Dec. 21, 1943. K. W. PFLEGER 2,337,493

CODE SIGNALING SYSTEM

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FIG. 1

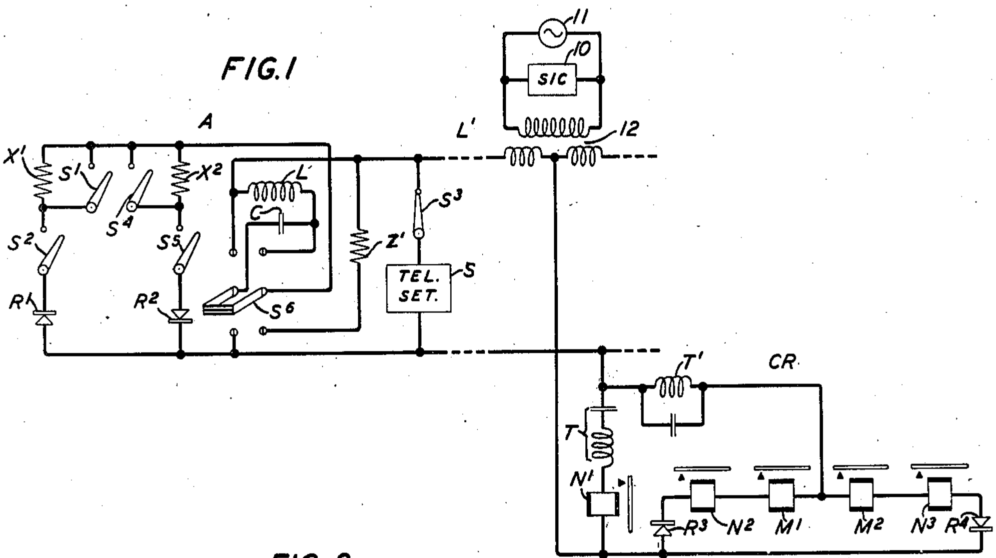
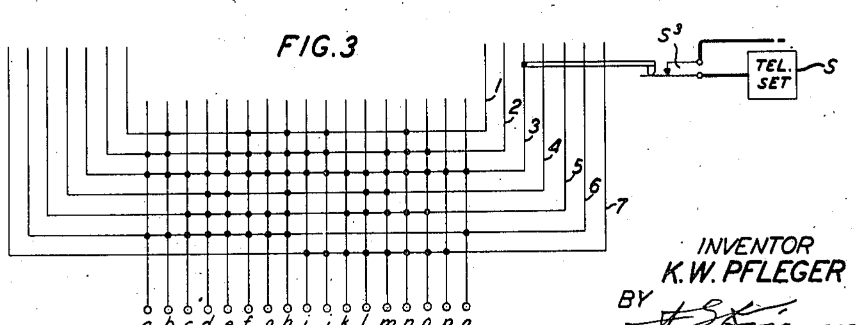


FIG. 2

KEY	LINE CURRENT	SWITCH POSITIONS						RELAYS OPER.				
		S^1	S^2	S^3	S^4	S^5	S^6	N^1	N^2	N^3	M^1	M^2
	DIAL TONE			X			OPEN	X	X	X	X	X
a	- DC		X				UP		X			
b	**- DC**	X	X				UP		X		X	
c	+ DC					X	UP			X		
d	**+ DC**				X	X	UP			X		X
e	- DC, **+DC**		X		X	X	UP		X	X		X
f	**- DC**, +DC	X	X			X	UP		X	X	X	
g	- DC, + DC		X			X	UP		X	X		
h	**- DC, +DC**	X	X		X	X	UP		X	X	X	X
i	- DC, 3F		X				DN	X	X			
j	**- DC**, 3F	X	X				DN	X	X		X	
k	+DC, 3F					X	DN	X		X		
l	**+DC**, 3F				X	X	DN	X		X		X
m	-DC, **+DC**, 3F		X		X	X	DN	X	X	X		X
n	**-DC**, + DC, 3F	X	X			X	DN	X	X	X	X	
o	-DC, + DC, 3F		X			X	DN	X	X	X		
p	3F						DN	X				
q	ZERO						UP					

FIG. 3



INVENTOR
K. W. PFLEGER
BY
ATTORNEY

CODE SIGNALING SYSTEM

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FIG. 4

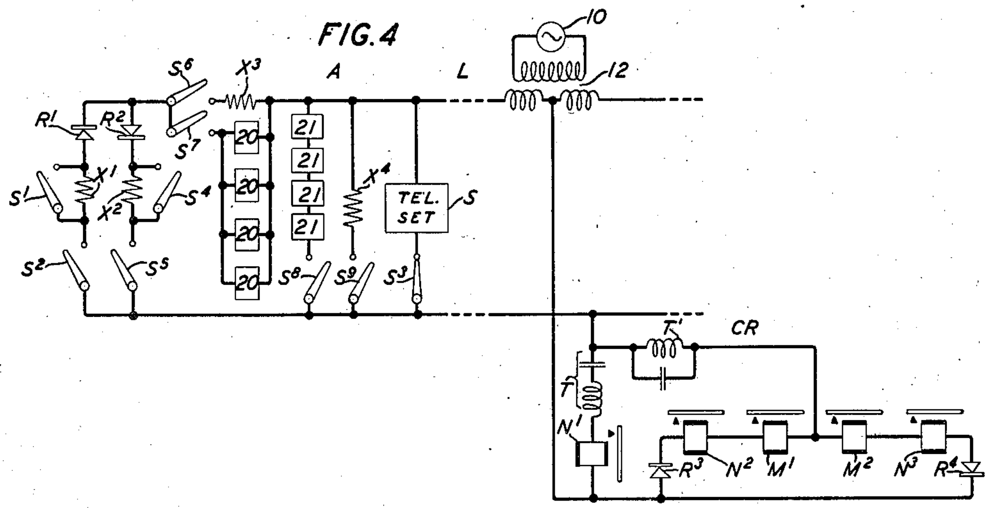
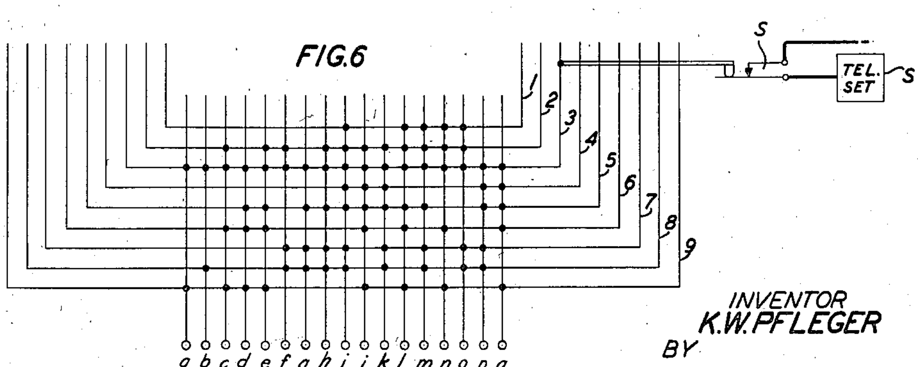


FIG. 5

KEY	LINE CURRENT	SWITCH POSITIONS									RELAYS OPER.				
		S^1	S^2	S^3	S^4	S^5	S^6	S^7	S^8	S^9	N^1	N^2	N^3	M^1	M^2
	DIAL TONE			X								X	X	X	X
a	F									X					
b	F, 3F								X		X				
c	-DC		X				X			X		X			
d	+DC					X	X			X			X		
e	-DC, +DC		X			X	X			X		X	X		
f	-DC, 3F		X					X	X		X	X			
g	+DC, 3F					X		X	X		X		X		
h	-DC, +DC, 3F		X			X		X	X		X	X	X		
i	-DC, +DC, 3F	X	X		X	X		X	X		X	X	X	X	X
j	-DC, +DC		X		X	X	X			X		X	X		X
k	-DC, +DC, 3F		X		X	X		X	X		X	X	X		X
l	-DC, +DC	X	X			X	X			X		X	X	X	
m	-DC, +DC, 3F	X	X			X		X	X		X	X	X	X	
n	-DC	X	X				X			X		X		X	
o	-DC, 3F	X	X					X	X		X	X		X	
p	+DC, 3F				X	X		X	X		X		X		X
q	+DC				X	X	X			X			X		X

