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G. PAPAICONOMOU
CONTROL SYSTEM FOR SEPARATE AS WELL AS SIMULTANEOUS
OPERATION OF REMOTE WORKING ELEMENTS

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2 Sheets-Sheet 1

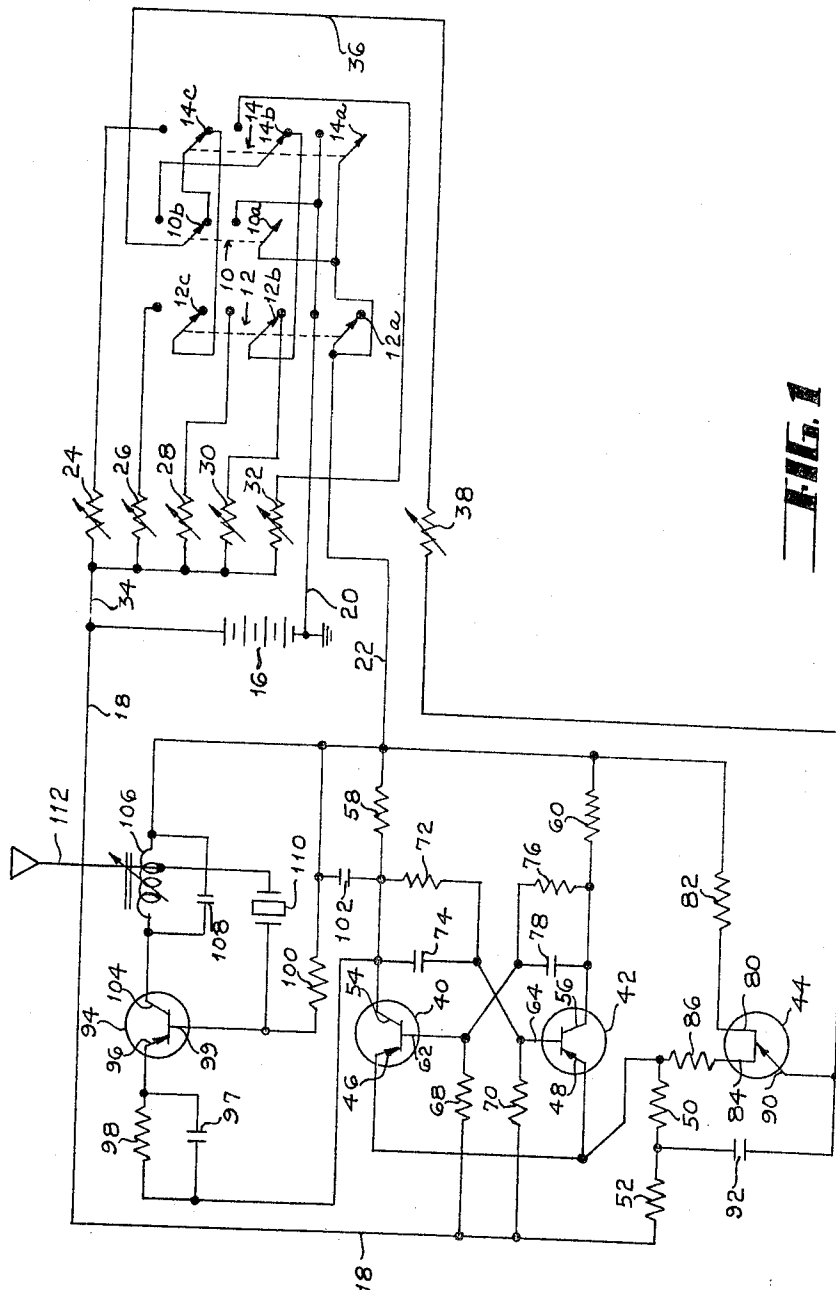


FIG. 1

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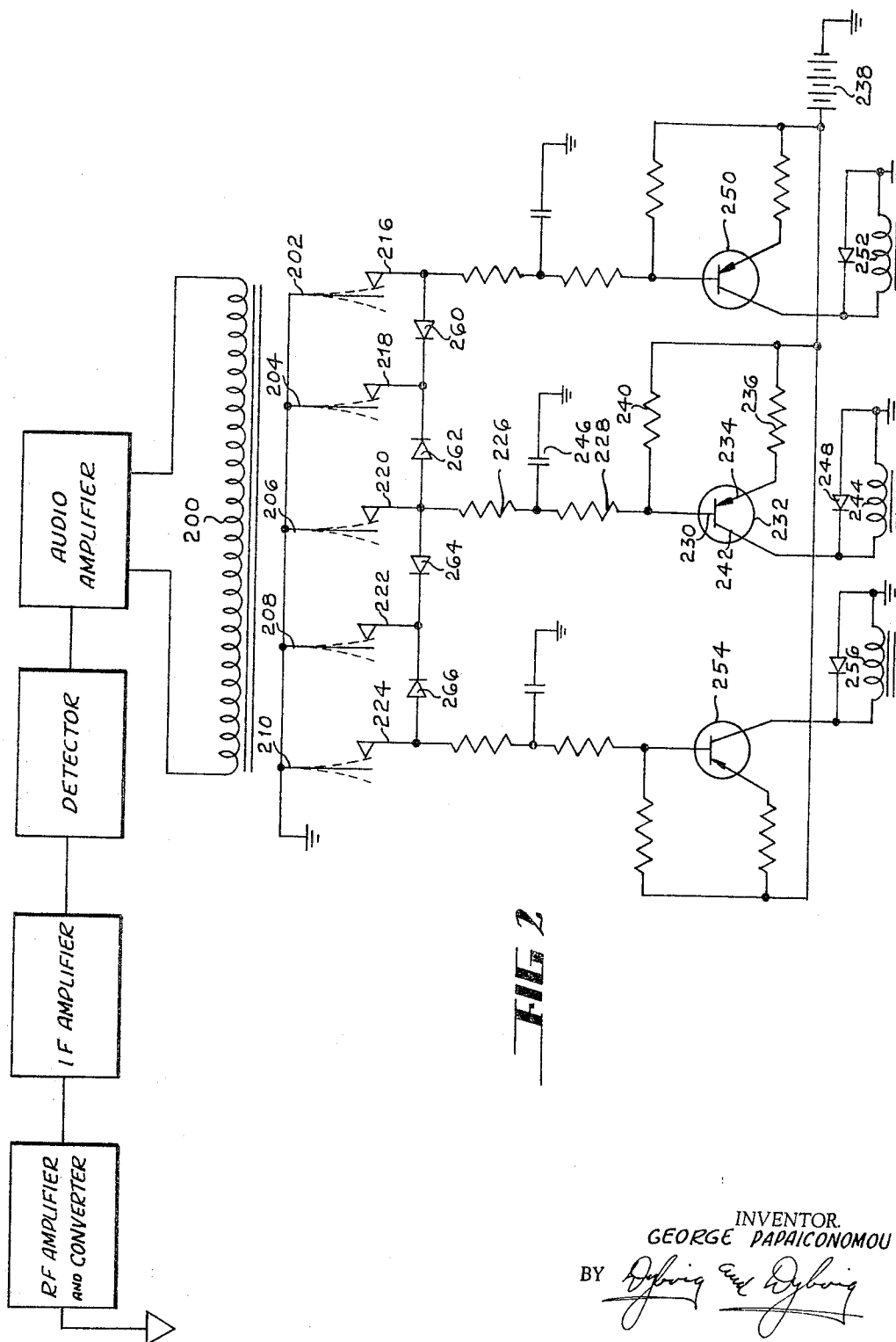


FIG 2

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3,270,323

**CONTROL SYSTEM FOR SEPARATE AS WELL AS
SIMULTANEOUS OPERATION OF REMOTE
WORKING ELEMENTS**

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4 Claims. (Cl. 340-171)

This invention relates to a remote control circuit and more particularly to circuitry for encoding input information to produce frequency signals representing the states of a plurality of control elements, transmitting the frequency signals on a carrier wave to a remote station, receiving the frequency signals at the remote station, and decoding the frequency signals so as to initiate operation of working elements corresponding to the local control elements. However, the invention is not necessarily so limited.

