No. 828,966. PATENTED AUG. 21, 1906.

S. A. REED.

SELECTIVE SIGNALING SYSTEM.

APPLICATION FILED OCT. 26, 1905.

3 SHEETS—SHEET 1.

Fig. 1.

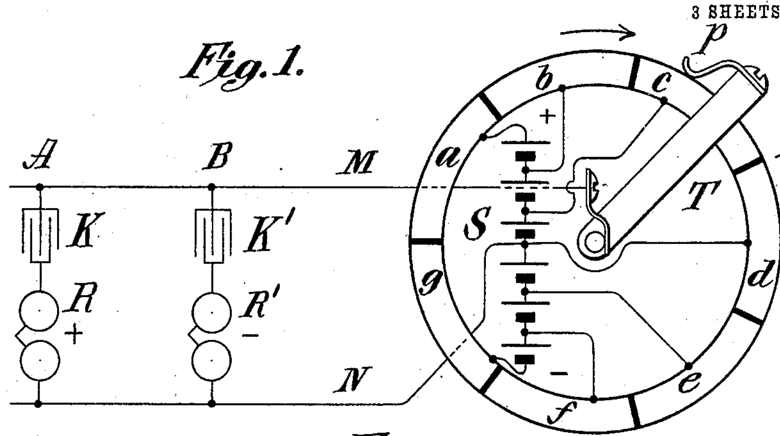



Fig. 2.

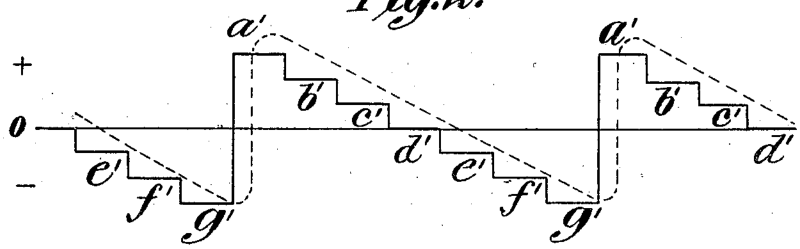



Fig. 3.

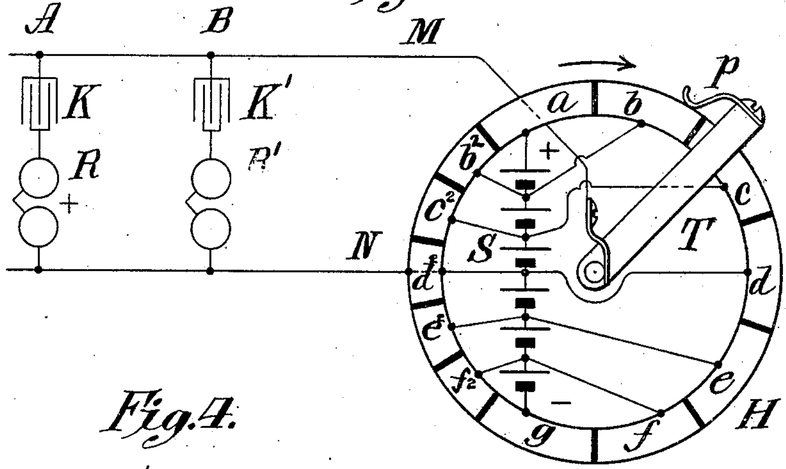
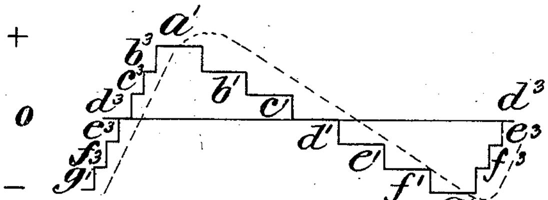



Fig. 4.

