United States Patent [19]

Wycoff

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[45] **Sept. 3, 1974**

[54] **SIGNAL SUBSTITUTION SYSTEM**

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[22] Filed: **Apr. 12, 1972**

[21] Appl. No.: **243,150**

Related U.S. Application Data

[63] Continuation of Ser. No. 75,417, Sept. 25, 1970, abandoned.

[52] **U.S. Cl.** ..... **331/48,** 178/2 B, 179/1 SW, 325/64, 331/117 R, 331/179, 331/181, 334/72

[51] **Int. Cl.** **H03j 5/08**

[58] **Field of Search** ..... 331/48, 49, 56, 117 R, 331/177 R, 179, 181; 334/72; 178/2 B; 179/1 SW; 325/64

[56] **References Cited**

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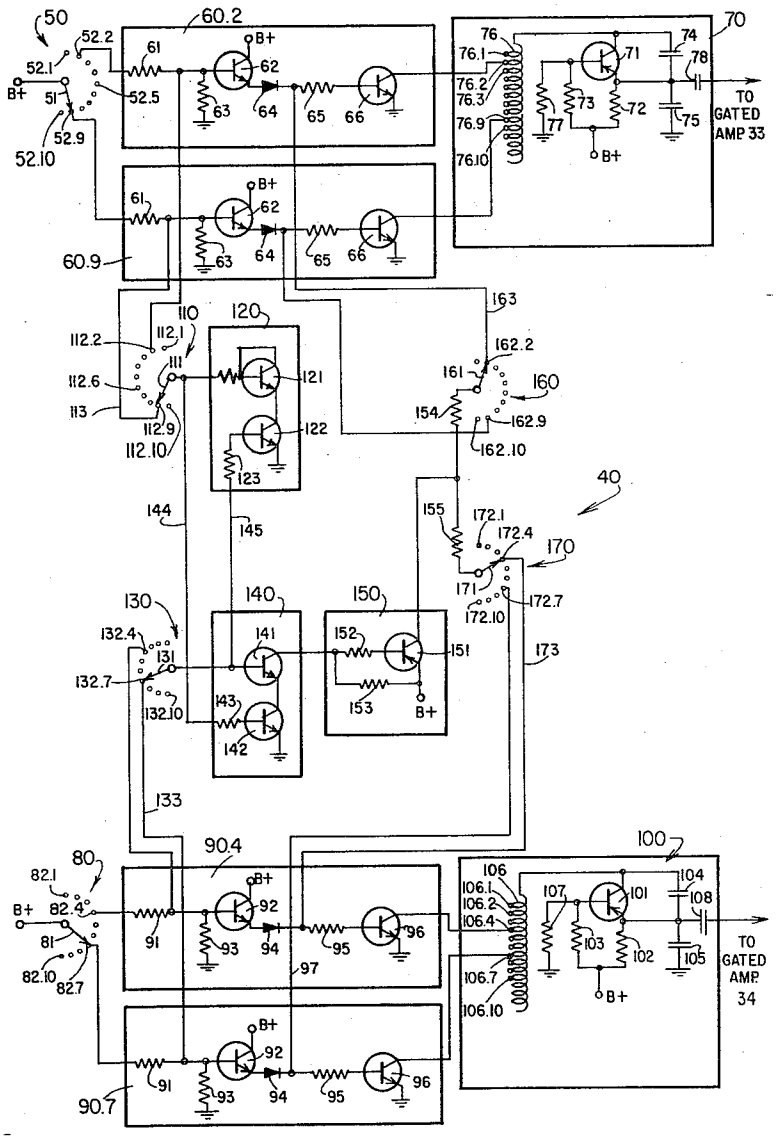
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Attorney, Agent, or Firm—Prangley, Dithmar, Vogel, Sandler & Stotland

[57] **ABSTRACT**

A first selector is to be set up to cause the control tone produced by a variable frequency oscillator to have a first selected frequency. A second selector is set up to cause the control tone to have a second selected frequency. A third selector set at a third selected frequency determines which of the first or second selectors is operable to control the oscillator. The second selector is operative to cause the control tone to have the second selected frequency when the first and third selectors are set in corresponding conditions, and the first selector is operative to cause the control tone to have the first selected frequency when the first and third selectors are set in noncorresponding conditions.

