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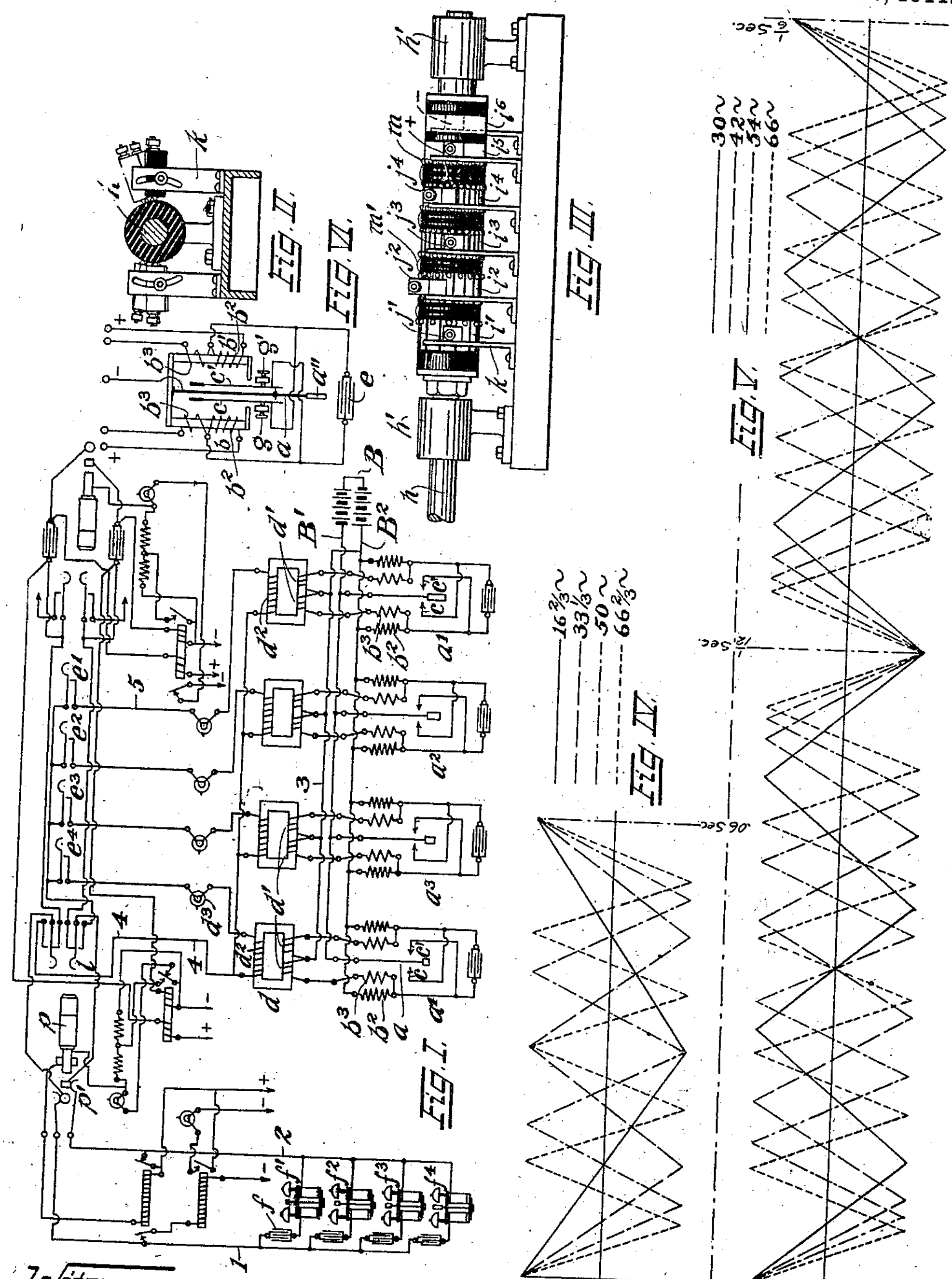
SELECTIVE TELEPHONE SIGNALING SYSTEM.

APPLICATION FILED OCT. 11, 1907.