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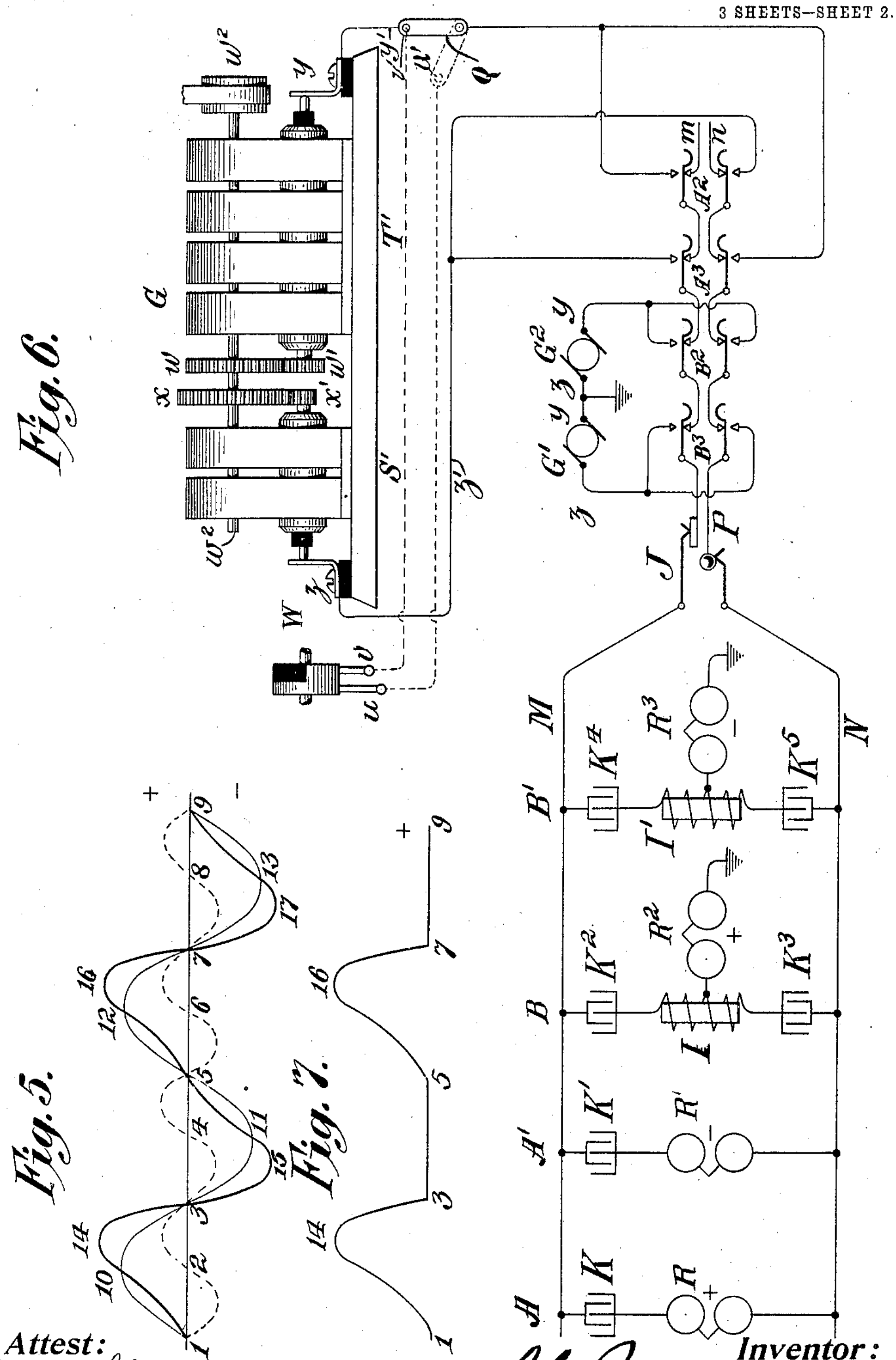
3 SHEETS—SHEET 2.

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3 SHEETS—SHEET 3.

