capacity 11 and inductance 12, and a non-inductive resistance 13 and is coupled through the resistance 14 and primary windings of the transformer 16 to the output circuit 17. Relay 5 besides controlling the impulsing means normally shunts, through its lower armature and back contact, the non-inductive resistance 13 in the second tuned circuit and when actuated includes this resistance in the second tuned circuit and shunts the condenser 10 in the coupling between the first and second tuned circuit.

It is now assumed that impulses are to be produced by the operation of dial 1 for transmission over the output circuit 17 as dialing impulses. The first tuned circuit which is employed as the source of the signals or trains of oscillations is normally connected with the direct current path from battery through resistance 4, armature and back contact of relay 2, capacity 7 to ground. A charge is therefore normally maintained on the condenser 7. When the dial is operated a circuit is completed each time the pulse contacts are opened for the operation of relay 2 over a circuit from battery, resistance 3, upper outer armature and back contact of relay 5, winding of relay 2, upper inner armature and back contact of relay 5, off-normal contacts of dial 1 to ground. Consequently relay 2 follows the pulsing of the dial.

It should now be observed that each time relay 2 is operated the condenser 7 will discharge through the first tuned circuit by the closing of this circuit through the armature and front contact of relay 2. A series of damped waves or a train of oscillations is thereby set up in this circuit. The damping factor of this circuit is determined by the characteristics of the elements 7 and 8 and in this arrangement it may be assumed for the sake of illustration that these characteristics are such that a train of oscillations

having a frequency of 500 cycles per second is produced in the circuit. These oscillations are effective to produce oscillations in the second tuned circuit through the coupling condensers 9 and 10 by the alternate charging and discharging thereof into the second circuit. Signals produced in the second circuit are transmitted through repeating coil 16 to the output circuit 17.

It is a well known phenomenon that two oscillatory circuits will produce a fundamental frequency and component frequencies and that the component frequencies may be both of a higher and a lower frequency than the fundamental frequency. If now as in this case, a second tuned circuit is coupled to a first tuned circuit it is evident that this second circuit can be made to oscillate at a fundamental frequency which may be of the same frequency as that of a component frequency of the first circuit, for example a component frequency that is higher than the fundamental frequency of the first circuit. To accomplish a result of this nature the characteristics of the elements 11 and 12 in the second circuit have been made, or may be made for the sake of illustration, such that the produced trains of oscillations have a frequency of approximately 1000 cycles per second. In other words, this second circuit will produce a fundamental frequency corresponding to a higher component or the second higher harmonic of the fundamental frequency of the first circuit. It should be understood that 500 cycles per second as a fundamental frequency for the first circuit and 1000 cycles per second as a fundamental frequency for the second circuit have been merely arbitrarily mentioned for the sake of illustration and because currents of 1000 cycles per second frequency are particularly suitable as signaling currents in telephone circuits. It should, however, be understood that this invention is not primarily concerned with the exact value of the frequencies in these two circuits but rather with the employment of tuned circuits of the character that may produce an output frequency suitable for dialing and signaling in telephone systems. For further reference in regard to the principles involved in coupled circuits of this nature, reference may be had to the patents to Stone No. 726,368 of April 28, 1903, and 726,476 of April 28, 1903.

Another reason for employing two tuned circuits of the character described to secure signals having the desired frequencies is to produce signals that at the same time are of such duration, strength and amplitude characteristics as to make them desirable for signaling purposes as will hereinafter be described.

Relating to the length or duration of each train of oscillations in a tuned circuit, it is well known in the art that this depends on

the degree of damping in such a circuit. It is also well known in the art that with commercial apparatus employed in circuits of the type shown in the drawing for the generation of trains of damped oscillations, the damping factor is relatively high. It is also well known that the damping factor controls the total number of oscillations in any one train. It is apparent therefore that each train will be of a longer duration when the generated frequency is low than it would be when the generated frequency is high. Therefore, in order to secure oscillations in the output circuit 17 that are sufficiently sustained to serve as signals, the first circuit is damped as low as can be obtained practically and tuned to resonate at a lower frequency than the frequency desired for the output signals. In the example cited, 500 cycles per second has been arbitrarily mentioned for the sake of illustration as the fundamental frequency for the first circuit, whereas 1000 cycles per second has been considered as the desirable output signal frequency for the second circuit.

