April 19, 1955 E. W. HULLEGÅRD ET AL 2,706,746

FIGURE SELECTION WITH PUSH BUTTONS

Filed July 11, 1951 3 Sheets-Sheet 1

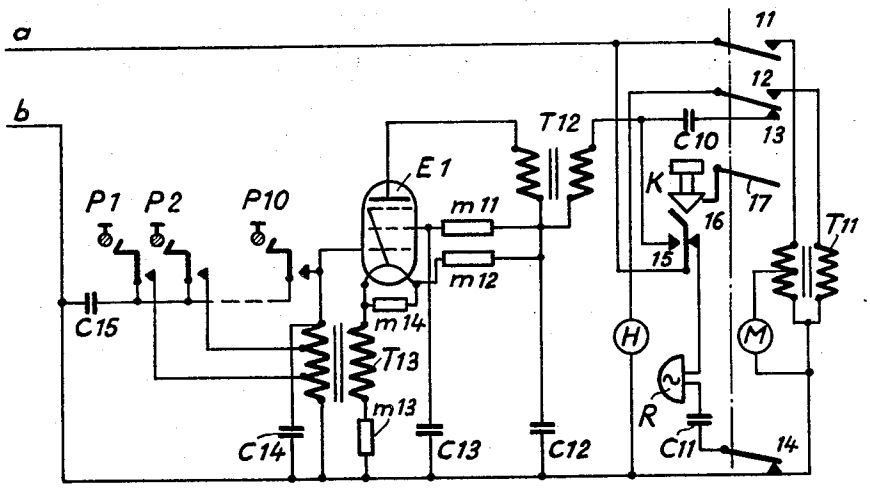

Fig. 1

Fig.3	Fig.2	Fig.1

Fig. 4

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FIGURE SELECTION WITH PUSH BUTTONS

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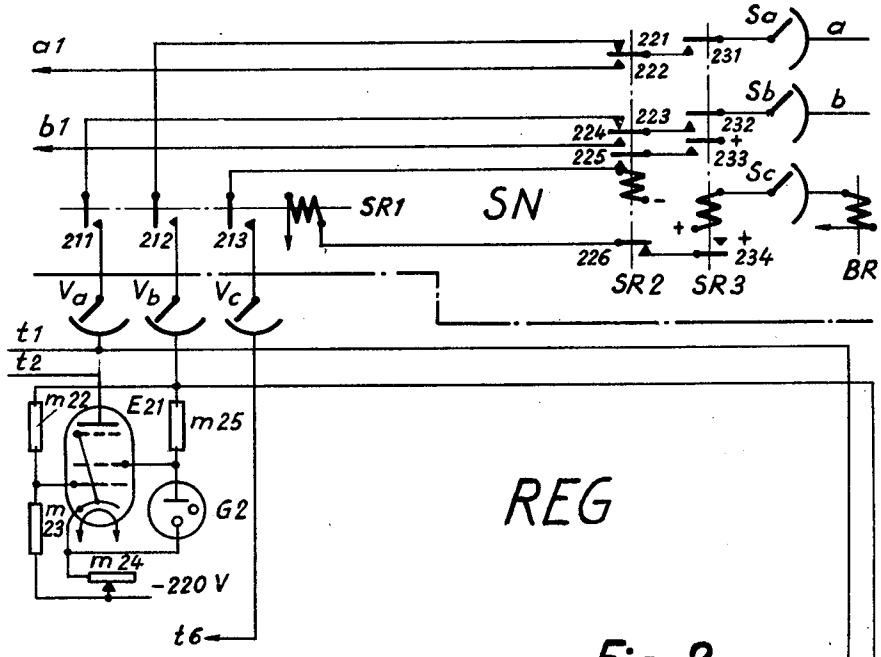