The simplest remote control circuits involve a single local control element, a single remote working element, and means to transmit a signal from the local control element to initiate operation of the remote working element. More complicated circuits involve a plurality of local control elements and an equal number of remote working elements and, to avoid a scrambling of the signals transmitted from the local to the remote station, a different signal frequency is assigned to each control element and corresponding working element. In such circuits each working element responds to one and only one control element. These plural frequency circuits have an important limitation, however, in that it is ordinarily not practical with a single transmitter and a single receiver to transmit two frequencies simultaneously and thereby initiate simultaneous operation of two working elements. In other words, a remote control circuit of the type described is not ordinarily amenable to the control of remote control apparatus having a plurality of individual working elements which are sometimes required to operate simultaneously.

An object of the present invention is to provide an encoder for translating information derived from a plurality of control elements, each having an operative and an inoperative state, to a single signal frequency representative of the combined states of the control elements.

A further object of the present invention is to provide a decoder for translating a single signal frequency representative of the combined states of a series of control elements, each having an operative and an inoperative state, into operative and inoperative states of working elements responding to the control elements.

Another object of the present invention is to provide a simplified remote control circuit for regulating at one time the operation of more than one remote working element.

Other objects and advantages reside in the construction of parts, the combination thereof, the method of manufacture and the mode of operation, as will become more apparent from the following description.

In the drawings:

FIGURE 1 is a wiring diagram of an encoder and associated transmitter employed in the subject remote control circuit.

FIGURE 2 is a combined wiring diagram and schematic illustration of a receiver and decoder employed in the subject remote control circuit.

Referring to the drawings in greater detail, FIGURE 1 illustrates a circuit diagram for a circuit for transmitting signal frequencies representing the states of local control elements adapted to control the operation of a remote mechanism. For convenience, the circuit of FIG-

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URE 1 may be subdivided into three subcircuits namely, an encoding circuit, a modulation oscillator circuit and a high frequency carrier wave transmitter circuit.

Encoding circuit

The encoding circuit includes three control elements 10, 12 and 14, which are adapted to be operated locally so as to control the operation of a remote mechanism. The control element 10 comprises a double pole double throw switch having poles 10a and 10b. The control element 12 comprises a triple pole double throw switch having poles 12a, 12b and 12c. The control element 14 comprises a triple pole double throw switch having poles 14a, 14b and 14c. Each of the control elements 10, 12 and 14 is illustrated in an inoperative or inactive position.

In the operation of the particular circuit disclosed, it is intended that the control elements may be operated individually one at a time and, at certain times, certain of the control elements may be operated simultaneously in pairs. More specifically, it is intended that each of the control elements may be operated individually to accomplish a given function in the remote apparatus, there being a separate function for each control element and, further, certain pairs of control elements may be operated simultaneously, so that their particular functions are accomplished simultaneously in the remote mechanism.

In the circuit of FIGURE 1, each of the control elements 10, 12 and 14 when operated performs two functions. One function is that of completing an electrical circuit for supplying electrical power from a battery 16 to the modulation oscillator and to the transmitter. As will be described more fully subsequently, the positive terminal of the battery 16 is permanently connected to both the modulation oscillator and the transmitter by means of conductor 18. The negative terminal of the battery 16 is engaged by conductor 20, which, upon operation of any of the control elements 10, 12 or 14, is connected to a conductor 22 leading to the negative side of both the modulation oscillator and the transmitter. The connection between the conductors 20 and 22 is effected with the poles 10a, 12a and 14a of the control elements 10, 12 and 14. Thus, movement of any one of the control elements 10, 12 and 14 to its operative position, or movement of any combination of these control elements to their operative positions, completes the power supply to the modulation oscillator and to the transmitter.