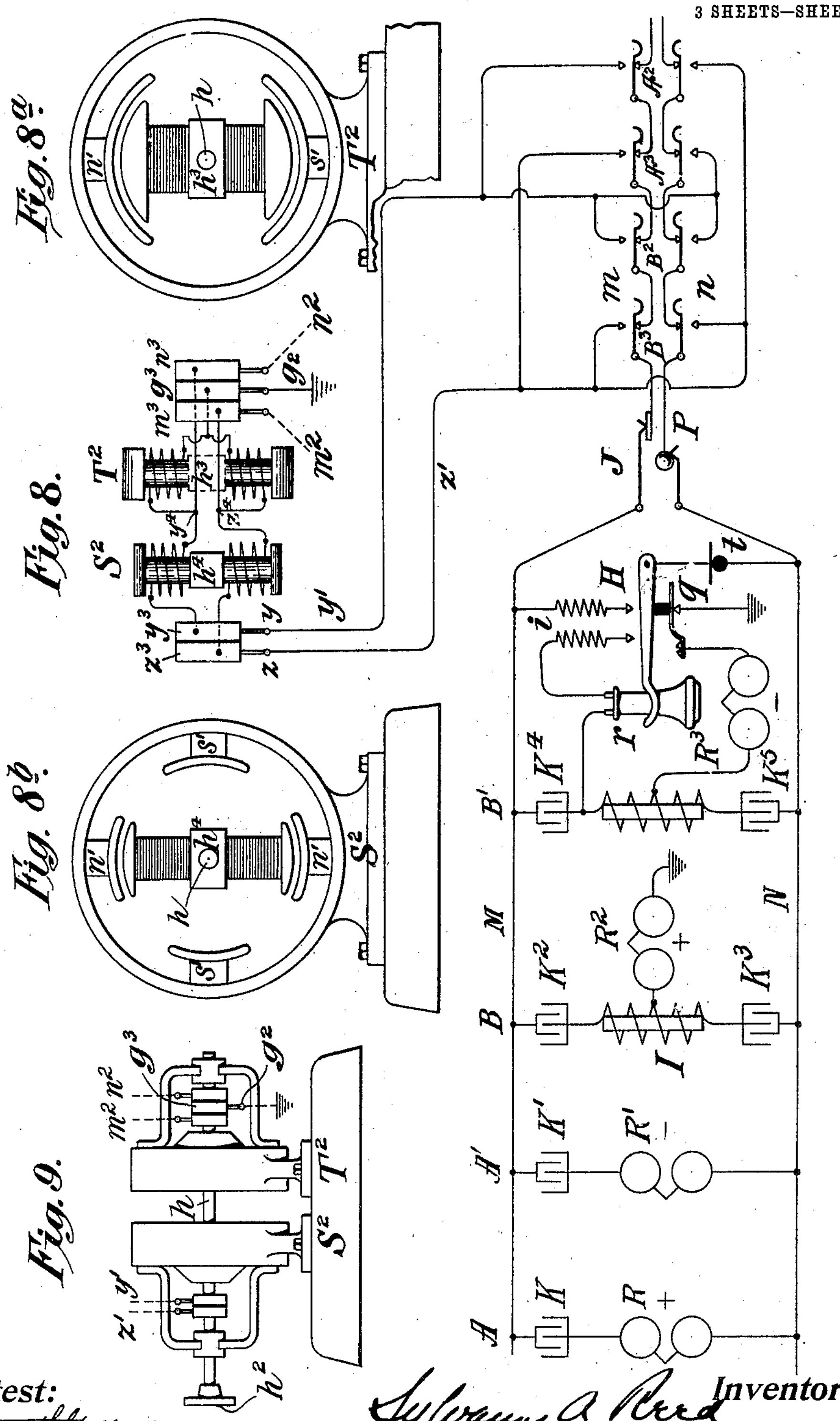

Fig. 8a. Fig. 8. Fig. 8b. Fig. 9.

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# UNITED STATES PATENT OFFICE.

SYLVANUS ALBERT REED, OF NEW YORK, N. Y.

## SELECTIVE SIGNALING SYSTEM.

No. 828,966. Specification of Letters Patent. Patented Aug. 21, 1906.

Application filed October 26, 1905. Serial No. 284,476.

*To all whom it may concern:*

Be it known that I, SYLVANUS ALBERT REED, a citizen of the United States, residing in the city, county, and State of New York, have invented certain new and useful Improvements in Selective Signaling Systems, of which the following is a full, true, and concise specification.

My invention relates to selective signaling systems wherein the operating-current is transmitted selectively through condensers to the signal-receiving mechanism.

The present invention involves the employment of alternating currents in producing selective effects according to the principle referred to, and further consists in certain hereinafter-described improvements in the mode of applying the same to practical use.

Referring to the accompanying drawings, Figure 1 is a diagrammatic representation of the principle of my invention in which an alternating current is produced having a graphic wave form represented by Fig. 2, in which one slope is substantially vertical and the other gradual. Fig. 3 is a diagrammatic representation of the principle of my invention in which an alternating current is produced having a graphic wave form represented by Fig. 4, in which both slopes are gradual, but differ in degree of inclination. Fig. 5 is a modification of the wave form of Fig. 4, made by compounding a fundamental sine-wave with its octave. Fig. 6 is a special form of magneto-generator adapted to produce a current of wave form analogous to that of Fig. 5. Fig. 7 is the wave form of Fig. 5 with alternate half-waves cut out by means of a commutator or equivalent device. Fig. 8 is a diagram of a circuit and the preferred form of compound generator for producing a current of wave form analagous to that of Fig. 5, the compound generator consisting of a two-pole and a four-pole dynamo-generator coupled directly together, the generator being also so constructed that it will supply all the necessary ringing-currents of a central station, so that additional generators may be dispensed with. Figs. $8^a$ and $8^b$ are respectively end elevations of the generators $T^2$ and $S^2$. Fig. 9 is a side elevation of the compound generator shown in Figs. 8, $8^a$, and $8^b$.