Fig. 2

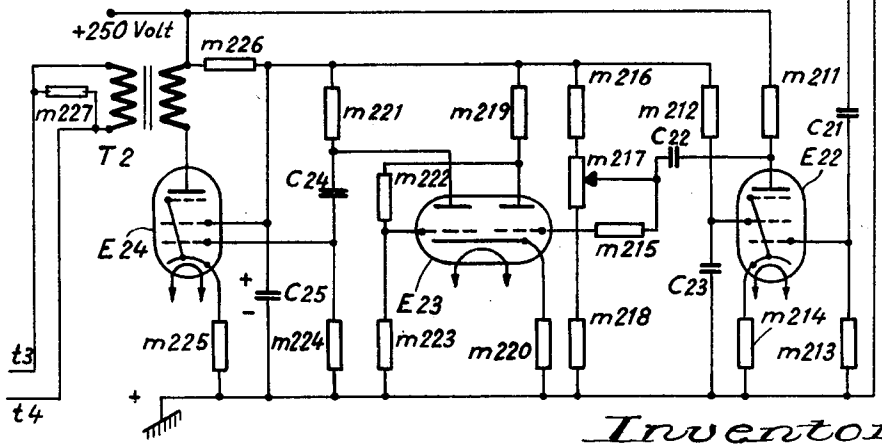

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FIGURE SELECTION WITH PUSH BUTTONS

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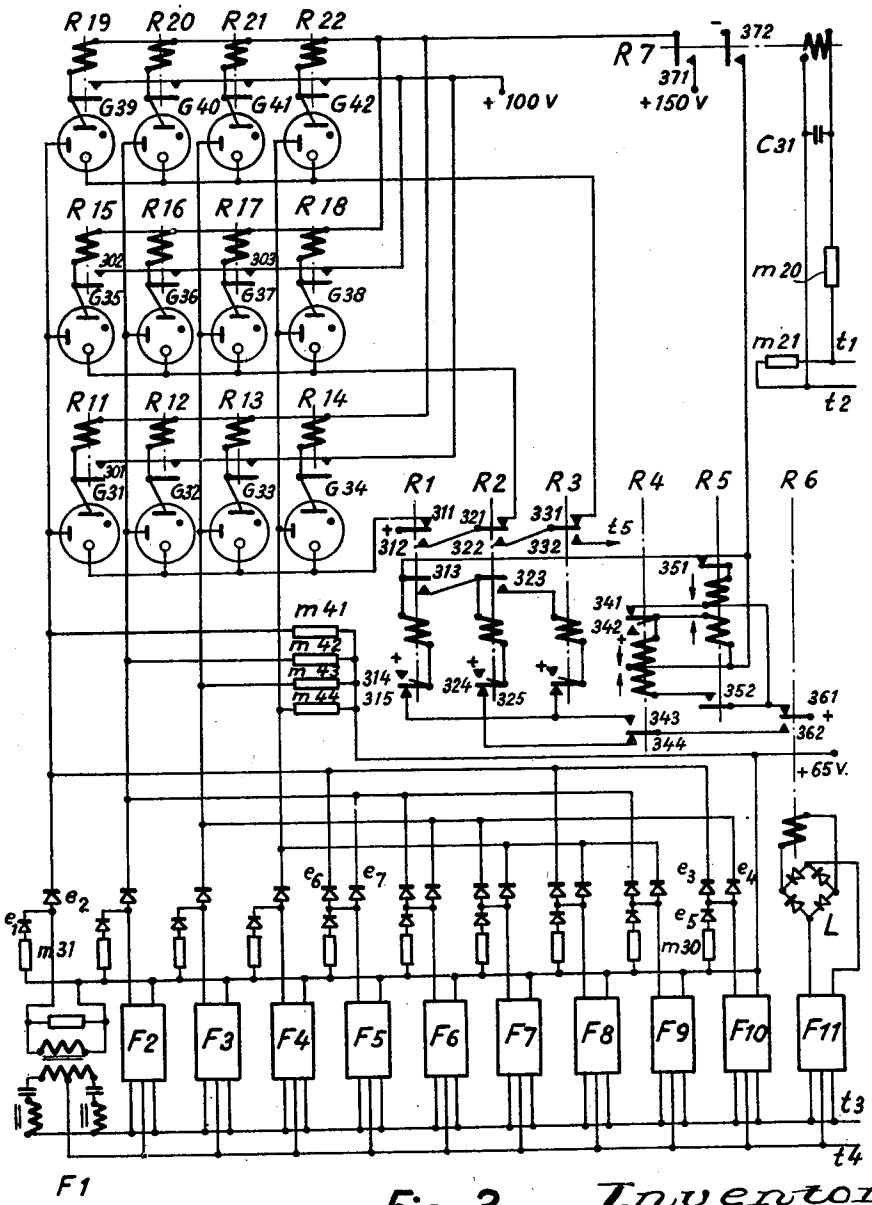