Having obtained long sustained trains of oscillations in the first circuit, the output signals of the desired frequency in the second circuit may be sustained for an even longer period of time, by making the coupling between the two circuits rather loose, that is, the condensers 9 and 10 of small capacity, permitting a lower degree of damping to be maintained in the second circuit than in the first.

Relating to the securing of output signals of the proper amplitude, it is desirable to further adjust the values of the tuning elements, condensers 7 and inductance 8 of the first circuit and the energy supply therefor through resistance 4, so that the effective voltage variations in the second circuit are such as to produce trains of oscillations of the desired amplitude. In other words, the capacity of condenser 7 is comparatively large and the resistance of the inductance element 8 comparatively small. With this arrangement the high amplitude of the fundamental frequency of the first circuit will naturally tend to produce oscillations in the second circuit of considerable amplitude even though the coupling between the circuits is rather low.

However, the trains of oscillations produced in the above manner in the first circuit are likely to have the effect that the first few waves will have an amplitude beyond that acceptable for the desired signal. The loose coupling on the other hand prevents these peaks from affecting the second circuit. That is, the capacity of the coupling condensers is such that the energy of the first few oscillations of the fundamental frequency of the first circuit will not be fully effective to produce oscillations of an objectionable amplitude in the second circuit, while the amplitude of the succeeding oscillations in the

first circuit will become more fully effective as the capacity of the condensers 9 and 10 is adequate in this respect. Hence, the train of oscillations produced by the second circuit will have more gradually decreasing amplitudes than the waves in the first circuit and thereby make them more suitable for output signals.

When, therefore, these circuits are operated through dial 1, output signals are produced at 17 having duration and amplitude characteristics particularly suitable for dialing impulses for use in automatic telephone systems. It should be understood that these impulses are sustained and are of such an amplitude that they will be effective for the desired period of signaling even though the amplitude is gradually decreasing towards the end of this period. The effective period should also be so proportioned in this respect that when it comes to an end the impulses will have decreased in amplitude to such an extent that they will cease to have any further effect on the apparatus that they are intended to control. If the impulses are so controlled they will provide sharply defined operating impulses equivalent to alternating current impulses or direct current impulses.

This system is also arranged for the transmission of signals that may be used, for example, as supervisory signals in telephone systems. Signals of this type may, of course, be sent out at a faster rate than dial impulses but be of the same general character, that is, the impulses may decrease in amplitude more rapidly and hence be shorter in duration as far as their effectiveness is concerned.

For this purpose the non-inductive resistance 13 is inserted in the second circuit and one of the coupling condensers, condenser 10, is short-circuited under control of relay 5. As the length of the trains of oscillations in the second circuit depend on damping effects and damping may be increased by increasing the resistance in this circuit, it follows that by allowing resistance 13 to remain in the second circuit, more sharply damped output signals will be produced, to wit, signals of a shorter duration. It also follows that by short-circuiting condenser 10 the second circuit will assume more nearly the damping characteristics of the first circuit. Therefore the trains of oscillations will have a still shorter duration.

When supervisory signals are to be transmitted relay 5 is operated in any suitable manner. This causes the resistance 13 to be inserted in the second circuit through the opening of the short circuit through the lower armature and back contact of relay 5 and, due to the closing of the connection through the lower armature and front contact, condenser 10 is short-circuited. The connections for controlling the relay 2 by the dial 1 are also opened at the upper armature and

back contact of relay 5, and a connection to ground and to the alternating current source 6 are established for the control of relay 2.