38 Claims, 5 Drawing Figures



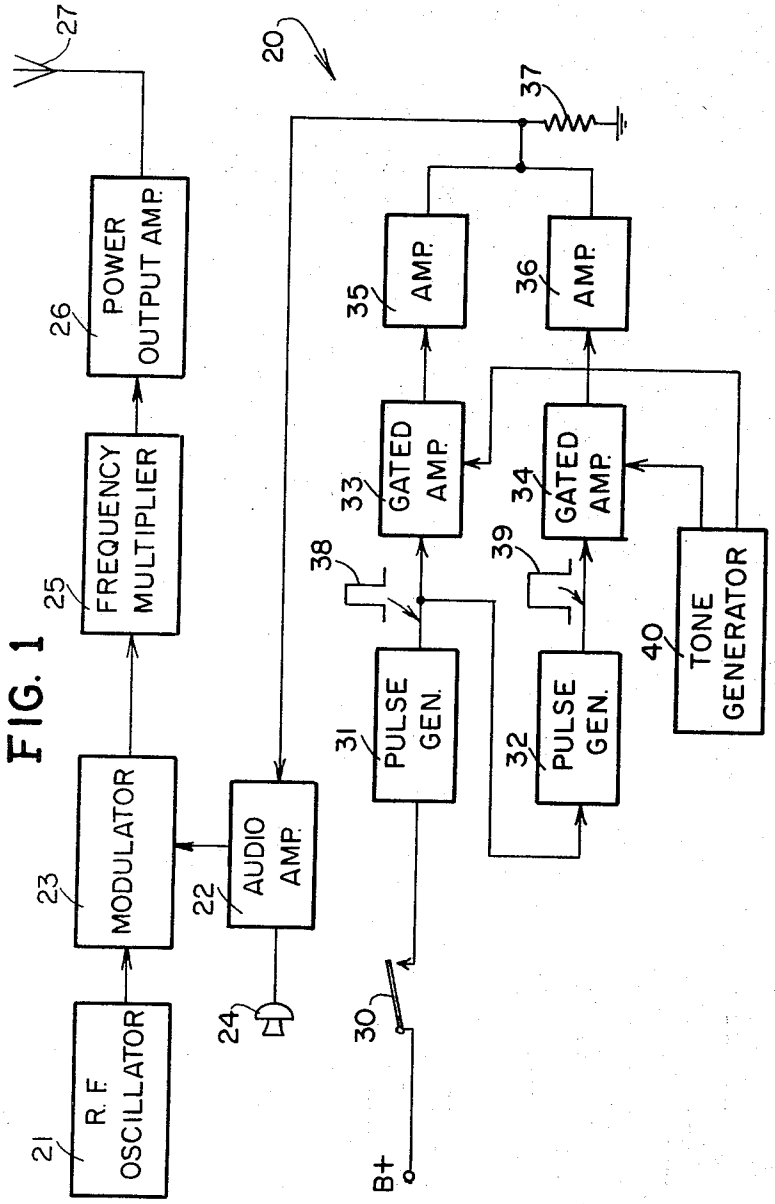


FIG. 1

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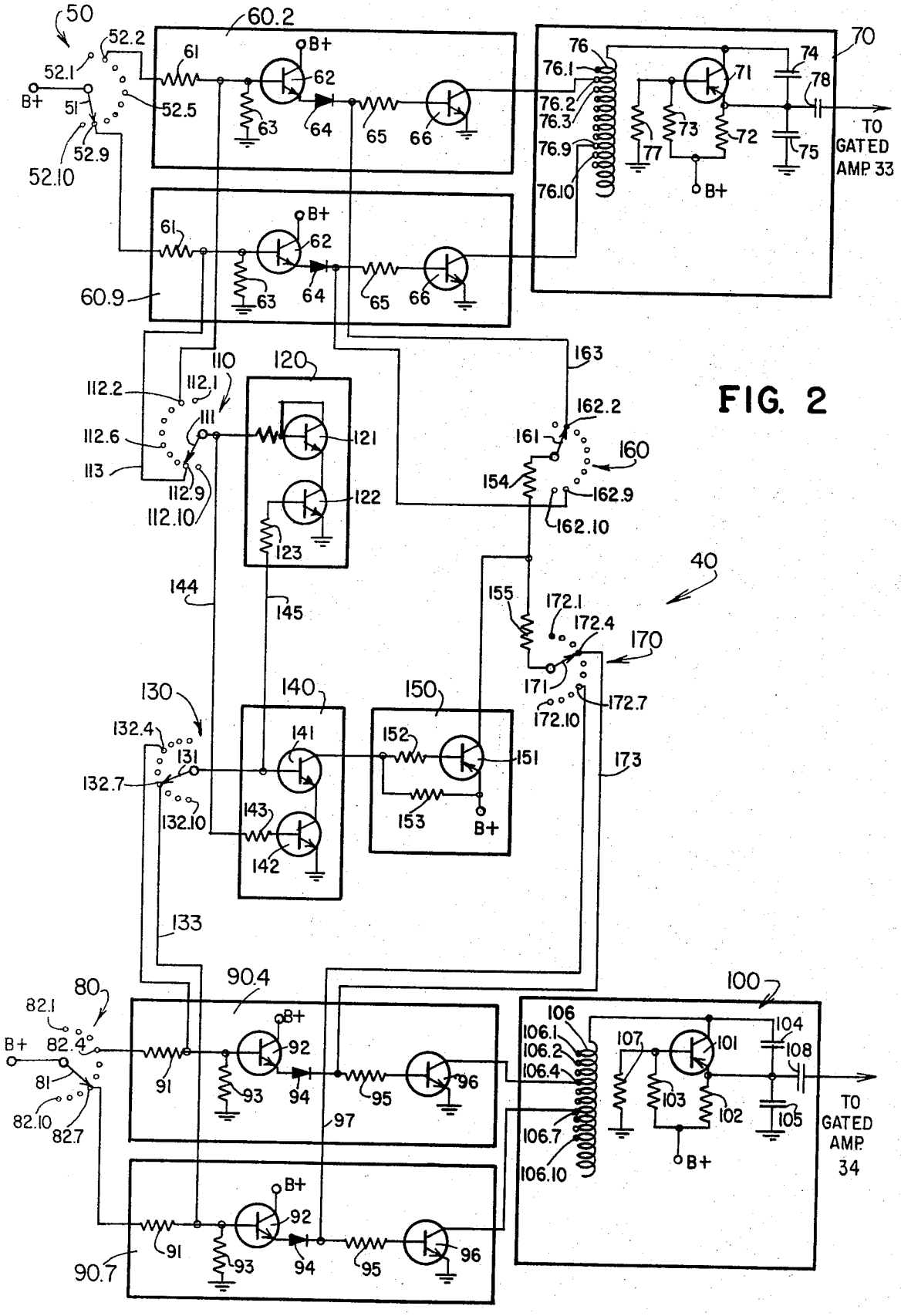