Fig. 3

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FIGURE SELECTION WITH PUSH BUTTONS

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4 Claims. (Cl. 179—16)

The present invention relates to such automatic telephone systems, in which the subscribers' instruments are for the sending of figures provided by means of push buttons instead of dials, and besides comprise a tone frequency generator for emission of different tone frequency currents depending on which one of the push buttons is pressed down.

The tone frequency currents actuate a tone signal receiver at an exchange and are transmitted to a register, which provides for the connection to a called line. Each tone signal receiver is suitably connected with a register and the so connected units are common to a great number of subscribers' lines. Due to the subscribers' lines being of varying lengths and having different electrical properties difficulties thereby arise in separating tone frequency signals by means of filters and preventing the effect of disturbing voltages.

According to the invention disturbances from harmonics in non-sinusoidal waves, which are prevented by for at least one of the voice frequency currents to be a harmonic at the fundamental frequency for another one of the voice frequency currents, and by connecting the band pass filters to allow a harmonic to pass to only one receiving circuit to designate a signal in the receiver, while a band pass filter for a fundamental frequency is connected to at least two receiving circuits, one of which is also connected to the filter for one harmonic corresponding to the fundamental frequency, and which two circuits in combination designate a separate signal.

An embodiment of the invention will be described more fully below with reference to the accompanying drawings Figs. 1–4.

Fig. 1 shows a subscriber's instrument;

Fig. 2 shows on the upper part of the drawing a part of a connecting link and on the lower part of the drawing a part of the tone signal receiver in a register comprising a trigger and a device for supplying the subscriber's instrument with direct current;

Fig. 3 shows relays for the register and filters for the tone signal receiver in the register; and,

Fig. 4 shows how Figs. 1–3 must be assembled.

In Fig. 1, M designates a microphone, H a telephone receiver and T11 a transformer and R a bell connected in series with a condenser C11. The switch hook actuates the contacts 11—14, which are shown in their rest position on the drawing. A push button K with contacts 16—16 depends in such a manner on the switch hook of the instrument, that if the push button is pressed down while the micro-telephone rests on the switch hook it is then held by a spring 17 until the micro-telephone is lifted.

The instrument further comprises a tone frequency generator consisting of an electron tube E1, two transformers T12 and T13, the resistances *m*11—*m*14 and the condensors C13—C14. The frequency developed by the generator can be varied by means of 10 push buttons P1–P10 and a condenser C15.

The subscriber's line *a*—*b* is connected to a telephone exchange and upon originating a call is connected over a line finder S*a*—C*c* in Fig. 2 to a connecting link SN, which is connected to a register REG by means of a register finder V*a*—V*c*.

The electron tube E21 and the discharge lamp G2 form, together with the resistances *m*22—*m*25, a device for supplying the calling subscriber's line with constant current.

The electron tube E23, together with the resistances *m*215—*m*223, forms a wave shaper connected between the two amplifying tubes E22 and E24. The transformer T2 is an output transformer for adapting the tube E24 to its load, which consists of the resistance *m*227 and the filters F1—F11 in Fig. 3.