1,008,282.

Patented Nov. 7, 1911.



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UNITED STATES PATENT OFFICE.

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SELECTIVE TELEPHONE SIGNALING SYSTEM.

1,008,282. Specification of Letters Patent. **Patented Nov. 7, 1911.**

Application filed October 11, 1907. Serial No. 396,933.

To all whom it may concern:

Be it known that I, CHARLES H. NORTH, a citizen of the United States of America, and a resident of Cleveland, in the county of Cuyahoga and State of Ohio, have invented certain new and useful Improvements in Selective Telephone Signaling Systems, of which the following is a specification.

My invention relates to a selective telephone-signaling system, affording for telephone exchanges an improved method of selective signaling, and has for its object the modification of selective signaling methods of the prior art, which shall be an advance in efficiency and eliminate false signals.

More particularly, my invention is applicable to telephone systems, wherein selective calling or signaling of a plurality of subscribers upon a given line is required, and my invention has been perfected with this single end in view, whereby signaling currents are impressed upon the line alternatively, which shall avoid the more or less active tendency observed in previous signaling systems to actuate two or more of the selective calling appliances.

Until a comparatively recent date, it has been deemed commercially practicable to actuate signaling systems known as "harmonic-ringing" systems, by means only of generator currents, which are respectively in step or tune with the signaling appliances used upon the multiple party lines. These currents, by reason of the fact that a single generator outfit was almost universally used in practice, operating at a substantially fixed rate of speed, presented in frequency of alternations, multiples of 2, 4, 6 and 8, corresponding to the respective brushes of the dynamo. In consequence, there existed a coincidence in the electro-magnetic impulses, which constantly tended to interfere with the successful working of the system, and produced false signals, particularly for any extended or intermittent period of signaling or ringing. Prior to my application of the principles of non-coinciding currents to selective signaling, I believe that the undesirable feature just alluded to, had never been theoretically or practically overcome.

Although I do not deem my invention restricted to particular apparatus, it may most readily be practiced by the employment of interrupters having definite rates of speed, in association with a source of direct current, but commutator devices, one of which I shall briefly advert to, may also be resorted to for practicing my invention, as herein described and claimed.

Before explaining the means for practicing my invention, I may state, in a preliminary way, that the system of telephone signaling herein set forth, is one wherein the signaling currents adapted to be impressed upon the party line, are of such frequencies that they are non-coinciding in effect upon the several translating devices or ringers. In the simple four-party line system, set forth for the exemplification of my improvement, the current frequencies are multiples of 5, 7, 9 and 11, whose respective effects, I shall best be able to explain in connection with diagrammatic representations plotted to indicate the different currents throughout their periods of non-coincidence, and compare them with a diagram similarly plotted to represent the commercial four-party signaling currents known to the prior art.

In said drawings, Figure I, represents a telephone system equipped with interrupters and signaling bells assumed to be respectively tuned in accordance with my improvement. Fig. II is a cross-sectional view of a commutator device; and Fig. III is a view in side elevation of said multiple commutator, which represents other means for applying non-coinciding currents to a telephone signaling system. Fig. IV is a diagrammatic representation of the electro-magnetic effect of the four partially coinciding signaling currents of the prior art, and Fig. V is a similar diagram of the electro-magnetic effect of the four non-coinciding signaling currents, preferably employed in practicing my invention. It should be explained, that in the latter diagrams, I have not attempted to reproduce the theoretical sine-wave, which the signaling currents approach, but I have employed straight lines meeting at angles instead of such curves, for making more apparent the "peak", or effective magnetic variation of the respective alternating currents of different frequencies. These same diagrams may be taken, as well to indicate the respective relations between the preferred alternating currents employed in practicing my invention, but this specification may be made a little more direct and clear, by alluding to the diagrams as representative of the magnetic effect and relations resultant from said currents. Fig. VI is an enlarged detailed diagram of an interrupter-device.

Throughout the several figures of the drawings, I have employed the same character of reference to indicate similar parts, or corresponding diagrammatic representations.