Referring to Fig. 1, M N represent the two conductors of a party telephone-line, adapted to be connected by suitable switches (omitted in the diagram) with a battery S. A B are subscribers' stations at which are the polarized ringers R R′, biased, positive, and negative, respectively, in bridges from M to N, interrupted conductively by condensers K K′, respectively. The conductor N connects with the middle element of battery S, and the conductor M connects with the rotating arm T, carrying a brush *p*. The arm T is pivoted at the center of the contact-cylinder H, which carries a series of insulated contact-segments *a b c d e f g*, over which the brush *p* passes in succession as the arm T rotates. The several insulated contact-segments are respectively connected in the order named with successive points in the potential gradient of the battery S or between successive elements thereof, and as the brush *p* makes contact with segment *a* the plates of condensers K and K′ receive a positive charge with respect to the middle point of the battery taken as zero. When the brush *p* moves to segment *b*, the potential of the M plates of condensers K K′ will fall by the voltage of one element of battery S and similarly at segment *c*, whereas finally at segment *d* the potential is the same on both sides of the line and the condensers are fully discharged. When brush *p* moves to *e*, the plates of the condensers receive a negative charge with respect to the middle point of the battery taken as zero equal to the voltage of one element. At *f* the charge is increased to the voltage of two elements, and at *g* to the voltage of one-half the battery. When next the brush *p* moves from *g* to *a*, the entire negative charge is first discharged and the M plates of the condensers are immediately recharged to the maximum positive voltage. If the arm T rotates in the direction of the arrow, the change of voltage in passing from *g* to *a* in the diagram referred to will be six times that experienced in passing from any other segment to the next in succession and the corresponding flows of current at each step will be in the same ratio.

In Fig. 2 the datum-line represents the potential of the middle point of the battery S in Fig. 1, which point also connects with segment *d*. The references *a′ b′ c′ d′ e′ f′ g′* represent, respectively, by their distances from the datum-line the potentials of the segments *a b c d e f g*, respectively, with relation to the potential of *d*, positive being above and negative below the line. The time elapsed is represented by the horizontal dimensions. If the arm T rotates uniformly and the segments are of equal width, the changes of potential will be represented by the stepwise figure, and it is evident that the general contours of the stepwise waves may be represented by the dotted line and that they are those of an alternating current having a substantially instantaneous rise from maximum negative to maximum positive and a gradual fall from maximum positive to maximum negative, this condition being herein denominated as that of asymmetry of slope. It is also evident that by rotating the arm T in the opposite direction the asymmetry will be of the reverse character; also, that instead of six elements the battery S may have any convenient number.

Referring to Fig. 3, the conditions are similar to those of Fig. 1, except that the segments $a$ $b$ $c$ $d$ $e$ $f$ $g$ are reduced in width, so as to occupy only about two-thirds of the total circumference of the cylinder, and that between $g$ and $a$ is a series of narrower segments $f^2$ $e^2$ $d^2$ $c^2$ $b^2$, over which brush $p$ passes in that sequence in moving from $g$ to $a$. Segments $f^2$ $e^2$ $d^2$ $c^2$ $b^2$ are connected with the same battery elements, respectively, as $f$ $e$ $d$ $c$ $b$. If the rate of rotation of arm T is uniform in the direction of the arrow, the rate of stepwise change of potential difference between the two sides of the line M N will be proportional to the widths of the segments, and therefore the rate of change in passing from $g$ to $a$ will be in the particular case illustrated twice as great as that in passing from $a$ to $g$.

The form of wave may be graphically represented, as in Fig. 4, in which the steps have a significance similar to that of those in Fig. 2, $a'$ $b'$ $c'$ $d'$ $e'$ $f'$ $g'$ corresponding to the potential changes while the brush $p$ passes over the segments $a$ $b$ $c$ $d$ $e$ $f$ $g$, respectively, and $f^3$ $e^3$ $d^3$ $c^3$ $b^3$ corresponding to the potential changes while the brush $p$ passes over the segments $f^2$ $e^2$ $d^2$ $c^2$ $b^2$, respectively. The general contour of the stepwise waves shown in Fig. 4 may be represented by the dotted line and is seen to be that of an alternating current asymmetric as to slope, but having the steep sides less steep than in the case of Fig. 2. If the arm T rotates in the opposite direction, the asymmetry will be of the reverse character; also, that instead of six elements the battery S may have any convenient number. The effect of the alternating current produced by this simple apparatus is to cause a changing of the condenser charges, as will be presently described in detail, from maximum voltage of one polarity to maximum voltage of the opposite polarity, and vice versa, but at different rates or average rates of change, with the result that an alternating current passes through the ringers R and R′ which is of greater motor effect in one direction than in the other, and the ringers are respectively adjusted to respond to the stronger currents in opposite directions, but not to the weaker. Selection of ringer R or R′, therefore, depends upon the direction of rotation of the arm T or upon the connection of the line conductors M N with the operating apparatus for the reasons above explained.