The second function accomplished in the circuit of FIGURE 1 through operation of the control elements 10, 12 and 14 is that of selecting a resistance value for insertion into the modulation oscillator to select an operating frequency for the modulation oscillator. More specifically, the resistance value is inserted in a timing circuit for the modulation oscillator.

The resistance values available for selection are represented by the variable resistances 24, 26, 28, 30 and 32, each of which is connected to the positive terminal of the battery 16 by means of the conductor 34. The insertion of any of these resistances into the timing circuit is accomplished by placing the opposite end of the resistance in communication with a conductor 36, which communicates with a variable resistance 38. A more detailed description of the timing circuit and its operation will be given subsequently.

It will be apparent from an inspection of FIGURE 1 that, upon operation of the control element 10 only, the pole 10b operates to connect the resistance 30 to the conductor 36 through the medium of poles 12b and 14b of the control elements 12 and 14. Similarly, upon operation of the control element 12 only, the pole 12c thereof places the resistance 26 in communication with the con-

ductor 36 through the medium of pole 14c of control element 14 and pole 10b of control element 10. Upon operation of the control element 14 only, the pole 14c thereof places the resistance 24 in communication with the conductor 36 through the medium of the pole 10b of control element 10. Thus, the control elements 10, 12 and 14 are capable of individually selecting the resistances 30, 26 and 24 respectively, for controlling the timing of the modulation oscillator.

The frequency selector disclosed is also intended to accommodate simultaneous operation of the control elements 10 and 12 and of the control elements 10 and 14. Upon simultaneous operation of the control elements 10 and 12, the resistance 28 is placed in communication with the conductor 36 through the medium of poles 10b, 14b and 12b. Similarly, upon simultaneous operation of the control elements 10 and 14, the resistance 32 is placed in communication with the conductor 36 through the medium of poles 10b and 14b. Thus, the resistance 28 establishes a modulation oscillator frequency which is representative of the simultaneous operation of control elements 10 and 12, while the resistance 32 establishes a modulation frequency which is representative of the simultaneous operation of the control elements 10 and 14. In total, the encoder is capable of selecting five different operating frequencies, determined by the resistances 24, 26, 28, 30 and 32. Three of these five frequencies can be said to represent the operation of one only of the control elements 10, 12 and 14, while the other two frequencies can be said to represent simultaneous operation of certain pairs of the control elements 10, 12 and 14.

Modulation oscillator

The modulation oscillator utilizes two PNP transistors 40 and 42 and a third transistor 44 which is a PN uni-junction transistor. The transistors 40 and 42 are operated together as a flip-flop circuit. For this purpose, the emitters 46 and 48 of the transistors 40 and 42, respectively, are jointly connected to the positive terminal of the battery through resistances 50 and 52 and conductor 18. The collectors 54 and 56 of the transistors 40 and 42, respectively, are connected to the negative terminal of the battery through resistances 58 and 60 and conductor 22, subject to the control of the control elements 10, 12 and 14.

The bases 62 and 64 of the transistors 40 and 42, respectively, are connected to the positive terminal of the battery through resistances 68 and 70 respectively. Further, the base 62 of the transistor 40 is connected to the collector 56 of the transistor 42 through a parallel circuit including the resistance 76 and the capacitance 78. Similarly, the base 64 of the transistor 42 is connected to the collector 54 of the transistor 40 through a parallel circuit including the resistance 72 and the capacitance 74.

In operation, either the transistor 40 or 42 becomes conductive from its emitter to collector circuit upon application of power to the flip-flop circuit, while the other transistor is non-conductive. The states of these two transistors are reversed whenever a pulse of sufficient magnitude occurs across the resistance 52.