In Fig. 3, F1–F11 are filters for eleven (11) different frequencies, of which F1–F10 correspond to the push buttons P1–P10 in Fig. 1. The frequency F11 is developed by the generator E1 in the subscriber's instrument, when the push button K alone is pressed down and the micro-telephone is not lifted. The combined filters F1–F10 are over the rectifiers *e*1—*e*5, and others, connected to the discharge lamps G31—G42. A relay R11—R22 is connected to each discharge lamp. Four (4) discharge lamps with associated relays are used for each figure which is to be registered.

The relays R1—R5 shift the different groups of discharge lamps G31—G24, G35—G38 and G39—G42, as the figures arrive to the register. Relay R7 is a current feeding relay, which holds the connection between the calling subscriber and the register during dialing and establishing of the connection.

A call from the subscriber's instrument in Fig. 1 starts when the push button K is pressed down, after which it is locked by the spring 17. The contact 15 is closed and the contact 16 is broken. The line circuit is closed over the contact 15, the right winding on transformer T12, resistance *m*12, the filament in the electron tube E1, with the parallel resistance *m*14, the right winding on transformer T13 and resistance *m*13. A line relay at the telephone exchange starts a line finder S*a*—S*c*, which tests the cut off relay BR of the calling line. The test relay SR3 attracts its armature. The contacts 231—234 are closed. The register finder V*a*—V*c* selects a free register, after which relay SR1 attracts its armature and the contacts 211—213 are closed.

The following circuit is closed, ground Fig. 2, contact wiper V*b*, contacts 212, 221 and 231, contact wiper S*a*, conductor *a*, contact 15 in Fig. 1, T12, *m*12, and filament of E1, T13, *m*13, conductor *b*, contact wiper S*b* in Fig. 2, contacts 232, 223, 211, contact wiper V*a*, conductor *t*1, resistance *m*20 in Fig. 3, relay R7, conductor *t*2, electron tube E21 in Fig. 2, resistance *m*24, to —220 volts.

The electron tube E1 in Fig. 1 is actuated by said circuit. The filament is heated, the screen grid is energized over the resistance *m*11 and the anode is energized through transformer T12. The control grid is energized with help of suitable current over the left winding on transformer T13 through the voltage drop in resistance *m*13. The left winding on transformer T13 forms together with the condenser C14 an oscillating circuit, the frequency of which corresponds with the resonance frequency for the filter F11 in Fig. 3. Through the transformer T13, the oscillations in the oscillating circuit T13—C14 actuate the electron tube E1, which begins to oscillate and emits a tone frequency current through the transformer T12, the primary side of which is closed through the condenser C12. The voltage on the screen grid is thereby kept relatively constant by means of the condenser C13.

In order that the electron tube E1 with resistances *m*11—*m*14 may function independently of the resistance of the subscriber's line, the energizing current from the telephone exchange is kept constant by means of the electron tube E21 in Fig. 2. The voltage of the screen grid is kept constant with relation to the cathode of the tube by means of the discharge lamp G2, which is energized through a series circuit including the resistances *m*24 and *m*25. The voltage of the control grid of the electron tube E21 is kept constant by means of the resistances *m*22 and *m*23. When the anode circuit is closed, a current is obtained through the tube E21 and a change arises in the initial voltage of the control grid through increased voltage drop over resistance *m*24. The electron tube E21 is thereby automatically set on a fixed current independently of the resistance of the connected subscriber's line. The resistance *m*24 is adjustable so that the value of the anode current may be adjusted.

The energizing current over the subscriber's line actu-

ates relay R7 in Fig. 3. The contacts 371—372 are closed. Relay R7 is slow operating owing to the resistances *m*20 and *m*21 and the condenser C31, whereby relay R6 has time to attract and actuates the contacts 361—362 before contact 372 is closed. Relay R6 is actuated by the tone frequency current, the frequency of which is determined by condenser C14 in Fig. 1 and is allowed to pass through filter F11. The contacts 361—362 are actuated.