Having thus described briefly the principle of the operation of this invention, I now proceed to explain a mode of applying the same to practical use and adapting the same to commercial conditions. It should be first pointed out, however, that dynamo or magneto generators may be employed for producing the alternating currents appropriate for the purpose in hand and that in such machines the changes of potential may occur by imperceptible gradations, and instead of a stepwise character of the graphic wave form the slopes are usually smooth. In Fig. 5 is shown a graphic wave form represented by the heavy line, whose general contour is substantially of the same asymmetric character as is shown by the dotted line in Fig. 4, inasmuch as the change of potential from maximum positive to maximum negative occurs at an average rate and with a form of slope different from that at which the change occurs from maximum negative to maximum positive. A potential difference varying in accordance with this graphic wave form if impressed on either of the circuits of Fig. 1 and Fig. 3 would have the same selective action upon the ringers in those circuits as is the case with the current sources illustrated in those figures. The wave shown by the heavy line may be compounded from simple sine-waves—namely, a fundamental 1 10 3 11 5 12 7 13 9—and its octave 1 2 3 4 5 6 7 8 9—by assigning to the octave an appropriate voltage with relation to that of the fundamental.

A generator which may be used for producing at its terminals a potential variation corresponding to the wave form of Fig. 5 is illustrated in side elevation in Fig. 6 and consists of two magneto-generators—namely T′, which furnishes the fundamental, and S′, which furnishes the octave and whose armatures are so geared to a common driving-shaft $w^2$ that the armature of S′ makes two revolutions to one of that of T′. This is effected by making the relation of the gears $x$ to $x'$ double that of the gears $w$ to $w'$. The circuits are connected in series, and the respective neutral points are so adjusted that alternate neutral points of S′ coincide with the neutral points of T′. The relative voltages are appropriately adjusted by varying the armature-windings or the field-magnets, or both. In the figure one pole of each armature is in conductive relation with the generator-frames and these with each other, so that the generators are connected thereby in series, and the resultant current is taken off from insulated contact-pins at $y$ and $z$ by the ringing-key leads $y'$ and $z'$, respectively. Fig. 6 also illustrates one of the modes of applying the wave of the above-described compound generator to a preferred form of four-party telephone-line for ringing any one of the stations selectively. References M N are the two line-wires leading through subscribers' stations A A' B B' to a central exchange, at which it terminates in jack J. The line-signal and cut-off circuits are omitted from the figure for the sake of convenience. Stations A A', respectively, have oppositely-biased polarized ringers R R' in series with condensers K K' in bridges across the line. Stations B B', respectively, have oppositely-biased polarized ringers $R^2$ $R^3$ in ground branches to preferably the middle points of impedance-coils I I', I being in series with and between condensers $K^2$ $K^3$ in a bridge across the line at B, and I' being similarly placed with regard to condensers $K^4$ $K^5$ in a bridge across the line at B'. $m$ $n$ are the strands of a switchboard cord-circuit, which may lead, respectively, from the two poles of a common battery, (not shown in the figure,) strands $m$ $n$ terminating in plug P. Cut-off circuits and other usual connections with the cord-circuit are omitted from the figure for the sake of convenience, excepting keys $A^2$ $A^3$ $B^2$ $B^3$, which are selective ringing-keys adapted to be operated to ring selectively the bells at station A A', B, or B', respectively. The leads $y'$ $z'$ from the compound wave-generator T' S' are shown connected directly to keys $A^2$ $A^3$, and similar generators G' and $G^2$ are connected with keys $B^2$ and $B^3$.