Such pulse is supplied by a timing circuit including the uni-junction transistor 44. The first base 80 of this transistor is connected to the negative terminal of the battery through a resistance 82. The second base 84 receives a positive bias through resistances 86, 50 and 52. The emitter 90 of the uni-junction transistor 44 connects to one plate of a capacitance 92 which is charged at a rate determined by the resistance value selected in the encoder circuit, combined with the value of the resistance 38 and the resistance 52.

The operation of the timing circuit is as follows. Upon operation of any of the control elements 10, 12 or 14, the capacitance 92 charges at a rate dependent upon the particular resistance selected in the encoder circuit until such time as the potential difference between the emitter and first base of the uni-junction transistor reaches a criti-

cal value. When this critical value has been reached, the uni-junction transistor 44 fires, creating a conductive path between its emitter 90 and the first base 80. This conductive path permits the capacitance 92 to discharge through the resistor 82, creating a voltage pulse across the resistance 52 sufficient to cause the transistors 40 and 42 in the flip-flop circuit to exchange states. When the capacitance 92 has discharged below a critical level, the resistance in the emitter to first base section of the uni-junction transistor returns to a high level, initiating a new timing cycle.

It will be apparent from the foregoing discussion that the charging cycle for the capacitance 92 is dependent upon the particular resistance value selected in the selector circuit for combination with the capacitance 92 and for each resistance-capacitance combination selected there will be a different oscillating frequency in the modulation oscillator.

High frequency carrier wave transmitter

The transmitter includes a PNP transistor 94 having an emitter 96 which is connected to the collector of the transistor 40 in the flip-flop circuit through a resistance 98 and a capacitor 97 in parallel. The base 99 of the transistor 94 connects to the negative terminal of the battery through a resistance 100 and connects to the collector 54 of the transistor 40 in the flip-flop circuit through resistance 100 and a capacitance 102.

The collector 104 connects to the negative terminal of the battery through a tuned circuit including an inductance coil 106 and a capacitance 108. The oscillating frequency is controlled by a crystal 110 connected between the base 99 of transistor 94 and a tap in the inductance coil 106. The oscillations are transmitted by means of an antenna 112 connected to the aforementioned center tap of the coil 106.

The transmitter operates at two power levels, depending upon the conducting states of the transistors 40 and 42 in the flip-flop circuit. When the transistor 40 is non-conductive and, conversely, the transistor 42 is conductive, the emitter 96 of the transmitter transistor 94 connects to the positive terminal of the battery through parallel resistance paths, the first including the resistance 98, resistance 72 and resistance 70 and the second including the resistance 52, the resistance 50, the emitter to base section of transistor 42, and the resistance 72. When, however, the transistor 40 is conducting and the transistor 42 is non-conductive, a lower resistance path exists through the emitter to collector section of transistor 40, this path including the resistances 98, 50 and 52. When the transistor 40 of the flip-flop circuit is conducting, the transmitter broadcasts a signal of large amplitude and when the transistor 40 is non-conductive, the signal drops to a comparatively small amplitude.

In the preferred embodiment, the transmitter operates in the radio frequency range and the modulation oscillator is designed to operate in the audio frequency range. Accordingly, the output of the transmitter comprises a carrier wave having a radio frequency which has been modulated in amplitude to carry an audio frequency signal. As discussed previously, the particular audio frequency transmitted is dependent upon the particular one of five resistance values selected in the selector circuit.

FIGURE 2 illustrates a circuit for receiving and decoding the signal generated by the circuit of FIGURE 1. The receiver is a conventional superheterodyne receiver including an RF amplifier and converter, an IF amplifier, a detector and an audio amplifier. The output of the audio amplifier, which comprises a signal of the same frequency as that produced in the modulation oscillator in the circuit of FIGURE 1, is impressed upon a solenoid coil 200. This frequency signal is decoded with the following circuit.