FIG. 6



INVENTOR
K. W. PFLEGER
BY
A. S. Kungman
ATTORNEY

CODE SIGNALING SYSTEM

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FIG. 7

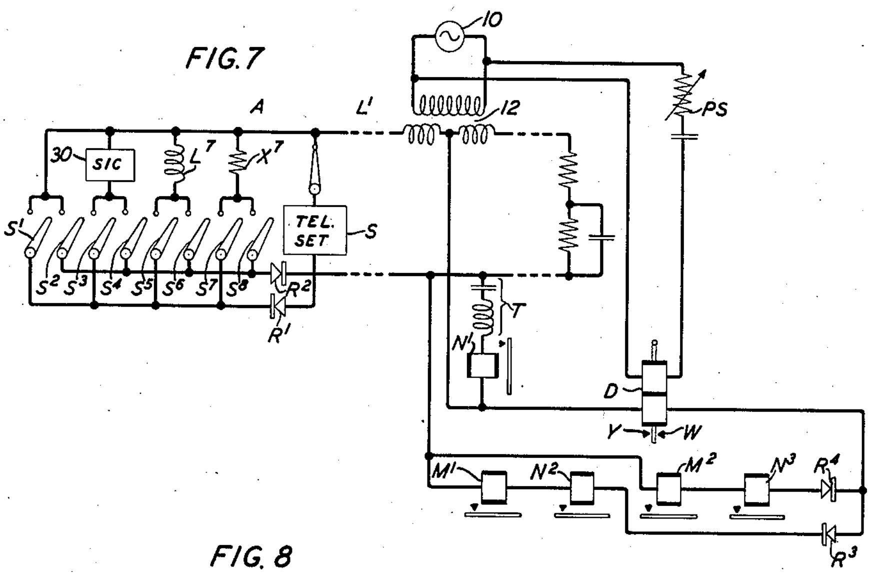
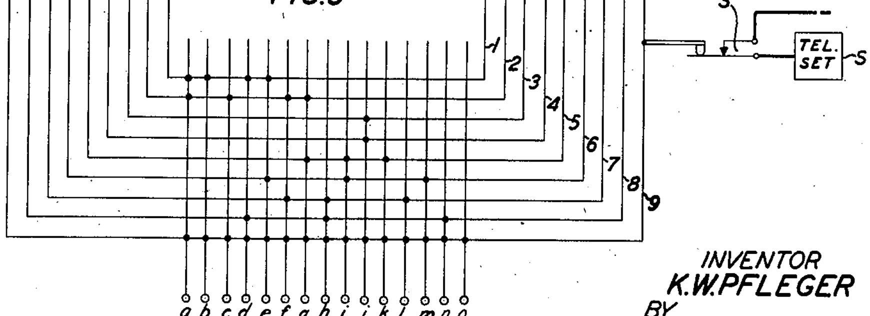


FIG. 8

KEY	LINE CURRNT				SWITCH POSITIONS									RELAYS OPER.					
	DC	3F	F	Θ	S^1	S^2	S^3	S^4	S^5	S^6	S^7	S^8	S^9	N^1	N^2	N^3	D	M^1	M^2
DIAL TONE			X	-									X		X	X	W	X	X
a			X	+	X	X									X	X	Y	X	X
b	-		X	+	X										X		Y	X	
c	+		X	+		X										X	Y		X
d	-		X	+	X							X			X	X	Y	X	
[illegible]	-		X	-	X					X					X	X	W	X	
f	+		X	+		X					X				X	X	Y		X
g	+		X	-		X			X						X	X	W		X
h			X	+							X	X			X	X	Y		
i			X	-					X	X					X	X	W		
j		X	X	+			X	X						X	X	X	Y		
k	-		X	-					X						X		W		
l	-		X	+							X				X		Y		
m	+		X	-						X						X	W		
n	+		X	+								X				X	Y		
o			X	+													Y		

FIG. 9



INVENTOR
K. W. PFLEGER
BY A. J. Kingsman
ATTORNEY

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UNITED STATES PATENT OFFICE

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CODE SIGNALING SYSTEM

Kenneth W. Pfleger, Arlington, N. J., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application May 29, 1942, Serial No. 444,948

15 Claims. (Cl. 179—16)

This invention relates to code signaling, and particularly to a system of telephone signaling in which station-identifying code signals, transmitted from a code sending station, comprise several components of an alternating current source which are transmitted to a code receiving station singly and/or in combinations.

Telephone signaling systems have been devised heretofore, in which the completion of connections between calling and called subscribers is effected, under the control of the calling subscriber, by the operation of a key-type code transmitting device which functions to select the positive and negative direct current components of an alternating current source and to group them in various combinations for transmission to a code receiving station where they serve to control the operation of station connecting translating devices. In order that the limited number of possible combinations of such components be utilized to advantage in systems requiring a minimum of fifteen station selections, it has been necessary to combine each line conductor, extending from the code transmitting station with a ground return so that some of the signals may be transmitted over one line conductor to ground and other signals may be transmitted over the other line conductor to ground. Such systems render it essential that a suitable ground connection be available at the code sending, or calling subscriber's stations.

It is the object of this invention to devise a system of code signaling which obviates the need for a ground connection at the code sending station, and which provides for a sufficient number of station identifying code signals, and for their transmission over the metallic loop which interconnects the code sending and receiving stations.

In a copending application, Serial No. 444,772, filed May 28, 1942, there is diclosed a telephone signaling system in which only the metallic loop extending between the code transmitting and receiving stations is employed as the signal carrying medium. This system is characterized by a rectifier-type key sender in which certain of the code signals are transmitted during the down stroke of a key; certain others are transmitted during the up stroke of a key; and still certain others require both the down and up strokes of a key for their transmission.

The system of the present invention distinguishes from that of the above-identified copending application, in accordance with a particular feature of the invention, by characterizing the code signals used to identify particular called subscribers' lines by various combinations of the components of a complex current impulse which has its origin in a source of alternating current, and in transmitting all code signals during the down strokes only of the keys of the key-type sender. More specifically, the key sender at the calling subscriber's station functions to translate the alternating current from the supply source into positive and negative direct current components, to emphasize a particular harmonic of the supply source, and to transmit signals consisting of various combinations of the direct current components characterized by either the presence or absence of the particular harmonic component of the supply frequency. The number of different code signals thus made available may be increased by utilizing several magnitudes of the direct current components.

In accordance with a modification of the arrangement described in the preceding paragraph, the alternating current supply source located at the code receiving station is applied to the line with a particular harmonic thereof emphasized, and the key-type sender is devised so as to suppress the emphasized harmonic for certain code signals and to pass it for certain other code signals.

A further modification of the invention contemplates shifting the phase of the signal current with respect to the current supplied directly from the alternating current source, selectively in either of two directions, and in detecting the phase shift by means of a dynamometer type relay in the code receiving circuit. Thus the phase detecting relay cooperates with those other relays of the code receiving circuit in recording signals comprising positive and/or negative pulsating direct current having an alternating current component whose phase displacement relative to the current supplied directly to the dynamometer type relay from the alternating current source is advanced or retarded.

As is well known to those skilled in the art of making electrical measurements, a dynamometer meter will have zero torque when the currents in its two windings are of the same frequency and 90 degrees out of phase. The same applies to a dynamometer used as a relay. If this 90 degree condition is obtained, then a slight shift θ in the phase of the current in one of the windings will swing the indicator or armature to the right or left depending upon whether the phase increment is negative or positive. The dynamometer is not sensitive to harmonics of the measuring frequency unless harmonics appear in both windings, which is not the case in the invention described below. The dynamometer is not sensitive to the direct current unless same occurs in more than one winding or an extraneous magnetic field is present.

These and other features of the invention will be readily understood from the following detailed description made with reference to the accompanying drawings, in which:

Figs. 1, 4 and 7 are diagrammatic illustrations of three code signaling systems embodying the features of the invention. Each of these figures shows a subscriber's station equipped with a rectifier-type key sender, a metallic loop interconnecting the subscriber's line and a code receiving station, and a code receiving circuit located at the code receiving station;

Figs. 2, 5 and 8 are tables which show the contacts controlled by each key of the key senders of Figs. 3, 6 and 9, respectively, the components of the signal impulse transmitted by each key, and the relays of the code receiving circuits which respond to the actuation of each of the keys; and

Figs. 3, 6 and 9 are schematic representations of the key-type senders employed in the systems of Figs. 1, 4 and 7, respectively.