In considering the current from T' S' in connection with the graphic wave form of Fig. 5, the datum-line will be taken to represent the potential at generator-pole $z$, taken as zero, while the heavy line will be taken to represent the changes of potential at generator-pole $y$ with relation to that at $z$. If the key $A^2$ is operated, the N plates of condenser K K' will be in conductive connection with $z$ through the path N, plug P, lower leaves of keys $B^3$, $B^2$, $A^3$, and $A^2$, and lead $z'$ and may be considered as of zero potential, while the M plates being in conductive connection with $y$ through the path M, jack J, upper leaves of keys, and $y'$ will experience the potential variation represented by the heavy line in Fig. 5. Conductive continuity in the circuit being broken by the condensers, current will flow into the M plates, not during the entire positive half of the cycle—namely, from neutral point 1 to neutral point 3—but only while the positive current is growing to maximum—namely, from 1 to 14. When it begins to diminish, a reverse current flows from the M plates and continues in the same direction during the period while the potential of $y$ passes through zero at 3 and again grows to maximum negative at 15. At 15 the negative potential begins to diminish, and the reverse condenser-current becomes zero and then resumes its original direction, continuing in that direction during the period in which the potential of $y$ passes through zero at 5 and grows to the maximum positive at 16. A reverse current flows again during the change of potential of $y$ from maximum positive at 16 to maximum negative at 17, and so on successively. Inasmuch as the same quantity of electricity passes into the condenser as out of it, the average current strength between any two current reversals will depend upon the time interval and will be represented by the average grade of the wave-slope, the steeper being the slope the stronger the current. When, as in Fig. 5, the steeper slope is on the advancing side of the wave, then the stronger current through the ringers will be during the flow into the condenser, whereas when the steeper slope is on the following side of the wave then the stronger current through the ringers will be during the flow out of the condensers. The keys $A^2$ $A^3$ are so related to the leads $y'$ $z'$ as to bridge the generator T' S', respectively, in opposite senses across the cord $m$ $n$, and consequently across the line M N. The biasing-springs of the ringers are adjusted to yield when the currents through their respective electromagnets are of the proper polarity, opposite respectively, and of a strength corresponding to the steep slopes of the wave of Fig. 6, but not to yield under the conditions corresponding to the more gradual slopes of that wave.

It is desirable that the currents corresponding to the differentiated wave-slopes should exhibit a maximum contrast in their relative power of overcoming the bias tension of the ringers. This contrast may be expressed as range or margin. Armature inertia, inductance, and frequency are of influence as well as mere preponderance of current strength. Strong irregularities in the wave form are of influence; but it is found that a remarkable range is obtained when the ringers are two thousand five hundred ohms resistance, the frequency one thousand alternations per minute, and the respective voltages of the two combined generators bear the inverse relation of their frequencies—namely, the voltage of the octave is half that of the fundamental. Considering the effect of operating the selective ringing-keys $A^2$ $A^3$ and assuming that connection with generator-pole $y$ corresponds to a superiority of inflowing current at the condenser, the ringer R will have its back-stop set against an outflowing current and its bias spring adjusted to yield to the superior inflowing current, but not to the inferior. Operation of key $A^2$ connects generator T' S' in a sense to cause a superiority of the inflowing current. Hence ringer R will respond to the operation of key $A^2$. Ringer $R'$ will have its back-stop set against inflowing current and its bias spring adjusted to yield to the superior outflowing current, but not to yield to the inferior outflowing current. The operation of key $A^2$, which establishes an inferiority of the outflowing currents, fails to cause movement of the armature of $R'$ in either direction, and hence R alone is rung by the operation of $A^2$. Similarly, $R'$ alone is rung by the operation of $A^3$.

In the case of the keys $B^2$ $B^3$ it may be desirable on account of ground connections to provide the two other generators $G'$ and $G^2$ above mentioned, each a compound generator of the type of $T'$ $S'$, $G'$ being grounded on what may be called by analogy the "$z$ side" and $G^2$ on the "$y$ side." Generator $G'$ may be connected to the circuit through the key $B^3$, so as to deliver current over two sides of the line M N in multiple to ground—namely, through the condensers $K^2$ $K^3$ and $K^4$ $K^5$ in multiple, through the two halves of impedance-coil I in multiple, and the two halves of impedance-coil $I'$ in multiple, respectively, to and through the oppositely-biased ringers $R^2$ $R^3$ to ground. Generator $G^2$ is connected to the line by means of key $B^2$ in a similar circuit, but in a reversed polarity. Hence by a similar system of reasoning to that applied in the case of ringers R $R'$ it may be shown that the operation of key $B^3$ will ring $R^2$ exclusively and that the operation of key $B^2$ will ring $R^3$ exclusively so far as these two ringers $R^2$ $R^3$ are concerned. Ringers R $R'$ experience no current when generators $G'$ or $G^2$ are connected to the line in the manner shown, provided the resistances of M $m$ and N $n$ are substantially equal, and ringers $R^2$ $R^3$ experience no current when generator $T'$ $S'$ is connected across the line in the manner shown. Consequently ringers R $R'$ $R^2$ $R^3$ respond exclusively to the operation of their corresponding keys $A^2$ $A^3$ $B^3$ $B^2$, respectively. A compound generator of the type $T'$ $S'$ may by methods familiar in the art be arranged with a commutator so as to produce unidirectional current, the graphic wave form of which will be of the type shown in Fig. 7. Such a commutator is shown at W in Fig. 6. It is adapted to be mounted on an extension of the armature-shaft of the generator which furnishes the fundamental of the component currents and to cut out the positive or negative halves of the current, as desired. For illustration, in Fig. 6 by the opening of switch Q the lead from $y$ instead of passing directly to the ringing-keys may pass by the dotted line from $v'$ to brush $v$ of the commutator, while from brush $u$ a lead passes through $u'$ to the ringing-keys $A^2$ $A^3$.