Decoding circuit

A plurality of vibratory reeds 202, 204, 206, 208 and 210 are placed in the vicinity of the coil 200, so as to

respond to the magnetic field thereof. Electrical contacts 216, 218, 220, 222 and 224 are positioned, one adjacent each of the vibratory reeds, so as to contact the adjacent reed when such reed is caused to vibrate by the magnetic field created by the coil 200. Each of the reeds is grounded, as shown and, accordingly, with vibration of any one of the reeds, the contact adjacent that particular reed is intermittently grounded due to intermittent contact with the reed. For example, upon vibration of the reed 206, the adjacent contact 220 is intermittently grounded.

The contact 220 connects through resistances 226 and 228 to the base 230 of a PNP transistor 232. The emitter 234 of this transistor connects through resistance 236 to the positive terminal of a battery 238. The battery 238 is grounded at its negative terminal. A resistance 240, connecting the base 230 to the positive terminal of the battery, provides a positive base bias. A grounded relay coil 244 is connected to the collector 242 of the transistor 232.

In the circuit described, it will be apparent that intermittent grounding of the contact 220 due to vibration in the reed 206 will allow an emitter base current in the transistor 232 which, in turn, permits a current to flow from the battery 238 through the transistor 232 and through the relay coil 244. A capacitance 246, connected between ground and the base circuit of the transistor 232, as shown, maintains the base current during those intervals when the reed 202 is intermittently separated from the contact 216. It follows that vibration of the reed 206 results in energization of the relay coil 244. When the reed 206 ceases to vibrate, a diode 248 across the relay coil discharges the coil.

Referring to the circuit of FIGURE 1, it has been noted that operation of the control element 10 individually produces a modulation oscillator frequency determined by the resistance element 30. The reed 206 is tuned to vibrate at the frequency established by the resistance element 30 and, accordingly, the relay coil 244 can be used to initiate an operation which is controlled by the control element 10.

Utilizing a substantially duplicate circuit involving the transistor 250, a relay coil 252 is made responsive to the vibration of the vibratory reed 202. With still another substantially duplicate circuit utilizing the transistor 254, a relay coil 256 is made responsive to vibration of the vibratory reed 210. The reed 202 may be tuned to a frequency established by the resistance element 26 in FIGURE 1 and, accordingly, vibrates subject to the control of the control element 12. Similarly, the reed 210 may be tuned to vibrate to the frequency established by the resistance element 24 in FIGURE 1, whereupon the relay 256 operates subject to control of the control element 14. Accordingly, the relays 244, 252 and 256 respond directly to the control elements 10, 12 and 14 when these control elements are operated individually.

As mentioned previously, it is contemplated that the control elements 10 and 12 may be operated simultaneously and, furthermore, the control elements 10 and 14 may be operated simultaneously. Also, it has been previously noted that simultaneous operation of the control elements 10 and 12 establishes a modulation frequency determined by the resistance element 28, while simultaneous operation of the control elements 10 and 14 establishes a modulation frequency determined by the resistance element 32 in FIGURE 1. In accordance with this arrangement, the vibratory reed 204 in FIGURE 2 may be tuned to the oscillator frequency established by the resistance element 28 and the vibratory reed 208 in FIGURE 2 may be tuned to vibrate at the oscillator frequency established by the resistance element 32 in FIGURE 1.

The contact 218 adjacent the vibratory reed 204 is coupled to each of the contacts 216 and 220 through opposed diodes 260 and 262, respectively, such diodes

being unidirectional current conductors. Accordingly, when the vibratory reed 204 vibrates, conductivity is established in both the transistors 232 and 250, with the result that both relay coils 244 and 252 are energized. Thus, simultaneous operation of the control elements 10 and 12 of FIGURE 1 results in simultaneous energization of their corresponding relay coils 244 and 252.

The contact 222, which is adjacent the vibratory reed 208, is similarly coupled to the contacts 220 and 224 through opposed diodes 264 and 266. As a result of this coupling, vibration of the reed 208 results in simultaneous operation of the relay coils 244 and 256, which correspond to the control elements 10 and 14. Thus, simultaneous operation of the control elements 10 and 14 results in simultaneous energization of their corresponding relay coils 244 and 256.