50
52.2
52.1
B+
51
52.5
52.9
52.10
60.2
61
B+
62
63
64
65
66
60.9
70
76
76.1
76.2
76.3
76.9
76.10
71
74
78
73
77
72
75
B+
TO GATED AMP 33
110
112.1
112.2
111
112.6
113
112.9
112.10
120
121
122
123
163
162.2
161
160
154
162.9
162.10
144
145
155
172.1
172.4
170
171
172.7
172.10
40
130
132.4
131
132.7
132.10
140
141
143
142
150
152
151
153
B+
173
133
80
82.1
B+
82.4
81
82.10
82.7
90.4
91
92
93
94
95
96
97
90.7
100
106
106.1
106.2
106.4
106.7
106.10
107
101
104
108
103
102
105
B+
TO GATED AMP 34

FIG. 2

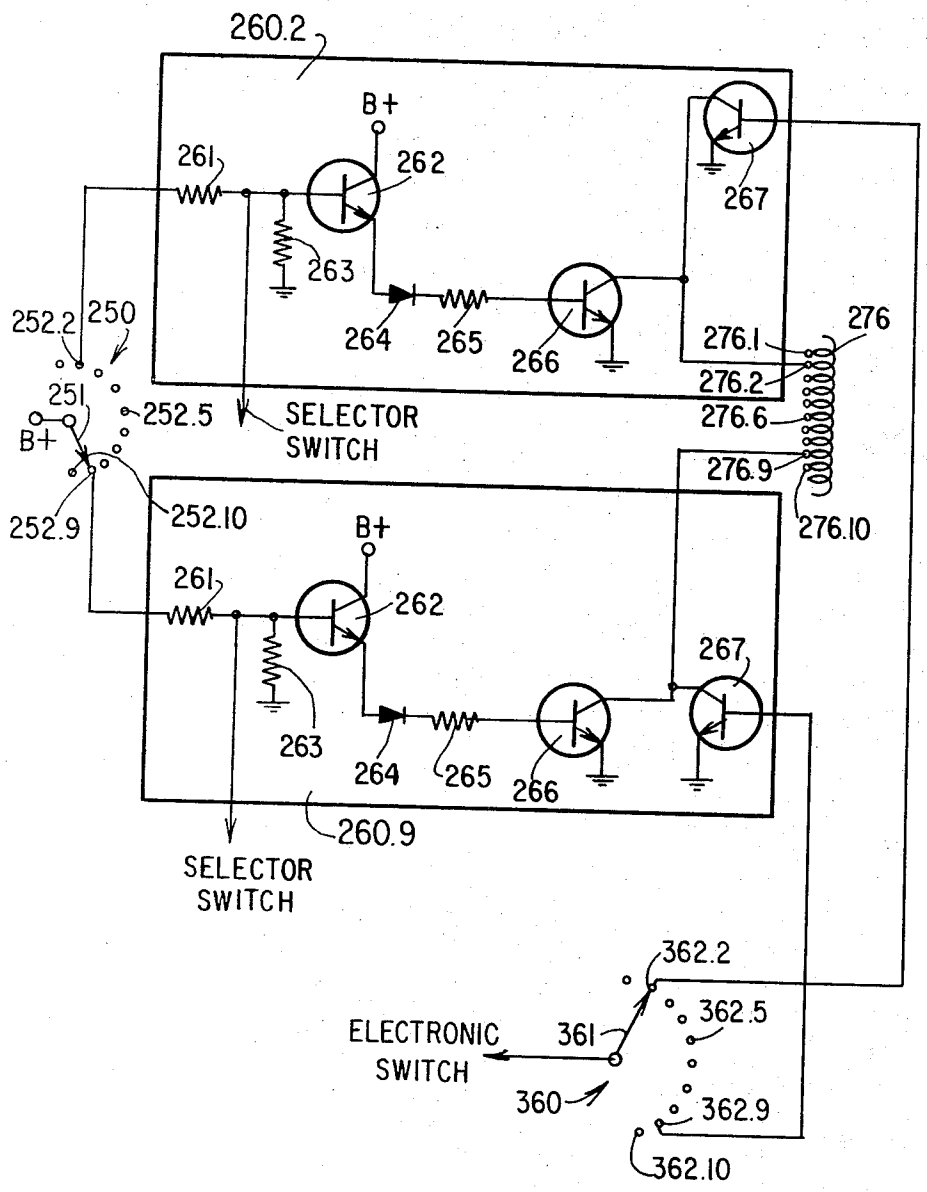

260.2
B+
261
262
263
264
265
266
267
276
276.1
276.2
276.6
276.9
276.10
252.2
250
251
252.5
SELECTOR SWITCH
252.9
252.10
260.9
362.2
362.5
362.9
362.10
ELECTRONIC SWITCH
361
360