As stated, the alternating currents for selective singnaling, may be arbitrarily varied, so long as substantially the non-harmonic or discord relation exists between the respective currents. Thus, for five-party selection, the cycles per second may best range between 30 and 78, being multiples of the odd numbers from 5 to 13 inclusive.

Fig. I representing the preferred means for practicing my invention, will be explained in more detail as it embodies novel features in addition to those herein claimed. In said figure are shown four sets of interrupters, which are so adjusted with respect to each other as to impress alternating currents when respectively connected to line, which have frequencies representing substantially the multiples of five, seven, nine and eleven; these four being the simplest combination for practically operating selective signaling systems. In this instance, we may further assume that the common multiple is six, which I have found most desirable for practical purposes. Accordingly, the respective interrupters a', a^2, a^3 and a^4 will be so constructed and justified as respectively to impress upon the line alternating currents of thirty, forty-two, fifty-four and sixty-six alternations per second.

Explaining first the structural features of the interrupter, it will be seen that the vibrating member or reed a, equipped with a variable weight a'', is designed, under the influence of laterally positioned electro-magnates bb', alternatively to engage the contact springs c c' thereof. These electro-magnets each comprise a high and low resistance coil b^2 b^3, shunting each other and terminating respectively in the contact spring c c'.

In the preferred embodiment of my invention, the source of current, as battery B, has one of its poles connected directly with the tongue or vibrating member a of the interrupter, while the other pole of the battery is connected directly with the high resistance shunt coils b^2, and preferably through the windings d' d' of a converter d, with the low resistance coils b^3, in series with said windings. It will be understood, however, that the series windings may be connected instead, directly to any suitable translating device or switch mechanism without the intermediation of the converter.

The respective windings upon the electro-magnets b b' are cumulative in effect, and their respective excitations generate poles of like sign in each of the magnet cores. The reed or tongue a preferably is of steel and is polarized, more readily to respond to the excitation of the magnet coils. Bridged about the contact springs c c' and their respective associated windings b^2 b^3 is the condenser e.

As shown in the diagram, Fig. I, the secondary d^2 of each converter d, is connected through a resistance lamp d^3 with the corresponding contacts e', e^2, e^3, e^4 of an operator's selective key, controlling the flow of current to the calling plug p of the cord circuit, which is shown inserted in the pack p' of a four-party selective telephone line. Each station upon said line, connected between conductors 1, 2, is designated by a signaling bell f', f^2, f^3, f^4 with its associated condenser f; the ordinary sub-station apparatus being omitted as unnecessary. Moreover, the customary cord circuit and line signaling apparatus is conventionally indicated in the diagram, sufficiently to illustrate the principal application of the invention, but I do not consider that these features require explanation herein.