In the embodiment of applicant's invention shown in Fig. 1, a symmetrical varistor 10, such as a silicon carbon unit, is connected in parallel with the alternating current source 11. This varistor serves to distort the wave shape of the source 11 and to emphasize the third harmonic of the frequency of the supply source. A transformer 12 is utilized to connect the supply source 11 with the line L^1. This transformer may be a hybrid coil and is intended as such in Fig. 1 with the artificial line or balancing network omitted. The omission of the artificial line is permissible when the line loop is short, but may be required on long line loops. The power source 11, symmetrical varistor 10 and transformer 12 are located at the code receiving station which may be a telephone central office. Also located at the central office, or code receiving station is a code receiving circuit CR which will be described in detail hereinafter.

At the code sending station A, which may be a telephone subscriber's station, there is located a key-type sender, or transmitter of the general type disclosed in Patent 2,147,710, issued Feb. 21, 1939 to R. F. Mallina. The key-type sender, as schematically illustrated in Fig. 3 comprises seven U-shaped code bars identified by the numerals 1 to 7, inclusive, which may be selectively operated in various combinations by the seventeen keys *a* to *q* inclusive. In the schematic illustration, Fig. 3, the operating levers of the keys are disposed at right angles to the crossbar portions of the code bars, and the code bars actuated by each key are indicated by dots shown at certain of the crossover points. For example, key *a*, when depressed causes the actuation of code bars 2, 3 and 6; key *b*, when depressed actuates code bars 1, 2, 3 and 6; key *c*, when depressed operates code bars 2, 5 and 6; key *d* causes the operation of code bars 3, 4, 5 and 6; key *e* operates code bars 2, 3, 4, 5 and 6; key *f* operates code bars 1, 2, 3, 5 and 6; key *g* operates code bars 2, 3, 5 and 6; key *h* operates code bars 1, 2, 3, 4, 5 and 6; key *i* operates code bars 2, 3, and 7; key *j* operates code bars 1, 2, 3 and 7; key *k* operates code bars 3, 5 and 7; key *l* operates code bars 3, 4, 5 and 7; key *m* operates code bars 2, 3, 4, 5 and 7; key *n* operates code bars 1, 2, 3, 5 and 7; key *o* operates code bars 2, 3, 5 and 7; key *p* operates code bars 3 and 7; and key *q* operates code bars 3 and 6.

The mechanical structure of the key-type sender disclosed schematically in Fig. 3 constitutes no part of the present invention, and since the above-identified patent furnishes a complete description of a sender employing design principles similar to those contemplated for the sender which functions with the system shown in Fig. 1, no further description of the mechanical construction is required. Suffice it to say that each code bar is furnished with one or more integral projections which extend within the line of action of the keys, so that each key will engage all the code bar extensions which are located within its line of action. For example, key *a*, when depressed, engages the integral projections of code bars 2, 3 and 6 and causes the corresponding code bars to be actuated; similarly, key *b* engages the integral extensions of code bars 1, 2, 3 and 6 so as to operate corresponding code bars when the key is depressed. It is believed unnecessary to illustrate any further.

Each code bar controls a set of contacts, not shown in Fig. 3 but indicated in Fig. 1 by the switches S^1, S^2, S^3, S^4, S^5 and S^6, the last switch being shown as a double pole-double throw switch for purposes of simplicity. The switch S^6, as illustrated in Fig. 1 is capable of assuming either of two positions, one position is assumed when the switch is moved upwardly, and the other position is assumed when the switch is moved downwardly.

In accordance with the arrangement of the switches with respect to the code bars of the key-type sender, the code bar 1 functions to actuate switch S^1; the code bar 2, switch S^2; the code bar 3, switch S^3; the code bar 4, switch S^4; the code bar 5, switch S^5; the code bar 6, the switch S^6 to its "up" position; and the code bar 7, the switch S^6 to its "down" position.

When switch S^2 is closed, the negatively poled rectifier R^1 is connected across the two conductors of the line L^1 by way of the resistance X^1 to cause a negative direct current impulse of relatively small magnitude to be transmitted to the code receiving circuit CR; when switches S^1 and S^2 are operated the rectifier R^1 is connected directly across the line conductors to cause the transmission of a negative direct current impulse of greater magnitude; switches S^5 and S^4 correspond to switches S^1 and S^2, respectively, and function in the same manner to associate the positive poled rectifier R^2 with the line L^1; switch S^3 serves to control the connection of the subscriber's telephone set S to the line L^1, it being understood that this switch is normally closed; switch S^6 when actuated to its "up" position connects the filter elements L and C in parallel with each other and in series with the line and when actuated to its "down" position, connects the filter elements L and C in series with each other across the line in parallel with the resistance Z^1.

When the switch S^6 is operated to its "up" position, the coil L and condenser C are connected in parallel as stated above. These elements are so proportioned as to cause them to resonate at the third harmonic of the supply source 11, so that this harmonic is effectively prevented from entering the rectifiers R^1 and R^2. Therefore, the third harmonic component is absent from the current transmitted to the code receiving circuit CR when switch S^6 is actuated to its "up" position. It will be observed, by referring to Fig. 3, that this condition prevails for the operations of keys *a, b, c, d, e, f, g, h* and *q*.

When the switch S^6 is closed to its "down" position, incident to the actuation of any of the keys *i, j, k, l, m, n, o,* or *p*, the coil L and condenser C are connected in series across the line so that a maximum amount of the third harmonic flows over the line to the code receiving circuit CR. The impedance Z^1, which is connected when switch S^6 is closed to its "down" position is adjusted to give substantially the same current in rectifiers R^1 and R^2 as when switch S^6 is in its "up" position.

From the description thus far advanced, it is apparent that the code signals transmitted over the line may be characterized by line currents made up of various combinations of positive and/or negative direct current components of light and/or heavy magnitudes, with or without the third harmonic component of the supply source.

The receiving circuit CR located at the central office consists of two marginal relays M^1 and M^2, two neutral relays N^2 and N^3, a third neutral relay N^1, two oppositely poled rectifiers R^3 and R^4 and two tuned circuits T and T^1, each including a coil and a condenser. The coil and condenser of T are connected in series with each other and in series with the winding of relay N^1, while the circuit T^1, consisting of a parallelly connected coil and condenser, is connected between one of the line wires of the line L^1 and a point midway between the two sections of the code receiving circuit, comprising relays N^2, M^1 and rectifier R^3, and relays N^3, M^2 and rectifier R^4, respectively.

The neutral relays N^2 and N^3 operate upon the closure of the switches S^2 and S^5, respectively. Closure of switches S^1 and S^4, together with the closure of switches S^2 and S^5, respectively, cause the operation of marginal relays M^1 and M^2, respectively, these latter two relays requiring more current than the former two relays.

The contacts of code relays N^1, N^2, N^3, M^1 and M^2 are not shown connected to any other equipment. It is to be understood that these relays are intended to be used to control the operation of station-connecting relays, or translating devices in a telephone station-selecting system, such as an executive call system.

In describing the operation of the system shown in Fig. 1, it will be assumed that, in response to the initiation of a call at station A, the power supply 11 becomes effectively associated with the line L^1. When the subscriber at station S removes the receiver from its support, the switch S^3 is closed. With only switch S^3 operated, the calling subscriber hears dial tone which is made up of the frequency of the supply source 11 and its harmonics. Since the telephone set S at the subscriber's station A has a low impedance, the current in the loop, which now includes the telephone set S, is of sufficient magnitude to operate all relays N^1, N^2, N^3, M^1 and M^2 of the receiving circuit CR, as indicated by the table, Fig. 2. These relays perform no useful function at this time.