FIG. 3

FIG. 4

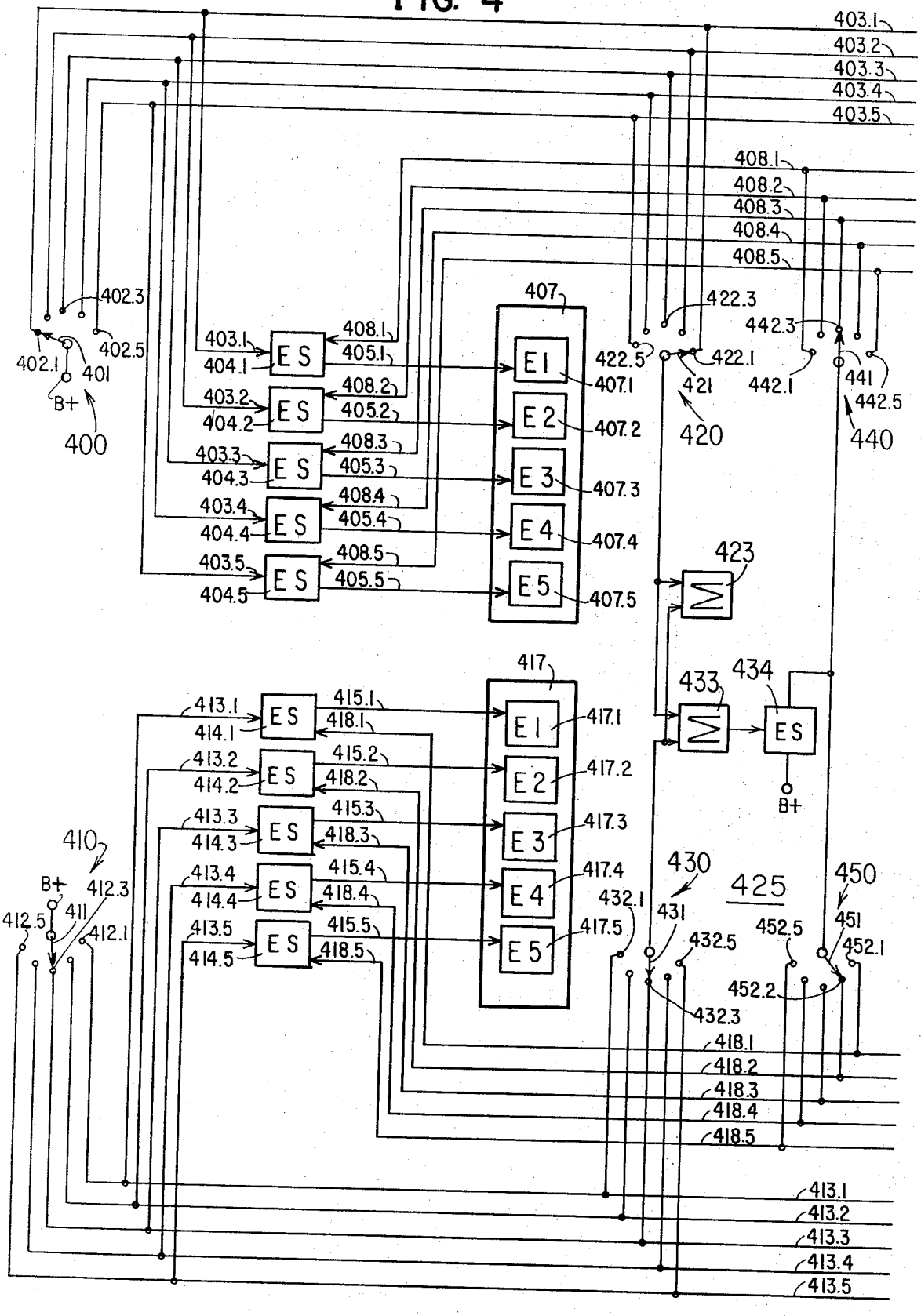
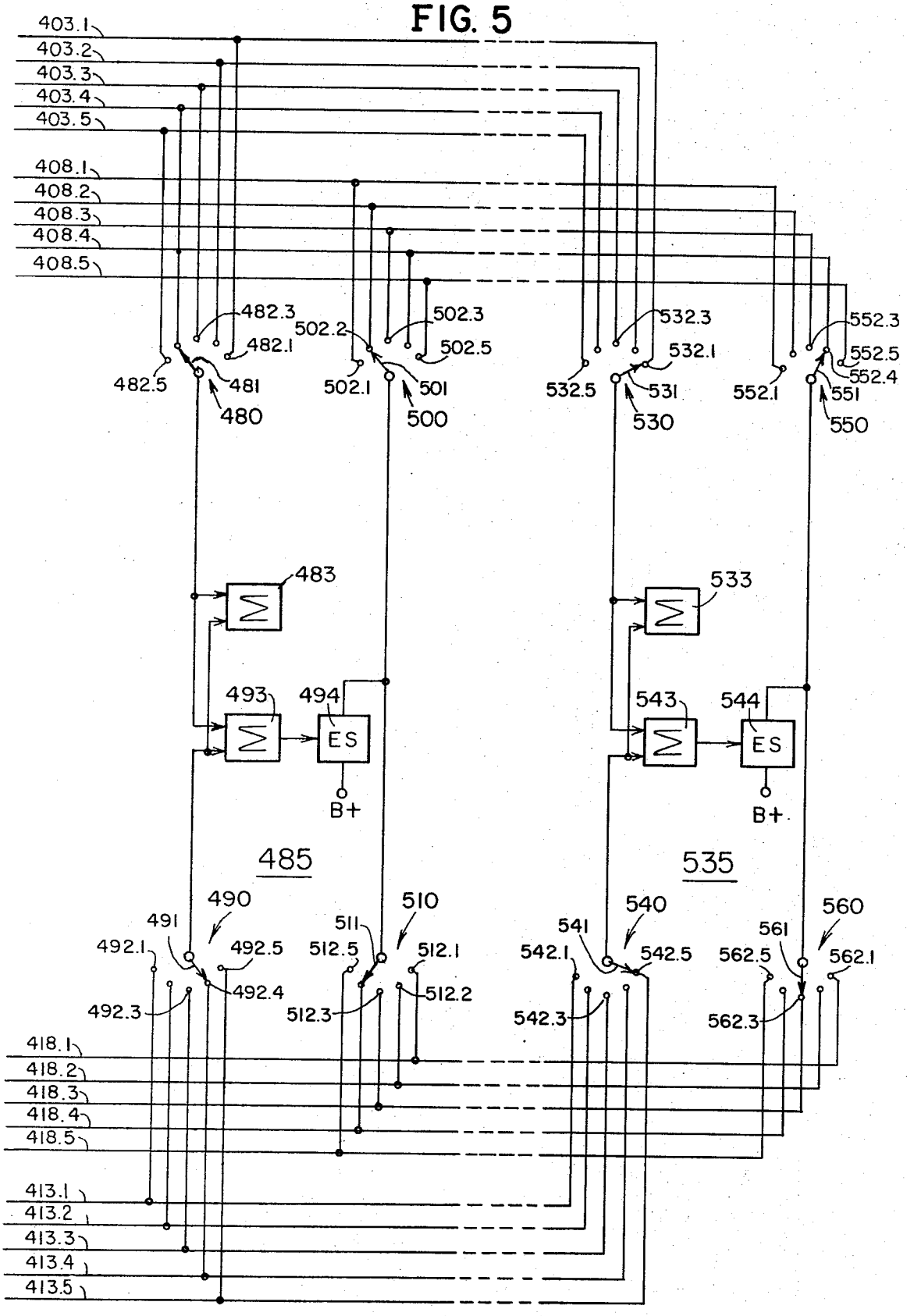