Each of the interrupters a', a^2, a^3, a^4 is connected in circuit precisely as explained above, employing converters d whereby to transmit current to the signaling circuit, but the reeds or vibrating member of said interrupters and their weights, are respectively made stiffer and lighter for the high frequencies, and more flexible and heavier for the low frequencies. Practically any desired number of these adjusted interrupters may be employed. With respect to the windings upon the electro-magnets b b' of these interrupters, the series coils, are provided with more turns upon the high frequency interrupters than upon the low, while the co-acting shunt coils are provided with fewer turns upon the coils of the high frequency interrupters, than upon the corresponding windings of the low frequency interrupters. Preferably this is found to be desirable in practice, for the reason that with the stiffer reeds and higher rates of vibration, more work must be done by the high frequency electro-magnets, and as an example of approximately the preferred number of turns for a four-party line employing twenty-four volts on the primaries, I may say that the highest frequency interrupter will have 100 turns upon its series coil, and 6500 turns upon the shunt coil, while the lowest frequency interrupter will have 40 turns upon the series coil, and 12,500 turns upon its shunt coil; the windings upon the other interrupters being intermediate of these two. I have preferably wound the secondaries to generate 160 volts in the signaling circuit, and this I find is transmitted with relatively small drop in voltage, even to the most distant stations. This is because of the fact that the series coils are energized by the full flow of current and impart a more powerful vibratory movement to the contact member a, thereby insuring a longer closure of the respective magnet circuits, tending to secure approximate magnetic saturation of the iron body of the converter, and thereby transmitting the maximum voltage from the secondary winding. This operation probably will be better understood by making further reference to the diagram, Fig. I, and assuming that one of the stations is to be rung, as station f'. Assuming too, that the line has been tested, and the calling plug p inserted in the proper jack, the operator will actuate her selective key, closing together the contact e'. All of the interrupters are in operation under the impulse of their respective shunt windings, but immediately upon the closure of the contacts e', the impedence of the converter connected with interrupter a' will at once be reduced, thereby permitting the flow of exciting current through the divided primary windings d'. Current may be traced from the upper pole of the battery, through the common conductor to the vibrating member a, contact c, series winding b^2, the right hand portion of the primary winding d', and conductor 3 to the lower pole of the battery. The vibratory member is augmented in its motion and is actuated by the series winding out of engagement with contact c and into engagement with contact c', thereby opening circuit with contact c and its connected windings, and closing the circuit with contact c' and the connected windings upon the left. Current then flows through windings b^3 thereof, and the left hand coil of the primary winding d' upon the converter. This, as will be well understood, causes alternating currents of the required frequency to flow through the circuit closed by the plug and contacts e'; said circuit being traced from the left hand side of the secondary d^2 through conductor 4, the contacts of the operator's key l to the tip of the plug, conductor 1, through the bell f', conductor 2, the sleeve of the plug, the contacts of the operator's key, and contacts e' (assumed to be closed), and conductor 5 to the right hand side of the secondary windings. The bell f', will, of course, respond to this current of proper frequency, while the remaining bells upon the line circuit will fail to be actuated, as will be well understood by those conversant with the art.

In practice, each of the interrupters, upon installation is connected in circuit as shown. The adjusting screws g g', are separated to such an extent that neither of the contact springs c c' is in engagement with the vibratory member a. One of these screws as g is then turned until the contact spring c is brought into engagement with the contact of the vibratory member, whereupon it will start under the impulse of but a single magnet. This screw is then turned back slightly, say to the extent of one quarter turn, and the opposing screw g' is then turned until the contact c' similarly is brought into engagement with the contact of the vibrating member, whereupon this screw is also set in its adjusted position and the interrupter device will continue normally under the impulse of its shunt windings. It will be seen, however, that with a slight bias, the vibrating member may be actuated by a single electromagnet, but preferably I employ the arrangement herein set forth. The mechanical features thereof are explained at greater length and claimed in the application of John F. Engle, filed June 12th, 1907, Serial No. 378,549.

Instead of the interrupters, I may employ, but do not ordinarily recommend the use of the commutating device, such as shown in Figs. II and III. Any suitable source of direct current may be assumed to be connected between the main brushes + and — with which the remaining commutator segments are connected. Shaft h of said device, moreover, is assumed to be driven by a suitable source of power, at a substantially constant speed; together with the multiple rotary commutators i'—i^6, being supported between the bearings h' h'. The respective sets of brushes j' j^4, engage the commutator segments, and the same are individually adjustable within the slotted arcs provided in their supporting standards k. From these brushes, the respective alternating currents are taken off in lieu of the several transformer currents of Fig. I, to which they may correspond in non-harmonic relation. The several commutators j'—j^4 are respectively provided with an increasing number of segments, which are so coupled or connected together between their terminals m by cross wires m' disposed therebetween, as to secure substantially non-harmonic relation between the respective alternating currents. This relation is also adjustable or alterable in large measure by moving the respective brushes within their arced paths. The relative number of cycles per second, will, of course, be dependent upon the speed at which the multiple commutator device is rotated, and since substantially constant speed is required, I do not recommend or rely upon the mechanical features just above explained in practicing my invention. Commutators or rotary contacts i^5 i^6, are merely slip-rings engaging the main brushes, and are suitably connected up with the multiple commutator contacts.