Signaling is done by depressing the keys *a* to *q*, each key being assigned to a particular called line. It will now be assumed that a connection with a subscriber's line to which the key *a* is assigned is desired, and that the key *a* is actuated after the removal of the receiver at station A. The actuation of key *a* causes the code bars 2, 3 and 6 to operate, as clearly indicated in Fig. 3, which results in the closure of switch S^2, the opening of switch S^3 and the closure of switch S^6 to its "up" position. The opening of switch S^3 disconnects the telephone set S from the line L^1. The closure of switch S^6 to its "up" position connects the coil L and condenser C in parallel while the closure of switch S^2 includes the resistance X^1 and rectifier R^1 in series with the parallelly connected condenser and coil. Since L and C resonate at the third harmonic, this component is effectively excluded from the line circuit which now includes rectifier R^1 and resistance X^1. Therefore impulses of negative direct current of relatively small magnitude are transmitted over the metallic loop to effect the operation of relay N^2. The circuit in which relay N^2 operates may be traced from the mid-point of the secondary of transformer 12, rectifier R^3, windings of relays N^2 and M^1, coil of filter T^1, lower conductor of the line L^1, rectifier R^1, closed contacts of switch S^2, resistance X^1, contacts of switch S^6 in its "up" position, coil L, left winding of the secondary of transformer 12 to the mid-point thereof. Marginal relay M^1 does not operate in this circuit due to the inclusion of resistance X^1 therein which limits the line current to a value which is insufficient to operate relay M^1. Relay N^2, however, does operate and serves to register the code transmitted incident to the actuation of key *a*.

When the key *a* restores to normal, the switches S^2 and S^6 are opened and switch S^3 is closed, the last reconnecting the subscriber's telephone set S to the line.

It is not believed necessary to trace circuits effected as a result of the operation of each of the keys of the key sender, since the table of Fig. 2 illustrates clearly the switches actuated for each key, the nature of the line current transmitted, and the relays of the code receiving circuit which operate incident to the actuation of each key. It may be well, however, to explain that in Fig. 2 the magnitudes of the positive and negative direct current components are indicated in the column headed Line current by light and heavy characters. A light —DC, for example, indicates a negative direct current component of relatively small magnitude which occurs when the resistance X^1 is included in series with the rectifier R^1, and a heavy —DC indicates a negative direct current component of greater magnitude which occurs when the resistance X^1 is not included in circuit with rectifier R^1. Also, the designation 3F indicates the third harmonic component of the supply source 11 which is transmitted when the switch S^6 is actuated to its "down" position. An "X" in the columns headed by the switch designations S^1 to S^6, inclusive, and also in the columns headed by the relay designations N^1, N^2, N^3, M^1 and M^2 indicate the operation of the corresponding switches and relays, respectively.

The table of Fig. 2 is interpreted as follows: key *a* operates switch S^2 and switch S^6 to its "up" position to cause the transmission of negative impulses of relatively small magnitude which results in the operation of relay N^2; key *b* operates switches S^1 and S^2, and switch S^6 to its "up" position, to cause the transmission of negative impulses of greater magnitude which results in the operation of relays N^2 and M^1; key *c* operates switch S^5 and switch S^6 to its "up" position, to cause the transmission of positive impulses of relatively small magnitude which results in the operation of relay N^3; key *d* operates switches S^4 and S^5, and switch S^6 to its "up" position, to cause the transmission of positive impulses of greater magnitude which causes the operation of relays N^3 and M^2; key *e* operates switches S^2, S^4 and S^5, and switch S^6 to its "up" position, to cause the transmission of line current consisting of a light negative pulsating component and a heavy positive pulsating component (actually it is biased alternating current), which results in the operation of relays N^2, N^3 and M^2; key *f* operates switches S^1, S^2 and S^5, and switch S^6 to its "up" position, to cause the transmission of line current consisting of a heavy negative pulsating direct current component and a light positive pulsating direct current component (which actually is alternating current biased in the opposite direction) which results in the operation of relays N^2, N^3 and M^1; key *g* operates switches S^2 and S^5, and switch S^6 to its "up" position to cause the transmission of line current made up of a light negative pulsating direct current component and a light positive pulsating direct current component (actually light unbiased alternating current) which results in the operation of relays N^2 and N^3; key *h* operates switches S^1, S^2, S^4, S^5, and switch S^6 to its "up" position, to cause the transmission of line current consisting of a heavy negative pulsating direct current component and a heavy positive pulsating direct current component (actually heavy unbiased alternating current), which results in the operation of relays N^2, N^3, M^1 and M^2; key *i* operates switch S^2 and switch S^6 to its "down" position to cause the transmission of a light negative pulsating direct current component and the third harmonic of the supply frequency which results in the operation of relays N^1 and N^2; key *j* operates switches S^1 and S^2, and switch S^6 to its "down" position, to cause the transmission of a heavy negative pulsating direct current component and the third harmonic of the supply frequency which results in the operation of relays N^1, N^2 and M^1; key *k* operates switch S^5 and switch S^6 to its "down" position, to cause the transmission of a light positive pulsating direct current component and the third harmonic of the supply frequency which results in the operation of relays N^1 and N^3; key *l* operates switches S^4 and S^5, and switch S^6 to its "down" position, to cause the transmission of a heavy positive pulsating direct current component and the third harmonic of the supply frequency which results in the operation of relays N^1, N^3 and M^2; key *m* operates switches S^2, S^4 and S^5, and switch S^6 to its "down" position, to cause the transmission of a light negative pulsating direct current component, a heavy positive pulsating direct current component and the third harmonic of the supply frequency which results in the operation of relays N^1, N^2, N^3 and M^2; key *n* operates switches S^1, S^2 and S^5, and switch S^6 to its "down" position, to cause the transmission of a heavy negative pulsating direct current component, a light positive pulsating direct current component and the third harmonic of the supply frequency which results in the operation of relays N^1, N^2, N^3, and M^1; key *o* operates switches S^2 and S^5, and switch S^6 to its "down" position, to cause the transmission of a light negative pulsating direct current component, a light positive pulsating direct current component and the third harmonic of the supply frequency (actually unbiased alternating current of two frequencies), which results in the operation of relays N^1, N^2 and N^3; key *p* operates switch S^6 to its "down" position to cause the transmission of the third harmonic of the supply frequency which results in the operation of relay N^1; and key *q* operates switch S^6 to its "up" position which results in all relays remaining unoperated.

Thus the code receiving relays N^1, N^2, N^3, M^1 and M^2 are operated in various combinations to register the code signal transmitted by each of the keys *a* to *q*, inclusive. As hereinbefore indicated, the relays of the code receiving circuit may be employed to control the operation of telephone line connecting apparatus, whereby a different line may be connected with the calling line L^1 for the operation of each of the keys of the key-type sender.

The symmetrical varistor 10 functions to emphasize the third harmonic of the supply frequency, so that the alternating current voltage is supplied to the line L^1 interconnecting the sending and receiving stations in such a manner as to provide a strong third harmonic. By combining the third harmonic component of the supply source with various combinations of positive and/or negative direct current pulsating components of light and/or heavy magnitudes, applicant has rendered it possible to transmit up to seventeen distinct code signals over a two-wire line without resorting to the use of a ground return. Signaling over a channel which comprises only the two wires of a telephone line is particularly desirable in that it obviates the need for a ground connection at the telephone subscriber's station. Suitable ground connections at the subscriber's stations are, in many instances, difficult to be found.

When alternating current power of two different frequencies is available, the varistor 10 may be omitted, and it is not necessary to have one frequency thrice the other, so long as the resonant circuits are tuned to one frequency or the other.

Fig. 4 and associated Figs. 5 and 6 are illustrative of a system of code signaling which distinguishes from that disclosed in Figs. 1, 2 and 3, primarily in that the symmetrical varistor, or varistors which function to emphasize the third harmonic of the supply frequency, are located at the sending station instead of being directly associated with the supply source at the central office, or receiving station. Also, there are provided nine switches which function to control the character of the current transmitted over the line and consequently the key sender, schematically shown in Fig. 6, is equipped with nine U-shaped code bars. These bars are actuated in the same manner as are the code bars of Fig. 3, through the media of the keys *a* to *q*, inclusive.

The code receiving circuit CR, located at the central office is identical to that shown in Fig. 1 and the elements thereof are identified by the same characters used to designate corresponding elements of the code receiving circuit of Fig. 1.

The code bars of Fig. 6 are designated 1 to 9, inclusive, and the keys of the key sender are designated *a* to *q*, inclusive. As in Fig. 3, the code bars which each key operates are designated by dots at the points where the key levers cross the code bars. In accordance with the illustration of Fig. 6, key *a* operates code bars 3 and 9; key *b* operates code bars 3 and 8; key *c* operates code bars 2, 3, 6 and 9; key *d* operates code bars 3, 5, 6 and 9; key *e* operates code bars 2, 3, 5, 6 and 9; key *f* operates code bars 2, 3, 7 and 8; key *g* operates code bars 3, 5, 7 and 8; key *h* operates code bars 2, 3, 5, 7 and 8; key *i* operates code bars 1, 2, 3, 4, 5, 7 and 8; key *j* operates code bars 2, 3, 4, 5, 6 and 9; key *k* operates code bars 2, 3, 4, 5, 7 and 8; key *l* operates code bars 1, 2, 3, 5, 6 and 9; key *m* operates code bars 1, 2, 3, 5, 7 and 8; key *n* operates code bars 1, 2, 3, 6 and 9; key *o* operates code bars 1, 2, 3, 7 and 8; key *p* operates code bars 3, 4, 5, 7 and 8; and key *q* operates code bars 3, 4, 5, 6 and 9.