403.1
403.2
403.3
403.4
403.5
408.1
408.2
408.3
408.4
408.5
407
422.3
442.3
402.3
402.1
402.5
401
B+
400
ES
404.1
404.2
404.3
404.4
404.5
405.1
405.2
405.3
405.4
405.5
E1
E2
E3
E4
E5
407.1
407.2
407.3
407.4
407.5
422.5
422.1
421
420
442.1
441
442.5
440
423
417
433
434
413.1
413.2
413.3
413.4
413.5
414.1
414.2
414.3
414.4
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415.1
415.2
415.3
415.4
415.5
418.1
418.2
418.3
418.4
418.5
417.1
417.2
417.3
417.4
417.5
410
412.3
411
412.5
412.1
430
425
450
431
432.1
432.5
432.3
451
452.5
452.1
452.2

FIG. 5


403.1
403.2
403.3
403.4
403.5
408.1
408.2
408.3
408.4
408.5
482.3
482.1
482.5
481
480
502.2
502.3
502.5
502.1
501
500
532.3
532.1
532.5
531
530
552.3
552.5
552.4
552.1
551
550
483
533
493
494
ES
B+
543
544
ES
B+
485
535
490
491
492.1
492.5
492.4
492.3
511
510
512.5
512.1
512.2
512.3
540
541
542.1
542.5
542.3
560
561
562.5
562.1
562.3
418.1
418.2
418.3
418.4
418.5
413.1
413.2
413.3
413.4
413.5

SIGNAL SUBSTITUTION SYSTEM

This is a continuation of the copending application of Keith H. Wycoff, U.S. Pat. Ser. No. 75,417, filed Sept. 25, 1970, for TONE SUBSTITUTION SYSTEM now abandoned.