In order to present my invention graphically and more clearly, I have plotted the diagrams of Figs. IV and V, the former of which is representative of the standard four-party frequencies of $16\frac{2}{3}$, $33\frac{1}{3}$, 50 and $66\frac{2}{3}$ cycles per second. The latter is representative of the current frequencies, preferably employed in practicing my invention. It will be appreciated, that as between the frequencies of $33\frac{1}{3}$ and 50 cycles per second, there exists the relation of a musical fifth, while between all of these current-cycles, excepting only the third, or 50, there exists the octave relation, hence the propriety of terming the systems of the art "harmonic signaling systems". The most casual comparison of these two figures, IV and V, demonstrates the vast superiority of the non-harmonic currents for selective signaling. Fig. IV, shows the coincidence of the four harmonic alternating currents, which occurs each .06 of a second, as opposed to the non-harmonic currents which coincide only six times each second, above the zero line. By reason of the necessary coincidence of the harmonic currents, false signals are constantly liable to occur, particularly as between the currents having respectively $16\frac{2}{3}$ and 50 cycles per second, which are in coincidence during two-thirds of the time. Another frequently observed source of interferences, is the coincidence likely to occur when the armatures of the bells, responsive to currents having $33\frac{1}{3}$ cycles per second, are slightly off center, thereby materially emphasizing the disturbing coincidence during half of the swing of said armature. More than this, bells responsive to the lowest frequency, are open to the serious objection of being responsive to currents transmitted by the ordinary hand generator, frequently employed upon party lines.

When frequencies of substantially 30 cycles per second, or higher, are employed, however, it is impossible to ring any of the selective bells by means of a hand generator, for the reason that it is impossible to turn the generator fast enough manually. It will be observed, that in the preferred frequencies, employed in practicing my invention, the lowest frequency corresponds approximately with the second frequency employed in the prior art, and the objection last alluded to, is at once eliminated. Considering Fig. V, it is seen that the magnetic effects of these currents are non-coinciding above the zero line, throughout the relatively long period of one-sixth of a second, and because of the diversity of these current effects, false signals are rendered impossible with the use of non-harmonic currents. To recapitulate, in comparison of these preferred methods of selective signaling, it will be noted as stated above that the frequencies employed in the non-harmonic system bear the relation of discords to each other, whereas the frequencies employed in the harmonic system bear, as the name would indicate, the relation of harmonics to each other. For example, reduced to their lowest terms it will be observed that the non-harmonic frequencies bear the relation to each other of 5, 7, 9, and 11, while the harmonic frequencies bear the relation to each other of 1, 2, 3, and 4.

One of the chief difficulties encountered in the operation of the harmonic system has been due to the liability to cross ring. This tendency has been particularly noticeable between the $16\frac{2}{3}$ cycle and the 50 cycle ringers, although the other frequencies have not been entirely free from the same character of trouble. Upon analyzing the waves of the various cycles or frequencies the reason for this interference is quite obvious. The laws governing the vibration of non-harmonic and harmonic ringers, vibrators or pole changers are the same as those governing the vibration of musical reeds or springs. It is well known that if a reed of any pitch or frequency is vibrated, all other reeds in close proximity to it, or which are subjected to the same force which actuates the reed in question, and which are either in synchronism or harmony with the reed vibrated are also caused to vibrate. When one vibrating reed in close proximity to another causes the latter to vibrate, it is known as sympathetic vibration.

Sympathetic vibration is most pronounced between two synchronous reeds, or reeds vibrating in the same period and as between these two reeds perfect harmony exists. Next in matter of harmony is the octave, as where one reed vibrates twice as rapidly as the other. Next follows the fifth with a ratio of two to three. It will be observed by reference to the ordinary harmonic frequencies that we have the ratio both of octaves and fifths between the several frequencies, and when a current of any given frequency is impressed on the line, it naturally follows that any ringer tuned in synchronism with the ringing current, will respond. This is as it should be, as this is the principle upon which the system is based, but it also follows that any ringer in harmony with the impressed current will also respond to a greater or less degree, dependent upon the ratio of coincidence. This latter application of the principles involved is the real root of the cross-ringing trouble experienced in harmonic systems, and it is seen that making one reed of such a system in harmony with another reed of a different frequency is really a violation of the very principle upon which the system is based, and upon which it depends for its margin of safety.