Code bar 1, when operated, closes switch S^1; code bar 2 closes switch S^2; code bar 3 opens switch S^3; code bar 4 closes switch S^4; code bar 5 closes switch S^5; code bar 6 closes switch S^6; code bar 7 closes switch S^7; code bar 8 closes switch S^8; and code bar 9 closes switch S^9.

Switch S^1, when closed, short-circuits resistance X^1; switch S^2 connects varistor R^1 to the line by way of resistance X^1; switch S^3, when opened, disconnects the telephone set S from the line L^1; switch S^4 short-circuits resistance X^2; switch S^5 connects the varistor R^2 to the line by way of the resistance X^2; switch S^6 connects the resistance X^3 in series with the line; switch S^7 connects the parallelly connected symmetrical varistors 20 in series with the line; switch S^8 connects the serially connected symmetrical varistors 21 across the line; and switch S^9 connects the resistance X^4 across the line.

The arrangement disclosed in Fig. 4 is particularly advantageous when long line loops are encountered. The silicon carbide units are located at the sending station in Fig. 4 instead of at the receiving station as in Fig. 1. In order to generate odd harmonics when switches S^1, S^2, S^4 and S^5 are all closed, the silicon carbide units 20 are placed in series with the line by means of switch S^7. In order to generate odd harmonics when no current is in the varistors R^1 and R^2, the silicon carbide units 21 are connected across the line by switch S^8. In order to keep the effective current in the varistors R^1 and R^2 the same when odd harmonics are not generated, resistances X^3 and X^4 are substituted by means of switches S^6 or S^9 when their adjacent symmetrical varistors 20 and 21 are out of circuit.

It is believed unnecessary to enter into a detailed description of the circuits effected incident to the actuation of each of the keys of the key sender. It is believed that a complete understanding of the invention will be had from the following discussion which deals particularly with the table shown in Fig. 5.

When a subscriber at the station A desires to initiate a call to another subscriber's station, the receiver at station A is removed from its support and a key, corresponding to the station with which a connection is desired, is actuated. Removal of the receiver closes the line circuit through the switch S^3, and, as in the case of Fig. 1, the calling subscriber hears dial tone which, in this case, causes relays N^2, N^3, M^1 and M^2 to operate. Relay N^1 does not operate since the third harmonic of the supply source 11 is absent from the line current at this time.

Should the calling subscriber actuate key *a* in establishing a connection to a corresponding called station, the code bars 3 and 9 are operated as indicated by Fig. 6. Code bar 3 functions to disconnect the telephone set S from the line by opening switch S^3, and code bar 9 functions to close switch S^9. With switch S^9 closed the resistance X^4 is connected across the line. The value of resistance X^4 is such that the current traversing the line is insufficient to effect the operation of any of relays N^2, N^3, M^1 and M^2 under this condition. This condition may be referred to as the zero condition because no relays are operated.

If key *b* is actuated, code bars 3 and 8 function, the former to disconnect the telephone set S from the line and the latter to close switch S^8. With switch S^8 closed, the symmetrical varistors 21 are connected across the line L^1 to cause the transmission of an emphasized third harmonic of the supply frequency over the metallic loop. The filter T being tuned to pass the third harmonic, effectively completes the energizing circuit for relay N^1, which relay operates to store the signal transmitted incident to the operation of key *b* at the calling station A. Relay N^1 functions to control the operation of equipment (not shown) which serves to complete the connection of the calling line to the called line to which key *b* is individually assigned. When the key *b* returns to normal switch S^3 closes to reconnect the telephone set S to the line for communication purposes.

When key *c* is operated at the subscriber's station A, code bars 2, 3, 6 and 9 function to close switch S^2, open switch S^3, close switch S^6 and close switch S^9, respectively. Relatively weak impulses of negative direct current now traverse a path extending from the mid-point of the secondary winding of transformer 12, rectifier R^3, windings of relays N^2 and M^1, coil of filter T^1, lower conductor of line L^1, switch S^2, resistance X^1, rectifier R^1, switch S^6, resistance X^3, upper conductor of line L^1, and the left winding of the secondary of transformer 12. Due to the inclusion of resistance X^1 in this circuit the magnitude of the current traversing the line is maintained at a value such as to cause only relay N^2 to operate. Relay M^1 does not receive sufficient current to operate. Relay N^2 operates to store the code signal transmitted in response to the actuation of key *c*. The restoration of key *c* to normal reconnects the telephone set S to the line for communication purposes.

Key *d* performs the same switching functions as does key *c* except that the switch S^5 replaces the switch S^2. Thus the rectifier R^2 and resistance X^2 are connected across the line instead of rectifier R^1 and resistance X^1 with the result that relatively light positive impulses of direct current are transmitted over the line to cause the operation of relay N^3. It is deemed unnecessary to trace the circuit in which relay N^3 operates. Relay N^3 functions to store the code signal transmitted over the line as a consequence of the operation of key *d*.

Key *e* is, in effect, a combination of keys *c* and *d* in that it functions to cause the transmission of light impulses of both positive and negative polarities (unbiased alternating current) over the line to cause both relays N^2 and N^3 to operate and collectively store the signal transmitted by the operation of key *e*.

When key *f* is operated code bars 2, 3, 7 and 8 are actuated to effect the closure of switches S^2, S^7 and S^8 and the opening of switch S^3. Switch S^3 disconnects the telephone set S from the line; switch S^2 connects rectifier R^1 across the line in series with resistance X^1; switch S^7 connects the silicon carbide units 20 in series with the line; and switch S^8 connects the silicon carbide units 21 across the line. The closure of these switches results in the transmission of line current comprising a pulsating component of light negative direct current on which is superimposed the third harmonic of the supply source. The fundamental of the supply source is also present but too weak to operate relays. Relay N^1 is very sensitive to and responds to the third harmonic component and relay N^2 operates on the negative pulsating direct current of relatively light magnitude. Relays N^1 and N^2 cooperate to store the code signal transmitted incident to the operation of key *f*.

Should key *g* be operated, code bars **3, 5, 7** and **8** function to open switch S^3, and to close switches S^5, S^7 and S^8, respectively, whereupon line current, consisting of a relatively light pulsating direct current component on which is superimposed the third harmonic of the supply source, is transmitted over the line to actuate relays N^1 and N^3. These relays cooperate to store the code signal transmitted as the result of the operation of key *g*.

Key *h*, operated, causes the actuation of code bars **2, 3, 5, 7** and **8**, whereupon relays N^1, N^2 and N^3 operate respectively, on the third harmonic component of the line current, light pulsating negative direct current components, and light pulsating positive direct current components. Relays N^1, N^2 and N^3 function to store the code signal transmitted when key *h* is operated.

Key *i* causes code bars **1, 2, 3, 4, 5, 7** and **8** to be actuated, whereupon code relays N^1, N^2, N^3, M^1 and M^2 operate. The line current in this case consists of heavy components of both positive and negative pulsating direct current equivalent to heavy alternating current and the third harmonic of the supply frequency. The five operated relays serve to store the code signal transmitted incident to the operation of key *i*.

Key *j* causes code bars **2, 3, 4, 5, 6** and **9** to operate and to effect the transmission of line current comprising negative pulsating direct current components of relatively light magnitude and positive pulsating direct current components of larger magnitude equivalent to biased alternating current which causes relays N^2, N^3 and M^2 to operate. These relays store the code signal transmitted over the metallic loop when key *j* is operated.

Key *k* operates code bars **2, 3, 4, 5, 7** and **8** which results in the transmission of line current similar to that transmitted in response to the operation of key *j* together with the third harmonic of the supply source. Relays N^1, N^2, N^3 and M^2 operate on this current to store the code signal transmitted incident to the operation of key *k*.