The half-waves are shown in Fig. 7, 1 14 3 and 5 16 7, the parts 3 5 and 7 9 having been cut out. In these half-waves there exists the same relation between the advancing and following slopes as exists in the case of the compound wave of Fig. 5, and it is obvious that they will have similar selective properties. The plan of commutation there illustrated may have advantages in the case where it is desirable to make a single compound generator supply appropriate current for all the ringing-keys of a switchboard. Such a commutator may have further contact members (not shown herein) for providing a short-circuiting path across the cord in the intervals of current pulsations in order to more completely discharge the condensers.

Referring now to Figs. 8, 9, I show a further application of the principle hereof to practical four-party selective signaling use, which is preferred, because but one generator need be employed for the four stations and that one will be also of service to supply the ordinary ringing-current for lines not selective. This generator is referred to herein as a "compound" generator, because it combines, in effect, two simple generators, one of the two-pole type and the other of the four-pole type, both connected in series and revolved by the same armature-shaft $h$ through its shaft-coupling $h^2$, (shown in Fig. 9,) which latter is adapted to be connected to any appropriate kind of rotary motor The two-pole generator of the compound apparatus is shown at $T^2$ and furnishes the fundamental wave, while the four pole generator (shown at $S^2$) furnishes the octave wave, it being understood that the fundamental and octave are superposed to form the asymmetric selective current heretofore fully described. In the generator $S^2$ the oppositely-disposed pole-pieces are of like polarity, which may be maintained by the usual field-windings, (not shown,) as may also the pole-pieces of generator $T^2$. The armatures $h^4$ of generator $S^2$ and $h^3$ of generator $T^2$ are shown as shuttle-wound for simplification; but other forms of winding may be adapted with equal effect, provided the windings be so disposed with reference to the center of rotation that the neutral points of the currents will coincide in the sense described in the case of the generator of Fig. 6

The windings of the two armatures $h^4$ and $h^3$ are clearly shown in Fig. 8 and may be traced as follows: first, from commutator-ring $y^3$ in a right-handed direction around the upper half of armature-bobbin $h^4$ toward the center, around the upper half of armature-bobbin $h^3$, also in a right handed direction to the commutator-ring $g^3$, which is grounded at $g^2$; second, from commutator-ring $z^3$ in a right-handed direction around the lower half of armature-bobbin $h^4$ toward the end, around the lower half of armature-bobbin $h^3$ toward the center, and also in a right-handed direction to the grounded commutator-ring $g^2$. The tap connections from the points $y^4$ and $z^4$ between the two sections of each generator-winding lead to the commutator-rings $m^3$ $n^3$ and brushes $m^2$ $n^2$, respectively, these being the points from which a simple alternating current may be derived for ringing lines not selective in the ordinary manner. The leads and keys for this purpose are not shown and so far as the present system is concerned are not necessary; but it will be observed that when these two rings are electrically connected a simple alternating current will be produced by the revolution of armature $h^3$ within its two-pole field, the generator $S^2$ being non-productive of current until the circuit of its two windings is completed.

It will be noted that the arrangement of the two armature-windings in halves which are respectively connected in series, as described, constitutes, in effect, two generators, either one of which alone, or both together, is capable of producing the current graphically represented by Fig. 5. Thus by connecting a circuit between the brush $z$ and ground the lower halves (in the diagram) of the armature-windings produce the selective current. By connecting it to brush $y$ and ground the upper halves produce a selective current, and by connecting the circuit between $y$ and $z$ both halves of both armatures coöperate in series to produce the described selective current therein, which current, however, is twice the strength of either of the currents in the first-mentioned connections, since both windings of both generators are in action. This compound generator is connected with the circuit shown by Fig. 8, so that the operation of key $B^3$ connects the lead $z'$ with both sides of the line, and the current passes through both of said sides and through the balanced impedances and capacities in the station-bridges at B B′ to the ringers $R^2$ and $R^3$ to ground the same as described with respect to key $B^3$ of Fig. 6. Ringer $R^3$ responds according to the principles above explained. Similarly, the operation of key $B^2$ connects the lead $y'$ to both sides of the line with same result, but with the response of the ringer $R^2$.