In the foregoing, means have been described for producing frequency signals representative of the states of the control elements 10, 12 and 14 and for decoding the frequency signals, so as to cause the relay elements 244, 252 and 256 to respond to operation of the control elements, a notable feature of the circuitry described being that, in certain cases, simultaneous operation of certain of the control elements establishes a representative frequency, which will cause simultaneous operation of their corresponding relays.

Although the preferred embodiment of the device has been described, it will be understood that within the purview of this invention various changes may be made in the form, details, proportion and arrangement of parts, the combination thereof and mode of operation, which generally stated consists in a device capable of carrying out the objects set forth, as disclosed and defined in the appended claims.

Having thus described my invention, I claim:

1. A decoder for translating coded information in the form of frequency signals, said decoder comprising a solenoid coil, receiver means connected with said solenoid coil adapted to receive and impress said frequency signals on said coil, first and second vibratory reeds positioned for interaction with the magnetic field of said coil, said first and second reeds being tuned to vibrate at different first and second signal frequencies, first and second work elements corresponding to said first and second reeds, a first circuit completed by said first reed upon vibration thereof for operating the work element corresponding to said first reed, a second circuit completed by said second reed upon vibration thereof for operating said second work element, a third vibratory reed positioned for interaction with the magnetic field of said coil and tuned to vibrate in response to a third frequency signal different than said first and second frequency signals, and means connected between said first and second circuits and responsive to vibration of said third reed to simultaneously complete said first and second circuits and thereby simultaneously operate said first and second work elements.

2. The decoder according to claim 1 wherein said third means includes a contact element for engaging said third reed on vibration thereof and first and second unidirectional current conductors connecting said first and second circuits respectively with said contact, said first and second unidirectional current conductors cooperating to oppose current flow between said first and second circuits.

3. A decoder for translating coded information in the form of frequency signals, said decoder comprising a solenoid coil, receiver means connected with said solenoid coil adapted to receive and impress said frequency signals on said coil, first and second vibratory members positioned for interaction with the magnetic field of said coil, said first and second members being tuned to vibrate at different first and second signal frequencies, first and second work elements corresponding to said first and second members, a first circuit energizable to operate the work element corresponding to said first member, means

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responsive to vibration of said first member to energize said first circuit, a second circuit energizable to operate said second work element, means responsive to vibration of said second member to energize said second circuit, a third vibratory member positioned for interaction with the magnetic field of said coil and tuned to vibrate in response to a third frequency signal different than said first and second frequency signals, and third means connected between said first and second circuits and responsive to vibration of said third member to simultaneously energize said first and second circuits and thereby simultaneously operate said first and second work elements.

4. A decoder for translating coded information in the form of frequency signals, said decoder comprising: a solenoid coil; receiver means adapted to receive and impress said frequency signals on said coil; first, second and third vibratory members positioned for interaction with the magnetic field of said coil; said first, second and third vibratory members each being tuned to resonate at a different frequency; first, second and third circuits each including a work element and each being energizable from a source of power effective to operate the work element therein, said circuits relating, respectively, to said first, second and third vibratory members; each said circuit including means responsive to resonant vibration of the related vibratory member to energize said circuit from said source and thereby operate the work element in said circuit; fourth and fifth vibratory members positioned for interaction with the magnetic field of said coil and each tuned to resonate at a frequency different than

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the other and different than the resonant frequencies of said first, second and third members; means connected between said first and second circuits and responsive to resonant vibration of said fourth member to simultaneously energize said first and second circuits from said source and thereby simultaneously operate the work elements in said first and second circuits, and means connected between said second and third circuits and responsive to resonant vibration of said fifth member to simultaneously energize said second and third circuits from said source and hereby simultaneously operate the work elements in said second and third circuits.

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