Key *l* causes code bars **1, 2, 3, 5, 6** and **9** to operate which results in the operation of relays N^2, N^3 and M^1 on line current consisting of negative pulsating direct current components of heavy magnitude and positive pulsating direct current components of light magnitude, which is equivalent to alternating current biased oppositely to that obtained with key *j*. Relays N^2, N^3 and M^1 store the code signal transmitted by key *l*.

Key *m* causes code bars **1, 2, 3, 5, 7** and **8** to be actuated, whereupon relays N^1, N^2, N^3 and M^1 operate to store the code signal transmitted by key *m*. The line current in this case consists of heavy negative pulsating direct current components, light positive pulsating direct current components and the third harmonic of the supply frequency.

Key *n* causes the operation of code bars **1, 2, 3, 6** and **9** which results in the operation of relays N^2 and M^1 on line current made up of only negative direct current impulses of heavy magnitude. Relays N^2 and M^1 store the code signal transmitted incident to the operation of key *n*.

Key *o* operates code bars **1, 2, 3, 7** and **8** which results in the operation of relays N^1, N^2 and M^1 on line current consisting of a heavy negative pulsating direct current component and the third harmonic of the supply frequency. Relays N^1, N^2 and M^1 store the code signal transmitted when key *o* is operated.

Key *p* operates code bars **3, 4, 5, 7** and **8** whereupon relays N^1, N^3 and M^2 operate to store the code signal resulting from the operation of key *p*. The line current in this case is the same as that caused by key *o* except that the pulsating direct current component is positive instead of negative.

When key *q* is operated, code bars **3, 4, 5, 6** and **9** respond to cause relays N^3 and M^2 to operate and store the transmitted code signal. This signal is characterized by positive direct current pulses of relative large magnitude.

The arrangement disclosed in Fig. 7 distinguishes from that shown in Fig. 4, principally in combining the five relays of the code receiving circuit of the latter with a sixth relay of the dynamometer type. This relay is designated on the drawings by reference character D, and causes a contact pointer to move to either of two contacts depending upon the phase relation between the alternating current supply and the alternating current components used for signaling purposes. This system utilizes two magnitudes of rectified current, superimposed alternating current components, and the third harmonic of the supply frequency. For certain of the code signals, a resistance X^7 is employed which has no appreciable reactive component, and by suitable adjustment of a phase shifter PS included between the supply source and one winding of the dynamometer D, the contact pointer, or armature thereof may be made to rest on the Y contact under this condition. Other code signals are effected by replacing the resistance X^7 with a coil L^7 so as to retard the phase angle θ of the current impressed on the other, or lower winding of the dynamometer D. This shift in phase angle is sufficient to produce operation of the pointer of the dynamometer to the W contact. Thus for each combination of switches closed at the calling subscriber's station A, a corresponding combination of relays in the receiving circuit is operated and each combination of relays operated, includes the operation of the dynamometer relay D to either its Y or W fixed contacts depending upon whether or not the coil L^7 is employed in setting up the code signals.

The key-type sender for this system is shown schematically in Fig. 9 and comprises nine code bars, identified by the numerals **1** to **9**, inclusive, and fifteen keys designated *a* to *o*, inclusive. As in the key senders of Figs. 3 and 6, each key is adapted to actuate one or more code bars and the dots located at the cross-over points of the key levers and code bars in the schematic showing in Fig. 9, indicates the code bars which are actuated by each key. Key *a* operates code bars **1, 2** and **9**; key *b* operates code bars **1** and **9**; key *c* operates code bars **2** and **9**; key *d* operates code bars **1, 8** and **9**; key *e* operates code bars **1, 6** and **9**; key *f* operates code bars **2, 7** and **9**; key *g* operates code bars **2, 5** and **9**; key *h* operates code bars **7, 8** and **9**; key *i* operates code bars **5, 6** and **9**; key *j* operates code bars **3, 4** and **9**; key *k* operates code bars **5** and **9**; key *l* operates code bars **7** and **9**; key *m* operates code bars **6** and **9**; key *n* operates code bars **8** and **9**; and key *o* operates code bar **9**.

The switches or contacts controlled by the code bars are shown in Fig. 7 as switches S^1, S^2, S^3, S^4, S^5, S^6, S^7, S^8 and S^9. The switches S^1, S^3, S^5 and S^7 control the connection of the negatively poled rectifier R^1 to the line L^1. Switch S^1, operated, connects the rectifier R^1 directly across the line; switch S^3, operated, connects the rectifier R^1 in series with the symmetrical varistor 30 across the line; switch S^5, operated, connects the rectifier R^1 in series with the coil L^7 across the line; and switch S^7 connects rectifier R^1 in series with the resistance X^7 across the line.

The switches S^2, S^4, S^6 and S^8 perform the same functions with respect to rectifier R^2 as do the switches S^1, S^3, S^5 and S^7 with respect to rectifier R^1. The switch S^9 controls the connection of the telephone set S to the line.

The procedure in initiating calls from the station A of Fig. 7 is the same as that described in connection with Figs. 1 and 4. The calling subscriber removes the telephone from its support and actuates the particular key which is assigned to the station with which a connection is desired. The switch S^9 is normally closed, and as indicated in Fig. 9, it is actuated to open position whenever any of the sender keys are operated. When the telephone is removed from its support at substation A the telephone set S is effectively connected across the line and alternating current from the source 10 traverses the line by way of the transformer 12. This current being devoid of the emphasized third harmonic at this time does not cause relay N^1 to operate. It does, however, cause the operation of relays N^2, N^3, M^1 and M^2 and moves the dynamometer point to the W contact. This last effect is produced by virtue of the setting of the phase shifter PS and because the subscriber's set which is included in the line circuit at this time has an appreciable reactive component. The current traversing the line under this condition activates the receiver of the telephone set S to caues it to emit a dial tone.

Depending upon which station is to be called, the subscriber at station A actuates one of the sender keys. It will now be assumed that key *a* of the sender is depressed causing the actuation of code bars 1, 2 and 9. The code bar 9 functions to actuate switch S^9 which disconnects the telephone set S from the line. Code bars 1 and 2 close switches S^1 and S^2, respectively, which causes the rectifiers R^1 and R^2 to be connected directly across the line L^1. Both positive and negative pulsating direct current components of relatively large magnitude are therefore transmitted over the line to cause the operation of relays N^2, N^3, M^1 and M^2. Since the third harmonic of the supply frequency is absent from the line current, relay N^1 does not operate, and since the impedance of the subscriber's station has no appreciable reactive component, due to the fact that the coil L^7 is not connected to the line, the dynamometer pointer is moved to the Y contact. Thus, when key *a* of the sender at the subscriber's station A is actuated, relays N^2, N^3, M^1, M^2 and the Y contact of relay D function to store the signal transmitted. This combination of contacts causes the operation of station selecting equipment (not shown) which results in the connection of the station, to which the key *a* is assigned, to the calling line L^1. When the key *a* restores to normal, the switch S^9 is closed to reconnect the subscriber's telephone set S to the line.

Should key *b* be actuated, code bars 1 and 9 function to close switch S^1 and to open switch S^9, respectively. Switch S^9 disconnects the telephone set S from the line L^1 and switch S^1 connects rectifier R^1 directly across the line. The connection of rectifier R^1 to the line results in the transmission of a pulsating negative direct current component of relatively large magnitude (biased alternating current) which causes relays N^2 and M^1 to operate. The dynamometer relay D moves its pointer to contact Y for reasons now apparent. Thus relays N^2 and M^1, and the contact Y of relay D function to store the code signal transmitted incident to the operation of key *b*.

Key *c*, operated, causes code bars 2 and 9 to operate and connect rectifier R^2 directly across the line L^1 and to disconnect the telephone set S from the line. The connection of rectifier R^2 to the line results in the transmission of line current consisting only of a pulsating positive direct current component of relatively large magnitude (alternating current biased oppositely to that described in the preceding paragraph) over the metallic loop which results in the operation of relays M^2 and N^3 and of relay D to its Y contact. These relays accordingly store the code signal transmitted from station A when key *c* is operated.

Should key *d* be actuated the code bars 1, 8, and 9 operate to close switches S^1 and S^8 and to open switch S^9. Switch S^9 disconnects the telephone set S from the line while switch S^1 connects rectifier R^1 directly across the line L^1 and switch S^8 connects rectifier R^2 across the line in series with resistance X^7. Thus the line current is characterized by a relatively small positive pulsating direct current component and a heavier negative pulsating direct current component which results in the operation of relays N^2, N^3, and M^1, and relay D to its Y contact. These relays cooperate in storing the code signal transmitted when key *d* is actuated.