In harmonic systems the margins are so small as to make it necessary to wind the ringers to different resistances. The 16⅔ cycle ringer is wound to 2500 ohms; the 33⅓ cycle from 500 to 2250 ohms, and the 50 cycle and, 66⅔ cycle ringers are usually wound to 500 ohms each, although the margin of safety could be made somewhat wider by varying these windings somewhat from those usually employed. In the herein described non-harmonic system, all ringers may be wound to the uniform resistance of 1000 ohms, and are in all respects precisely alike with the exception of the weight on the armature. The armatures for the various frequencies preferably are interchangeable, and if it should be desired to change a ringer from one frequency to another the only thing which it is necessary to do is to remove the armature from the ringer and replace it by an armature properly adjusted for the frequency upon which the ringer is to be used. This makes it unnecessary to keep a stock of ringers for the different frequencies on hand, but instead a supply of these interchangeable armatures alone is required. The margin of safety in the harmonic system is so slight as to make extremely accurate adjustment of the ringers necessary, and it is also essential that the condensers used in series with the ringers are of uniform capacity. With the non-harmonic system having much wider margins, this extreme care in adjustment and in the slection of condensers is not required. In the case of the foregoing system it will be noticed as stated above, that the frequencies employed bear the relation of discords to each other, and by using these frequencies the element of sympathetic vibration and consequent cross-ringing, is eliminated and the working margin greatly amplified.

Metallic circuit lines affording the best and most approved method of practicing my invention, have been considered alone herein, but it will be appreciated that the number of possible party line stations may be doubled with a given number of selective signaling currents, merely by resorting to the expedient of ringing over either limb of the metallic line to ground, in a manner well known in the art.

In the foregoing, I have endeavored to set forth the preferred practical details, and the theories of operation as understood by me, but I do not wish this to be interpreted as necessarily limiting my invention to such details, and accordingly claim the following:—

1. In a system of the class described, the combination with a central telephone exchange, of a plurality of multiple-station telephone-lines connected therewith; each of said lines being equipped with selective-signaling apparatus at the different stations respectively tuned to respond to currents of different inharmonic frequencies, and the said telephone exchange being equipped with calling-apparatus producing currents of corresponding inharmonic frequencies, substantially as set forth.

2. In a system of the class described, the combination with a telephone exchange equipped with signaling-apparatus producing currents approximately of 30, 42 and 54 cycles per second, of a plurality of multiple-station telephone-lines connected with said exchange; each of said lines being equipped with selective-signaling apparatus at the different stations respectively tuned to respond to currents of these inharmonic frequencies, substantially as set forth.

3. In a telephone exchange system, the combination with central-office equipment, including sources of alternating signaling currents whose frequencies are substantially multiples of five, seven and nine, of a multiple-station telephone-line, including at each station a signaling device respectively tuned to respond to currents of the different frequencies, substantially as set forth.

4. In a telephone exchange system, the combination with central-office equipment, including a source of current and associated converter and interrupter devices adjusted to supply currents of different non-harmonic frequencies, and a multiple-station telephone-line including at each station a signaling-bell respectively tuned to respond to currents of the different frequencies, substantially as set forth.

5. The combination with a telephone switchboard, of sources of signaling currents adapted alternatively to be connected in circuit with a called line; said currents being of non-harmonic frequencies, a multiple-station telephone-line connected to said switchboard, and at each station a signaling-bell respectively tuned to respond to currents of distinctive frequency, substantially as set forth.

6. In a telephone exchange system, the combination with central-office equipment, including a source of current and inter-

rupter devices adjusted to deliver currents of different non-harmonic frequencies, and a plurality of multiple-station telephone lines extending to the central-office; and at each station a signaling bell tuned to respond to currents of one of the non-harmonic frequencies, substantially as set forth.

Signed at Cleveland, this tenth day of October, A. D. 1907, in the presence of two subscribing witnesses.

CHARLES H. NORTH.

Witnesses:

JESSE A. BUEL,

ALBERT LYNN LAWRENCE.