It is an important object of the present invention to provide an improved tone substitution system for use in a transmitter of the type capable of sending a tone or set of tones to alert a remote receiver, which tone substitution system automatically substitutes a different tone or set of tones for the tone or tones selected.

Another object of the invention is to provide an improved tone substitution system which incorporates only electronic and manual switching, and does not incorporate patch-cords or the like.

Yet another object of the invention is to provide a tone substitution system capable of substituting any available tone or set of tones for the tone or tones actually selected.

Still another object of the invention is to provide an improved tone substitution system which is capable of substituting up to all of the available tones or sets of tones for the tone or sets of tones selected.

A further object of the invention is to provide a paging system in which a faulty receiver that is adapted to respond to a given tone or set of tones may be permanently replaced with a receiver adapted to respond to a different tone or set of tones.

In connection with the foregoing object, it is a further object to provide a tone substitution system which enables the faulty receiver to be repaired and then be used as a spare to replace another faulty receiver.

A still further object of the invention is to provide a tone substitution system which enables individuals to transfer their calls from their own selective calling receivers to the selective calling receiver of another, yet permitting the other to continue to receive calls directed to him.

Another object of the invention is to provide an improved tone substitution system which requires no particular tones or sets of tones to be set aside for use in connection with receivers used as spares.

In summary, there is provided a tone substitution system for use in a transmitter and comprising tone signal producing means, first selector means coupled to the tone signal producing means and placeable in one of a plurality of conditions to cause the tone signal to have a selected one of a corresponding plurality of first characteristics, second selector means coupled to the tone signal producing means and placeable in one of a plurality of conditions to cause the tone signal to have a selected one of a corresponding plurality of second characteristics, and third selector means coupled to the first and second selector means and placeable in one of a plurality of conditions for rendering the first selector means or the second selector means operative to control the characteristics of the tone signal, the tone signal having the selected one of the first characteristics when the conditions of the first and third selector means do not correspond, the tone signal having the selected one of the second characteristics when the conditions of the first and third selector means correspond.

Further features of the invention pertain to the particular arrangement of the elements of the transmitter and the tone substitution system therein, whereby the above outlined and additional operating features thereof are attained.

The invention, both as to its organization and the method of operation, together with further objects and advantages thereof, will best be understood by reference to the following specification taken in connection with the accompanying drawings, in which:

FIG. **1** is a block diagram of a transmitter incorporating therein a tone generator which includes the tone substitution system incorporating the novel features of the present invention;

FIG. **2** is a schematic diagram of the tone substitution system;

FIG. **3** illustrates an alternative form of a portion of the tone substitution system; and

FIGS. **4** and **5** illustrate a block diagram illustrating further features of the invention.

Referring now to FIG. **1** of the drawings, there is shown a communication transmitter **20** which is adapted to generate an RF carrier wave modulated selectively by audio signals and one or more control tones. Basically, the transmitter **20** is for use in a selective calling communication system which comprises, in addition to the transmitter, a number of receivers, all capable of processing the same frequency carrier wave. Each receiver is squelched in its stand-by condition and is automatically unsquelched with the carrier wave modulated by the proper control tone or set of control tones for which that receiver is designed. Each receiver will respond to a different control tone or set of control tones, whereby the operator of the transmitter can call a selected receiver without energizing any of the other receivers. In a communication system equipped to transmit and receive voice, the operator at the transmitter, wishing to communicate with a specific receiver or receivers, selects the proper set of control tones for that receiver, which tones are modulated on the carrier wave. The selected receiver will become unsquelched, whereupon the operator can actuate the push-to-talk switch and speak into the microphone. Sounds, of course, are converted into audio signals which are modulated on the carrier wave, the modulated carrier wave being processed by the selected receiver and reconverted to sound waves.

In such selective calling communication systems, a receiver may become faulty and in need of repair. In such case, it is desirable that the individual be given a different receiver while the faulty one is being repaired. It is unlikely that a receiver would be available that would be responsive to the same tone or tones to which the individual's original receiver was programed. Instead, the individual will be given a receiver responsive to a different tone or tones. It would be impractical to advise all pertinent persons who may have occasion to call the individual that his number has been changed. On the other hand, the instant invention enables the transmitter to be simply and rapidly adjusted so that the operator can select the individual's original number, but the transmitter transmits the tone or set of tones which activates his new receiver. Such a system functions in a similar fashion if used in connection with the telephone system. In other words, a person desiring to get in touch with the individual would dial the original number of the individual. The transmitter would, however, transmit the tone or tones to activate his new receiver.

Referring back to FIG. 1, the transmitter 20 includes an RF oscillator 21 which develops on its output a relatively low frequency oscillatory signal. An audio amplifier 22 has its output coupled to a first input of a modulator 23, the second input thereof being coupled to the oscillator 21. The signals from the audio amplifier 22, which may be either audio signals produced by conversion of sound waves applied to the microphone 24 or the control tones, are modulated by the modulator 23 onto the relatively low frequency oscillatory signal. The modulator oscillatory signals are applied to a frequency multiplier 25 which increases the frequency of the oscillatory signal. The relatively high frequency signal is applied to a power amplifier 26 where the signal strength is increased, thereby to provide a high level, frequency-multiplied carrier wave which is emitted from an antenna 27.