When key *e* is operated code bars 1, 6, and 9 function to close switches S^1 and S^6 and to open switch S^9. Switch S^9 disconnects the telephone set S from the line whereas switches S^1 and S^6 cause the connection of rectifier R^1 directly across the line and rectifier R^2 across the line in series with coil L^7. Rectifier R^1 produces a relatively heavy negative pulsing direct current component whereas the coil L^7 and rectifier R^2 produce delayed positive pulses of small amplitude. This is equivalent to biased alternating current, of frequency F. The coil L^7 causes a shift in phase in the alternating current portion of the line current traversing the lower winding of relay D relative to the phase that would exist were coil L^7 not present with the result that the pointer or armature of relay D remains on contact W. Relays N^2 and M^1 respond to the relatively heavy negative pulsating direct current component and relay N^3 responds to the rectified positive half waves of frequency F admitted by rectifier R^4. These relays function to store the code signal transmitted incident to the operation of key *e*.

Key *f*, operated, causes the operation of code bars 2, 7 and 9 which, in turn, effect the closure of switches S^2 and S^7 and the opening of switch S^9. Switch S^9 performs its usual function of disconnecting the telephone set S from the line while the closure of switches S^2 and S^7 produce a line current which is made up of a heavy positive direct pulsating current component and a lighter negative pulsating direct current component (actually biased alternating current), the latter resulting from the connection of resistance X^7 in series with rectifier R^1. Since the substation A now contains no reactive component, the phase of the alternating current portion of the line current is displaced in such a direction as to cause the armature of relay D to engage contact Y. Relays N^2, N^3 and M^2 operate and together with relay D, operated to its Y contact, store the code signal transmitted when key *f* is actuated.

Key *g* operates code bars 2, 5, and 9 to cause the transmission of line current consisting of a heavy positive pulsating direct current component, and a negative pulsating direct current component which traverses the coil L^7 connected to the line as a consequence of the operation of code bar 5. With coil L^7 connected in the signal transmitting circuit relay D remains with its armature on contact W while relays N^2, N^3, and M^2 operate their respective armatures. Thus relays N^2, N^3, M^2 and the W contact of relay D cooperate to store the signal transmitted as a consequence of the operation of key *g*.

Key *h*, when actuated, causes code bars 7, 8, and 9 to operate and close switches S^7 and S^8 and open switch S^9, respectively. Thus the telephone set S is disconnected from the line by the opening of switch S^9 and line current consisting of relatively light positive and negative direct pulsating current components (same as light alternating current of frequency F), is transmitted over the line and whose phase is advanced with respect to the phase of the current traversing the upper winding of relay D. Thus the armature of relay D engages the contact Y and relays N^2 and N^3 operate to store the signal transmitted incident to the actuation of key *h*.

Key *i*, operated, causes code bars 5, 6, and 9 to function and operate switches S^5, S^6, and S^9, the last to its open position. Thus line current consisting of light alternate positive and negative direct current pulses, and whose phase is retarded relative to that of the current traversing the upper winding of relay D, is transmitted over the line to effect the operation of relays N^2 and N^3, and of relay D to its W contact. Thus relays N^2, N^3, and D cooperate to store the signal transmitted when key *i* is operated.

Key *j*, causes the operation of code bars 3, 4, and 9 which, in turn, operate switches S^3, S^4, and S^9. Switches S^3 and S^4 connect the rectifiers R^1 and R^2, respectively, across the line in series with the symmetrical varistor 39, while switch S^9 disconnects the telephone set S from the line. Thus the line current resulting from the actuation of key *j* consists of alternate relatively light positive and negative direct current components and the third harmonic of the supply source 19. Relays N^1, N^2, and N^3 accordingly operate as does also relay D to its Y contact, to store the signal transmitted in response to the operation of key *j*. It is understood that the circuit T included in series with the winding of relay N^1 is tuned to the third harmonic of the frequency of supply source 19.

Key *k* operates code bars 5 and 9 which, in turn, operate switches S^5 and S^9, the latter disconnecting the telephone set S from the line, and the former connecting rectifier R^1 across the line in series with the coil L^7. Thus the resulting line current, comprising delayed negative pulsating direct current (same as delayed alternating current frequency F with bias) has an alternating current component whose phase is retarded relative to the phase of the current traversing the upper winding of relay D, and causes relay N^2 to operate and relay D to remain with its armature engagement with the contact W. Relay N^2 and relay D thus cooperate in storing the code signal transmitted incident to the actuation of key *k*.

When key *l* is operated, the code bars 7 and 9 function to operate switches S^7 and S^9, the latter disconnecting the telephone set from the line and the former connecting rectifier R^1 across the line in series with resistance X. Thus a relatively light negative pulsating direct current whose alternating current component has an advanced phase relative to that of the current traversing the upper winding of relay D, is transmitted over the line loop to cause relay N^2 to operate and relay D to operate its armature to the Y contact. In this manner the code signal transmitted incident to the operation of key *l* is stored by the code receiving circuit CR.

Key *m* functions to cause the transmission of line current which consists of a positive direct current component with alternating current of frequency F superimposed, whose phase, relative to the phase of the current traversing the upper winding of relay D is retarded or negative. This current causes relay N^3 to operate and relay D to remain with its armature on contact W. Thus relays N^3 and D cooperate to store the code signal transmitted over the metallic loop when key *m* is operated.

Key *n*, when operated, produces a line current similar to that transmitted when key *m* is operated except that its phase is positive rather than negative due to the substitution of resistance X^7 for coil L^7. Thus relay N^3 and the contact Y of relay D serve to store the signal resulting from the operation of key *n*.

Key *o* results in a complete opening of the line circuit at the subset. However, due to capacity in the line L^1 there may be a small amount of leading current of frequency F flowing through the lower winding of the dynamometer, unless it is balanced out by the artificial line. If leading current flows and if the dynamometer is sufficiently sensitive, it will cause the armature to swing to contact Y. In order to make sure that contact is made at Y the dynamometer is preferably adjusted to always make contact at Y when no current flows.

When a subscriber's loop is supposed to be open and relays at the central office deenergized, trouble may be experienced on long loops due to capacity and/or leakance, which permit spurious relay current to flow. This causes false operation of relays. This trouble may be eliminated whenever necessary by the use of an artificial line connected between the right-hand terminal of the right-hand secondary winding of transformer 12 and the lower conductor of line L or L^1 in Figs. 1, 4, or 7. This artificial line may be set to have the same impedance as the actual line when open at the subset, and then if the secondary windings of transformer 12 are balanced, no current flows in the relays.

What is claimed is:

1. The combination in a code signaling system, of a sending station, a receiving station, a metallic loop interconnecting said stations, a source of alternating current, means for translating the current from said source into components comprising positive and negative direct current and an emphasized harmonic of the fundamental frequency of said source, selectively operable means at the sending station for applying to the interconnecting metallic loop the said current components in various combinations to characterize signals, and means at the receiving station se-

lectively responsive to the current components applied to said loop.

2. The combination in a code signaling system, of a sending station, a receiving station, a metallic loop interconnecting said stations, a source of power associated with said loop and comprising an alternating current source having an emphasized harmonic, means for deriving positive and negative direct current components from said source, means at the sending station for selectively applying the positive and/or negative direct current components to said line in various combinations to characterize signals, means at the sending station for combining the emphasized harmonic of said source with various combinations of positive and/or negative direct current components to characterize other signals, and means at the receiving station selectively responsive to the various current components by which the signals are characterized.

3. The combination in a code signaling system, of a sending station, a receiving station, a signal channel comprising a metallic loop interconnecting said stations, a source of alternating current, means at said sending station for deriving from said source of alternating current an impulse consisting of positive and negative direct current components and an emphasized harmonic of the frequency of said source and for transmitting the impulse over said signal channel, and means at said receiving station selectively responsive to the positive and negative direct current components of the transmitted impulse and to the emphasized harmonic of said source.

4. The combination in a code signaling system, of a sending station, a receiving station, a signal channel comprising a metallic loop interconnecting said stations, a source of alternating current, means at said sending station for deriving positive direct current from said source, means for deriving negative direct current from said source, means for emphasizing a particular harmonic of the frequency of said source, means for simultaneously connecting said deriving means and said harmonic emphasizing means to said channel whereby a code signal consisting of positive and negative direct current components and the emphasized harmonic of said source is transmitted over said channel to said receiving station, and means at the receiving station selectively responsive to the several components of the transmitted code signal.