The a. c. generated by the electron tube E1 in Fig. 1 passes the condenser C21 and the resistance *m*213 in Fig. 2. The voltage over resistance *m*213 actuates the control grid of the amplifying tube E22, the screen-grid voltage of which is determined by the resistances *m*226 and *m*216—218. The resistance *m*212 and the condenser C23 keep the voltage of the screen-grid constant. The amplified a. c. passes over condenser C22 and resistance *m*215 to the above mentioned trigger.

The trigger consists of a double tube E23 with resistances *m*219—*m*223. At rest the left half of the tube E23 is energized and the voltage drop over resistance *m*220 produces a negative voltage on the control grid for the right half. If a voltage wave comes in over condenser C22 and resistance *m*215, one of its half waves will produce a change of the current through the tube E23 from the left half to the right half, so that the voltage drop over resistance *m*219, together with the voltage drop over resistance *m*220, produces on the control grid in the left half of the tube a negative voltage. When the current in the left half of the tube decreases, the voltage drop over the resistance *m*220 decreases, and the voltage on the right control grid increases. The current through resistance *m*221 suddenly ceases.

The current through the resistance *m*221 decreases and the voltage change on the condenser C24 actuates the control grid in the amplifying tube E24, the screen grid of which is energized over resistance *m*226 and is kept constant by means of an electrolytic condenser C25. A rectangular current wave is obtained through the tube E24, the resistance *m*225 and the transformer T2. The transformer T2 is matched to the filters F1–F11 and the load resistance *m*227. The electron tubes E22—E24 are energized with anode current from a battery with an electromotive force of 250 volts.

The transformer T2 in Fig. 2 is connected through the conductors *t*3—*t*4 to the filters F1–F11 in Fig. 3. Each filter comprises a transformer, two condensers, a coil and a load resistance, which are connected as is shown for filter F1 in Fig. 3. As stated above, the filter F11 is resonated for the frequency determined by condenser C14 and transformer T13 in Fig. 1. Each one of the filters F1–F10 allows one of the ten frequencies to pass, these being developed by connecting the condenser C15 by means of one of the push buttons P1–P10 to different terminals on the left winding of transformer T13.

The emitted frequency changes for each figure selected by the set of push buttons P1–P10, and thus relay R6 releases its armature; simultaneously, a voltage arises over one of the resistances *m*41—*m*44, whereby the corresponding discharge lamps G31—G42 glow. Assuming that the push button P1 is pressed down, voltage arises over resistance *m*41. The transformer in filter F1 is energized through the resonance filter F1. One of the half waves passes the rectifier *e*1 and the resistance *m*31 and the other one passes the rectifier *e*2 and the resistance *m*41. The voltage over resistance *m*41 is added to a voltage of 65 volts on the discharge lamp G31, which then glows. Relay R11 attracts its armature through the following circuit; +150 volts, contact 371, winding on relay R11, discharge lamp G31, contact 311 to +, which is at ground potential. The contact 301, and other contacts for registering operated by relay R11 (which are not shown on the figure), are actuated. Relay R11 holds itself with an auxiliary voltage of +100 volts. Simultaneously, two circuits are closed, one from contact 361 through the upper winding of relay R5 over contact 351 and one over contact 341 through the lower winding of relay R5 to contact 372. The two windings of relay R5 counteract each other, and therefore the said two circuits do not actuate relay R5. When contact 341 breaks and 342 closes, no other change takes place than that the lower winding is energized from contact 342 instead of over contacts 361 and 341. When the signal ceases, the tone frequency which actuates relay R6 resumes. Contact 361 breaks and contact 362 closes. The current through the upper winding on relay R5 is thereby broken, but not the current through its lower winding, and therefore relay R5 attracts its armature. The contacts 351—352 are actuated. Simultaneously the following circuit is closed; +, contacts 362, 343 and 315, winding on relay R1, contact 372 to negative. Relay R1 attracts its armature. The contacts 311—315 are actuated. Relay R1 is thereafter kept energized over contact 314.