Associated with the microphone 24 is a push-to-talk switch 30 which couples a B+ DC voltage to a first pulse generator 31, the output of which is coupled to a second pulse generator 32. The output of the first pulse generator 31 is also coupled to a first gated amplifier 33, and the output of the second pulse generator 32 is coupled to a second gated amplifier 34. The outputs of the gated amplifiers 33 and 34 are respectively coupled through and amplified by the signal amplifiers 35 and 36 and then combined across a load resistor 37. The junction of the two amplifiers 35 and 36 is coupled to one of the inputs of the audio amplifier 22.

In operation, actuation of the push-to-talk switch 30 in preparation to speaking into the microphone 24, causes the B+ voltage to be coupled to the first pulse generator 31 which causes a pulse 38 of predetermined duration to be produced at the output thereof. The pulse 38 is coupled to the second pulse generator 32 and causes the same to produce a pulse 39 commencing at the termination of the pulse 38 and lasting for a second predetermined duration. The pulses 38 and 39 are coupled to their respective gated amplifiers to render the same operative for the respective durations of the pulses. The tone generator 40, the details of which will be presently described, has one output thereof coupled to a second input of the gated amplifier 33 and has another output thereof coupled to the second input of the gated amplifier 34. When the gated amplifier 33 becomes activated by virtue of the pulse 38 being applied thereto, the amplifier amplifies the tone applied thereto from the tone generator 40, which tone is then applied to the amplifier 35 and is amplified therein to appear across the load resistor 37. The pulse 39, which commences upon termination of the pulse 38, activates the gated amplifier 34 so that it can amplify the tone applied thereto from the tone generator 40. The amplified tone is applied to the amplifier 36 wherein it is amplified and is applied across the load resistor 37. It may be seen, therefore, that across the load resistor 37 appears a sequence of two control tones, the first control tone persisting for a duration equal to the duration of the pulse 38 and the second control tone persisting for a duration equal to the duration of the pulse 39. This sequence of control tones is applied to the audio amplifier 22 wherein it is amplified, then modulated on the carrier wave as previously described. The oscillatory signal modulated by the control tones is increased in frequency by the frequency multiplier 25 and increased in amplitude by the power output amplifier 26 and radiated by the antenna 27. The receiver which is tuned to this particular sequence of control tones will become unsquelched and, therefore, operative to receive audio signals applied thereto. The operator then may speak into the microphone 24 which converts the sound waves into electrical signals that are modulated onto the carrier wave and transmitted to the selected receiver which then demodulates the same and reconverts them into sound waves. Further details of the construction of the elements 30–39 are not believed to be necessary to the description of the invention herein. However, should further information be needed on the manner in which these elements are constructed and interconnected, reference may be made to the inventor's copending U.S. Pat. application, Ser. No. 16,037, filed Mar. 3, 1970, now U.S. Pat. No. 3,619,784.

Referring now to FIG. 2, the details of construction of the tone generator 40 will be described. There is provided a rotary selector switch 50 having a movable contact 51 and ten stationary contacts 52.1–52.10. The fixed contact 52.2 is coupled to an electronic switch 60.2, the electronic switch 60.2 including a resistor 61 coupled between the contact 52.2 and the base of an NPN transistor 62, the collector of which is coupled to the B+ supply voltage. A resistor 63 is coupled between the base of the transistor 62 and ground reference potential. A diode 64 and a resistor 65 are coupled in series between the emitter of the transistor 62 and the base of a second NPN transistor 66, the emitter of which is grounded and the collector of which is coupled to a variable frequency oscillator 70.

The oscillator 70 includes a PNP transistor 71 having its emitter coupled through a resistor 72 to the B+ supply voltage, the base of the transistor 71 being coupled through a resistor 77 to ground reference potential and a resistor 73 coupled back to the B+ voltage. A pair of serially connected capacitors 74 and 75 is coupled between the collector of the transistor 71 and ground reference potential, the juncture of the capacitors 74 and 75 being coupled to the emitter of the transistor 71. An inductor 76 is coupled also to the collector of the transistor 71 and is effectively in parallel with the capacitors 74 and 75 as will be presently described. The inductor 76 has ten taps 76.1–76.10, only certain of the taps having been labeled for convenience. The tap 76.2 of the inductor 76 is coupled back to the collector of the transistor 66 in the electronic switch 60.2.

In operation, the movable arm 51 of the rotary selector switch 50 may be moved to engage the fixed contact 52.2, whereupon a path is completed from the B+ supply voltage through the resistor 61 to cause conduction of the transistor 62 through the diode 64, the resistor 65 and the base-emitter junction of the transistor 66. The transistor 66 thus becomes saturated and effectively grounds the collector thereof, which in turn effectively grounds the tap 76.2 on the inductor 76. Accordingly, that portion of the inductor 76 "above" the tap 76.2 will be in parallel with the serially connected capacitors 74 and 75, which parallel combination will determine the frequency of a control tone developed by the oscillator 70 at the juncture of the capacitors 74 and 75.