Operation of key $A^3$ connects the line-circuit between the leads $y'$ and $z'$ in one direction to actuate the ringer R′, and key $A^2$ connects them in the opposite direction to actuate R. The connection made by keys $B^3$ and $B^2$ obviously have no effect on ringers R R′, and, vice versa, those made by keys $A^3$ $A^2$ have none on ringers $R^3$ $R^2$. There may be also assumed to exist at each station A, A′, B, and B′ a telephone talking set capable of being bridged across the line according to customary methods, and suitable switches may be supplied whereby any of the condensers may be switched into appropriate relations with the talking-circuit for purposes familiar to the art. At stations A and A′ the talking-set connections need not vary from those customary in individual lines. At stations B and B′, I show a preferred modification to meet the condition that the ground connection must be removed during talking. $r$ is the receiver; H, the hook-switch; $t$, the transmitter, and $q$ a switch closed by the insulated block on H when H is down.

Other methods familiar to the art of combining the two component currents to form the desired compound current may be used. An obvious plan would be to combine them by induction without conductive connection.

The arrangement of the impedance-coils and their respective condensers with their ringers located in ground branches from the middle points of the bridges is not herein claimed, this being fully shown and claimed in a copending application by me filed of even date herewith, Serial No. 284,477.

Having described my invention, what I claim, and desire to secure by United States Letters Patent, is—

1. In a signaling system, the combination with a circuit, oppositely-biased electromagnetic annunciators therein and condensers in series with said annunciators, of means of impressing upon the circuit an alternating current which has its potential changes in attaining its maximum positive potential different from its changes in attaining its maximum negative potential, only the changes in attaining one of the two maximum potentials causing a current in the annunciators capable of overcoming their bias tensions.

2. In a signaling system, the combination with a circuit, oppositely-biased electromagnetic annunciators in said circuit and condensers in series with said annunciators, of means for impressing upon said circuit a cutrent comprised of a symmetrical alternating current of definite frequency compounded with a superposed symmetrical alternating current of twice that frequency.

3. In a signaling system, the combination with a circuit, oppositely-biased electromagnetic annunciators in said circuit and condensers in series with said annunciators, of a generator adapted to produce an alternating current having a wave form which is the composite of a sine-wave and its octave superposed thereon.

4. In a signaling system, a circuit, oppositely-biased ringers therein, and condensers in series with said ringers, in combination with a generator adapted to produce an alternating current which varies differently in attaining its opposite points of maximum potential, the two kinds of variations being respectively capable and incapable of causing current in the ringers of sufficient motor effect to overcome their bias tensions and means for connecting either pole of said generator to either side of said circuit.

5. In a signaling system, a circuit, oppo-

sitely-biased ringers and condensers in said circuit interrupting its conductive continuity, in combination with two generator-armature windings in series in the circuit, the second winding producing current of double the frequency of the first, the neutral points of the first coinciding with the alternate neutral points of the second, and the voltage of the second bearing a relation to that of the first such that the resultant potential difference impressed upon the line varies between maxima differently in opposite directions, the variations in one direction only causing current through the ringers which is capable of overcoming their bias tension.

6. In a signaling system, a circuit, oppositely-biased ringers and condensers therein interrupting the conductive continuity of said circuit, in combination with a generator having two armature-windings, the second adapted to revolve within twice the number of field-poles as the first, and the neutral points of the first coinciding substantially with the alternate neutral points of the second, and means for connecting either side of said generator to the line, whereby either of two ringers may be operated through its condenser to the exclusion of the other.

7. In a signaling system, the combination with a circuit having bridges thereacross and branches to ground from said bridges, impedance elements and condensers in said bridges on opposite sides of the ground branches and oppositely-biased annunciator elements in the path of current through said branches, of an operating-generator adapted to produce an alternating current which varies differently in attaining its opposite points of maximum potential, the two kinds of variations being respectively capable and incapable of causing current in said branches of sufficient motor effect to overcome the bias tensions of said annunciator elements, and means for connecting one of the poles of said generator to ground and the other to the two sides of the circuit in parallel.

8. In a signaling system of the kind described, an operating-generator comprising two armature-windings respectively producing different frequency of current and switch connections for joining the same either both in series with the sides of the line, or a half of each in series with ground and the two sides in multiple.

9. In a signaling-circuit of the kind described, an operating-generator comprising two armature-windings each divided in halves and the similar halves thereof being connected in series, in combination with a ground connection between two halves of one armature-winding and switch connections from the free terminals of the other halves adapted to be connected with the sides of the circuit.

In testimony whereof I have signed my name to the specification in the presence of two subscribing witnesses.

SYLVANUS ALBERT REED.

Witnesses:
H. G. KIMBALL,
G. A. TAYLOR.