5. The combination in a code signaling system, of a sending station, a receiving station, a signal channel comprising a metallic loop interconnecting said stations, a source of alternating current, means at said sending station for deriving positive and negative direct current components from said source, means at said sending station for emphasizing a particular harmonic of the frequency of said source, means at said sending station for transmitting various combinations of the direct current components over said channel and for superimposing thereon the emphasized harmonic of said source to characterize code signals, and means at the receiving station selectively responsive to the positive and negative direct current components and to the emphasized harmonic of said source.

6. The combination in a code signaling system, of a sending station, a receiving station, a signal channel comprising a metallic loop interconnecting said stations, a source of alternating current at said receiving station, means associated therewith for emphasizing a particular harmonic of the frequency of said source whereby current supplied from said source is characterized by an emphasized particular harmonic of said source, means at said sending station for deriving positive and negative direct current components from said source, a circuit at said sending station which resonates at the emphasized harmonic of said source, means at said sending station for connecting said circuit to said channel so as to suppress the emphasized harmonic of said source, means at said sending station for connecting said circuit to said channel so as to admit the emphasized harmonic of said source, means for operating said deriving means and said circuit connecting means in various combinations whereby signals comprising various combinations of positive and/or negative direct current components with or without the emphasized harmonic of said source are transmitted over said channel, and means at the receiving station selectively responsive to the several components of the transmitted signals.

7. The combination, in a code signaling system, in which signals are characterized by current impulses comprising positive and/or negative direct current components and a superimposed third harmonic of a source of alternating current, of a transmitting station, a receiving station, a metallic loop interconnecting said stations, switching means at said sending station for grouping the positive, negative and third harmonic components of the source of alternating current in various combinations for transmission over said metallic loop, and a receiving circuit at said receiving station comprising translating devices individually responsive to each of the components of the transmitted signals.

8. In combination, a code sending station, a code receiving station, a metallic loop interconnecting said stations, a source of alternating current associated with said metallic loop, means comprising a symmetrical varistor associated with said source of current whereby the current available for transmission over said loop from said source includes an emphasized particular harmonic of the frequency of said source, means at said sending station for simultaneously rectifying the current from said source and excluding the particular emphasized harmonic thereof from said loop to characterize a particular signal, other means at said sending station for simultaneously rectifying the current from said source and for permitting the passage of the particular emphasized harmonic, and means at said receiving station for recording the transmitted signals comprising a relay selectively responsive to the rectified component of said source and a relay selectively responsive to the particular emphasized harmonic thereof.

9. In combination, in a code signaling system, a metallic loop extending from a code transmitting station and terminating at a code receiving station in a code receiving circuit, a source of alternating current associated with said loop, said code receiving circuit comprising a relay connected across the line conductors of said loop in series with a circuit tuned to a particular harmonic of the frequency of said source, and a circuit connected in parallel with said series connected relay and tuned circuit comprising two similar branches, each branch comprising a unidirectional current conducting device and a pair of relays connected in series therewith, the unidirectional current conducting devices of said branches being poled oppositely, and means at

the sending station for transmitting a code signal over said loop, said signal being characterized by a current derived from said source and consisting of positive and negative direct current components and the particular harmonic component of said source, whereby a relay in each of said branch circuits and the relay serially connected with said tuned circuit operate to record the transmitted signal.

10. In combination, in a code signaling system, a metallic loop extending from a code transmitting station and terminating at a code receiving station in a code receiving circuit, a source of alternating current associated with said loop, said code receiving circuit comprising a circuit tuned to a particular harmonic of the frequency of said source connected across the line conductors of said loop and including a relay, and branch circuits connected in parallel with said tuned circuit, each comprising a pair of relays and a varistor connected in series, one relay in each group requiring an operating current of greater magnitude than the other relay and the varistors of said branch circuits being oppositely poled, and means at the transmitting station for transmitting code signals over said loop, said signals being characterized by a current derived from said source and consisting of various combinations of positive and/or negative direct current components of different magnitudes and the particular harmonic component of said source, whereby the relays in said tuned circuit and in said branch circuits operate in corresponding combinations to record the transmitted signals.

11. In combination, a code sending station, a code receiving station, a metallic loop interconnecting said stations, a source of alternating current associated with said loop, means at said sending station for rectifying the current from said source, means at said sending station for emphasizing the third harmonic of the frequency of said source, means at said sending station for connecting said rectifying means and said harmonic emphasizing means to said line in various combinations, whereby signals which are characterized by various combinations of positive and/or negative direct current components and the third harmonic component of said source are transmitted over said metallic loop, and means at said receiving station selectively responsive to the signal characterizing current components transmitted over said loop.

12. In combination, in a code signaling system, a transmitting station, a receiving station, a metallic loop interconnecting said stations, a source of alternating current associated with said loop, a receiving circuit terminating said loop at said receiving station comprising means selectively responsive to positive and negative direct current components derived from said source and a dynamometer type relay having a first winding included in series with said selectively responsive means and a second winding connected across said source of alternating current, whereby the operating member of said dynamometer type relay is adapted to operate either of two contacts depending upon the phase displacement of the current traversing its first winding relative to that of the current traversing its second winding, and means at said transmitting station for transmitting code signals over said loop characterized by current derived from said source and consisting of various combinations of positive and/or negative direct current components and an alternating current component which has a phase displacement relative to the current supplied by said source to said dynamometer relay, whereby said selectively responsive means and said dynamometer relay are operated in various combinations to record the transmitted signals.

13. In combination, in a code signaling system, a sending station, a receiving station, a metallic loop interconnecting said stations, a source of alternating current associated with said loop, a receiving circuit terminating said loop at said receiving station comprising means selectively responsive to positive and negative direct current components derive from said source and a dynamometer type relay having a first winding connected to said metallic loop and a second winding connected to said source of alternating current whereby the armature of said dynamometer type relay is adapted to engage either of two contacts depending upon whether the current in its said first winding leads or lags the current in its said second winding, means at said sending station for deriving positive and negative direct current components from said source, means at said sending station for shifting the phase of the current in said metallic loop relative to that of the current traversing said second winding of said dynamometer relay, and means at said sending station for connecting said deriving means and said phase shifting means to said metallic loop whereby the line current transmitted over the loop is composed of pulsating positive and negative direct current components and contains an alternating component whose phase relative to that of the current traversing the said second winding of said dynamometer relay is retarded to cause the operation of said selectively responsive means and the operation of the armature of said dynamometer relay to a particular one of its contacts.

14. The combination, in a code signaling system, of a sending station, a receiving station, a metallic loop interconnecting said stations, a source of alternating current for supplying alternating current to said loop, a code receiving circuit at said receiving station comprising translating devices selectively responsive to positive and negative pulsating direct current components of the alternating current source and a phase detector having one winding connected directly to said alternating current source and a second winding connected to said loop whereby said one winding is subjected to current from said source and said second winding is subjected to the current which traverses said loop, means at said sending station for translating the current from said source into positive and negative pulsating direct current components, means at said sending station for producing a shift in the phase of the alternating current component in said loop relative to that supplied to said first winding of said dynamometer relay, and means at said sending station for simultaneously operating said translating means and said phase shifting means, to produce in said loop a signal characterizing current consisting of positive and negative pulsating direct current components and containing an alternating component whose phase relative to that of the current traversing said first winding of said dynamometer relay is displaced, whereby said code receiving translating devices and said dynamometer relay operate to record the transmitted signal.

15. In a code signaling system, a sending sta-

tion, a receiving station, a two-conductor line interconnecting said stations, a source of power comprising an alternating current supply of fundamental frequency and an emphasized particular harmonic of the fundamental frequency, means connecting said source of power to said line, a pair of oppositely poled rectifiers at said sending station adapted when connected across said line to convert the fundamental frequency component of said source of power into positive and/or negative direct current components, a filter tuned to the emphasized harmonic of the fundamental frequency, switching means for connecting each of said rectifiers across said line, switching means for connecting said filter in series with said line or across said line to effectively pass or suppress the emphasized harmonic, means for operating said switching means in various combinations whereby code signals comprising various combinations of positive and negative direct current components with or without the emphasized harmonic are transmitted over said line to said receiving station, and means at said receiving station selectively responsive to the separate components of the transmitted code signals.

KENNETH W. PFLEGER.