On the following signal relay R6 releases its armature again. The lower winding on relay R4 is energized over the contacts 361, 352 and 372. Since the two windings on relay R4 counteract each other, relay R4 releases its armature. Relay R5 on the other hand is kept energized through its lower winding until the end of the signal and relay R6 attracts its armature, whereby the current is broken by contact 361. Relay R5 releases its armature. The following circuit is closed; +, contacts 362, 344 and 325, winding on relay R2, contacts 313 and 372 to negative. Relay R2 attracts its armature. Contacts 321—325 are actuated. Relay R2 is kept energized over contact 324.

Assume now that the push button P10 in the subscriber's instrument, Fig. 1, was pressed during the above mentioned second signal. The tone frequency for which the filter F10 is resonated, is emitted from the subscriber's instrument. One of the half waves of the alternating voltage arising in the secondary winding on the transformer in filter F10 produces a rectified current through the rectifier *e*5 and the resistance *m*30. The other half wave causes rectified currents through the rectifiers *e*3 and *e*4 and the resistances *m*41 and *m*43. The voltage drops across resistances *m*41 and *m*43 are added to the voltage of +65 volts and the discharge lamps G35 and G37 glow in the following circuit; +, contacts 312 and 321, discharge lamps G35 and G37 winding on relays R15 and R17, contact 371 to +150 volts. Relays R15 and R17 attract their armatures and are held across contacts 302 and 303. Simultaneously other contacts of the relays G35 and G37 are also closed (which contacts are not shown on the drawing, since they are now essential to the invention). The combination G35 and G37 indicates the figure corresponding to the signal.

According to the invention, a third figure can also be indicated in the register after relay R2 has attracted its armature. One or two of the discharge lamps G39—G42 thereby glow and the corresponding relays R19—R22 attract their armatures. At the end of the signal relay R3 attracts. Contact 331 breaks the current through the discharge lamps and a circuit is closed over contacts 312, 322 and 332 and wire *t*5 actuating parts of the register, which are not drawn on the figure, whereby an indication is given, that three figures have been received.

The register REG thereafter arranges a communication and is released by + being connected to wire *t*6 in Fig. 2, whereby a circuit for relay SR2 is closed over the contact wiper Vc and contact 213. Relay SR2 attracts its armature and the contacts 221—226 are actuated. The current for relay SR1 is broken by contact 226. Relay SR1 releases its armature and the register is released. Relay SR2 is kept energized over contacts 225 and 233. A communication is established between the wires *a*—*b* and the wires *a*1—*b*1.

Instead of rectifiers and discharge tubes it is of course possible to use different transformers in each one of the filters F5–F10 to select the receiving relays R11—R14 which are actuated by the same filter.

According to the description above the tone frequency currents received by the filters have a constant amplitude and a determined wave shape, whereby it becomes possible to avoid disturbances caused by harmonics. The wave shaper in Fig. 2 gives a rectangular voltage wave with marked harmonics. These are however determined as to their frequency and amplitude, and therefore it is possible to prevent disturbing effects. This can be done by selecting the eleven frequencies, which are used for signal emission, so that by means of well tuned filters they can be certainly distinguished from the disturbing harmonics.

Another way of preventing disturbances from harmonics is to select the eleven frequencies so that the high frequencies act as harmonics with respect to rectangular waves of some of the low frequencies and to connect a filter for a low frequency with a filter for a high frequency, the latter being a harmonic for the low frequency, and let the frequency combination represent a

signal. This method has been used in the above described embodiment and will be more clearly illustrated below with the aid of an example. In the table below the frequencies for which the filters F1–F10 are resonated are indicated in relation to those of the discharge lamps G31–G34, which glow at the first figure, and to the figures 1–0 corresponding to the push buttons P1–P10 in Fig. 1.