Relay 2 is polarized and the alternating current source 6 may be of such character as to produce alternating current impulses having a frequency of, for example, 20 cycles per second, which is generally adopted as the rate at which supervisory signals are transmitted. Hence, relay 2 will now be alternately operated and released 20 times per second by current from source 6 through the outer upper armature and front contact of relay 5, winding of relay 2, inner upper armature and front contact of relay 5 to ground. Output signals at this rate are now therefore produced in the same manner as when the dial is operated as hereinbefore described, except that due to the short-circuiting of the condenser 10 and the insertion of resistance 13 these signals will be shorter in duration and of a lower initial amplitude. The duration and the effective amplitude will be such as to make these signals suitable for supervisory purposes.

When, therefore, the system chosen to illustrate this invention is used to transmit dialing impulses, such impulses are produced to bear a certain relation in duration and amplitude to the rate at which the dial is operated, whereas when the system is used to produce supervisory impulses said impulses bear a certain other relation in regard to the duration and amplitude to the rate at which they are transmitted. When the rate of transmission is low, the signals are effective for longer periods than when the rate of transmission is high.

It should be understood that while the invention has been illustrated in connection with a given circuit arrangement, it is readily adaptable to other systems without departure from the spirit thereof and that the invention should only be limited by the scope of the appended claims.

What is claimed is:

1. In a signaling system a circuit tuned to a given frequency of oscillation, a second circuit tuned to a different frequency of oscillation, means for coupling said circuits, energizing means, means for applying said energizing means to said first circuit at a plurality of different rates to produce corresponding trains of oscillations in the second circuit, means to determine the rate at which said energizing means is applied to said first circuit, and means controlled by said determining means for changing the damping characteristics of said second circuit.

2. In a signaling system a circuit tuned to a given frequency of oscillation, a second circuit tuned to a different frequency of oscillation, means for coupling said circuits, energizing means, means for applying said energizing means to said first circuit at a plu-

ality of different rates to produce corresponding trains of oscillations in the second circuit, means to determine the rate at which said energizing means is applied to said first circuit, and a resistance controlled by said determining means for changing the damping characteristics of said second circuit.

3. A signaling system comprising two tuned circuits, a source of current, means for associating said source with one of said circuits periodically at different rates of occurrence to produce in said circuit trains of oscillations, coupling means between said circuits to produce trains of oscillations in the second circuit in response to trains of oscillations in the first circuit, and means controlled by said first mentioned means for changing the damping characteristics in the second circuit for the trains of oscillations produced thereby.

4. A signaling system comprising two tuned circuits, a source of current, means for associating said source with one of said circuits periodically at different rates of occurrence to produce in said circuit trains of oscillations, coupling means between said circuits to produce trains of oscillations in the second circuit in response to trains of oscillations in the first circuit, means for changing the damping characteristics in the second circuit for the trains of oscillations produced thereby so that the damping characteristics at any certain time bear a certain relation to the rate at which trains of oscillations are produced in the first circuit at that time.

5. A signaling system comprising a tuned circuit for producing trains of oscillations of comparatively high amplitude, another tuned circuit for producing trains of oscillations of similar amplitude but of a higher frequency, a source of current, means for associating said source with the first mentioned circuit periodically to produce in said circuit trains of oscillations of said high amplitude and at different rates of occurrence, coupling means between said circuits to produce trains of oscillations in the second circuit in response to trains of oscillations in the first circuit, said coupling means being comparatively loose so that the first few oscillations of each train of the first circuit cannot be fully effective in the production of trains of oscillations in the second circuit in regard to amplitude, and means for sustaining said trains of oscillations in said second circuit for a longer period than the trains of oscillations in the first circuit and for regulating said period to bear a certain relation to the rate at which the trains of oscillations are produced in the first circuit.

6. In a system for producing and transmitting trains of oscillations, the method comprising producing said trains of oscillations in two stages, increasing the rate of transmit-

ting the trains of oscillations in the first stage, and simultaneously increasing the damping of said trains of oscillations in the second stage.

In witness whereof, I hereunto subscribe my name this 3rd day of November 1928.

PAUL B. MURPHY.

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