Frequency	Discharge lamp	figure	filter
2,000 p. s.	G31	1	F1
1,700 p. s.	G32	2	F2
1,450 p. s.	G33	3	F3
1,240 p. s.	G34	4	F4
1,060 p. s.	G31+G32	5	F5
910 p. s.	G32+G33	6	F6
780 p. s.	G33+G34	7	F7
670 p. s.	G31+G34	8	F8
580 p. s.	G32+G34	9	F9
500 p. s.	G31+G33	0	F10

It appears from the above table that the filter F5 allows the frequency 1060 cycles per sec. to pass, the second hamonic of which is about 2000 cycles per sec. and passes the filter F1. To prevent disturbances, the filter F5 is connected across the rectifier *e6* to the discharge lamp G31, as well as the filter F1, and the combination of the discharge lamps G31 and G32 corresponds to the figure 5. The filter F8 is resonated for 670 cycles per sec., the third harmonic of which is about 2000 cycles per sec., and therefore F8 is connected as well to G31 as to G34 and the combination G31—+G34 corresponds to the figure 8.

We claim:

1. In an automatic telephone system, a line circuit, at least one sending station including a sender and at least one receiving station including a receiver therein, a voice frequency generator in said sender for transmitting voice frequency currents and a key set in said sender connected to said voice frequency generator for controlling the frequency of the currents transmitted by the sender over the line circuit to the receiver, a plurality of band pass filters in said receiver tuned respectively to the currents generated by said generator, and a plurality of designating circuits connected to said filters to be energized by the respective currents, the frequency of at least one of said currents being substantially a harmonic with respect to the fundamental frequency of another of said currents, the band pass filter for said harmonic being connected to only one of said designating circuits, and the band pass filter for said another of said currents being connected both to the last-named designating circuit and to at least one other of said circuits for designating another signal through the combination of the said latter two circuits.

2. In an automatic telephone system, a line circuit, at least one sending station including a sender and at least one receiving station including a receiver, a voice frequency generator in said sender for transmitting voice frequency currents and a key set connected to said voice frequency generator for controlling and selecting the frequency of the currents transmitted by the sender over the line circuit to the receiver, a wave shaper in said receiver connected to the incoming end of the line circuit for transforming incoming alternating voltage waves from said line circuit into alternating voltage waves of predetermined shape and constant amplitude having the same fundamental frequency as the incoming waves, said receiver also including a plurality of band pass filters connected to said wave shaper and individually tuned to the frequencies produced by said generator, and a plurality of circuits connected to said filters to be energized by the respective currents, the frequency of at least one of said currents being an harmonic with respect to the fundamental frequency of another of said currents, the band pass filter tuned to said harmonic being connected to only one of said circuits for designating a signal, and the band pass filter tuned to said fundamental frequency being connected both to said one circuit and to at least one other of said circuits, for designating another signal through the energization of the combination of said two circuits.

3. In an automatic telephone system, a line circuit, at least one sending station including a sender and at least one receiving station including a receiver, said sender including a switch and a tone frequency generator which emits tone frequency current having a fundamental frequency which indicates a signal and which frequency is determined by the position of said switch, in said receiver at least one registering device consisting of relays connected to be energized in combinations, and filters connected thereto, and a wave shaper connected ahead of said filters for transforming incoming alternating waves of arbitrary shapes and amplitudes into wave shapes of predetermined forms and constant ampiltude with the same fundamental frequency as the incoming alternating wave, at least one of said filters tuned to pass a low frequency signal being connected to more than one registering relay in said registering device, whereby signals passed by said filter are indicated by more than one simultaneously actuated registering relay, and another of said filters tuned to pass higher frequency signals being connected to only a single registering relay in said registering device, said higher frequency being harmonic with respect to the fundamental frequency of said low frequency signal, and one of said registering relays connected to said one of said filters being connected to the filter which passes said harmonic.

4. In an automatic telephone system in accordance with claim 1, a first and a second registering device in said receiver, each consisting of relays which are energized in combinations, means including a switch in the sending station for tuning said tone frequency generator to a predetermined frequency when said switch is in its rest position, and for changing said certain frequency to a signaling frequency when operated and restoring said predetermined frequency upon return to its rest position, controlling means in said receiver responsive to said predetermined frequency and a relay device operated by said controlling means for disconnecting said first and connecting said second registering device to said filters when said switch is operated and returns to its rest position.

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