The fixed contact 52.9 of the rotary selector switch 50 is coupled to another electronic switch 60.9, which electronic switch includes the same parts and is of the same construction as the electronic switch 60.2. The parts of the electronic switch 60.9 are labeled with the same reference numerals used to label the correspond-

ing parts in the electronic switch **60.2.** If the movable arm **51** of the rotary selector switch **50** is moved to engage the fixed contact **52.9,** a path will be defined for current to flow from the B+ supply voltage to cause the transistors **62** and **66** in the electronic switch **60.9** to conduct as previously described with reference to the electronic switch **60.2.** Conduction of the transistor **66** effectively grounds the collector thereof, thereby grounding the tap **76.9** on the inductor **76** in the oscillator **70.** This places the quantity of inductor "above" the tap **76.9** in parallel with the capacitors **74** and **75** to cause the oscillator **70** to oscillate at a frequency lower than the frequency at which the oscillator **70** oscillated with the contact **51** in position to engage the contact **52.2.**

It is to be understood that, although only two electronic switches **60.2** and **60.9** have been shown, there will be 10 such electronic switches **60.1–60.10** respectively coupling the contacts **52.1–52.10** to the taps **76.1–76.10** in the oscillator **70.** By moving the arm **51** to the desired fixed contact, the associated electronic switch will be rendered operative to couple a predetermined portion of the inductor **76,** in circuit with the rest of the oscillator **70,** thereby to select the frequency of the control tone produced by the variable frequency oscillator **70.** Each position of the movable arm **51,** therefore, corresponds to a different control tone.

Corresponding circuitry is provided to generate the second control tone in the sequence of control tones, which circuitry is labeled with numerals corresponding to those used in connection with the circuitry provided in the first control tone, except that **30** has been added to each number. Specifically, there is provided a rotary switch **80** having a movable contact **81** and 10 stationary contacts **82.1–82.10.** The fixed contact **82.4** is coupled to an electronic switch **90.4,** the electronic switch **90.4** including a resistor **91** coupled between the contact **82.4** and the base of an NPN transistor **92,** the collector of which is coupled to the B+ supply voltage. A resistor **93** is coupled between the base of the transistor **92** and ground reference potential. A diode **94** and a resistor **95** are coupled in series between the emitter of the transistor **92** and the base of a second NPN transistor **96,** the emitter of which is grounded and the collector of which is coupled to a variable frequency oscillator **100.**

The oscillator **100** includes a PNP transistor **101** having its emitter coupled through a resistor **102** to the B+ supply voltage, the base of the transistor **101** being coupled through a resistor **107** to ground reference potential and a resistor **103** coupled back to the B+ voltage. A pair of serially connected capacitors **104** and **105** is coupled between the collector of the transistor **101** and ground reference potential, the juncture of the capacitors **104** and **105** being coupled to the emitter of the transistor **101.** An inductor **106** is coupled also to the collector of the transistor **101** and is effectively in parallel with the capacitors **104** and **105** as will be presently described. The inductor **106** has 10 taps **106.1–106.10,** only certain of the taps having been labeled for convenience. The tap **106.4** of the inductor **106** is coupled back to the collector of the transistor **96** in the electronic switch **90.4.**

In operation, the movable arm **81** of the rotary selector switch **80** may be moved to engage the fixed contact **82.4,** whereupon a path is completed from the B+ supply voltage through the resistor **91** to cause conduction of the transistor **92** through the diode **94,** the resistor **95** and the base-emitter junction of the transistor **96.** The transistor **96** thus becomes saturated and effectively grounds the collector thereof, which in turn effectively grounds the tap **106.4** on the inductor **106.** Accordingly, that portion of the inductor **106** "above" the tap **106.4** will be in parallel with the serially connected capacitors **104** and **105,** which parallel combination will determine the frequency of a control tone developed by the oscillator **100** at the juncture of the capacitors **104** and **105.**

The fixed contact **82.7** of the rotary selector switch **80** is coupled to another electronic switch **90.7,** which electronic switch includes the same parts and is of the same construction as the electronic switch **90.4.** The parts of the electronic switch **90.7** are labeled with the same reference numerals used to label the corresponding parts in the electronic switch **90.4.** If the movable arm **81** of the rotary selector switch **80** is moved to engage the fixed contact **82.7,** a path will be defined for current to flow from the B+ supply voltage to cause the transistors **92** and **96** in the electronic switch **90.7** to conduct as previously described with reference to the electronic switch **90.4.** Conduction of the transistor **96** effectively grounds the collector thereof, thereby grounding the tap **106.7** on the inductor **106** in the oscillator **100.** This places the quantity of inductor "above" the tap **106.7** in parallel with the capacitors **104** and **105** to cause the oscillator **100** to oscillate at a frequency lower than the frequency at which the oscillator **100** oscillated with the contact **81** in position to engage the contact **82.4.**

It is to be understood that, although only two electronic switches **90.4** and **90.7** have been shown, there will be ten such electronic switches **90.1–90.10** respectively coupling the contacts **82.1–82.10** to the taps **106.1–106.10** in the oscillator **100.** By moving the arm **81** to the desired fixed contact, the associated electronic switch will be rendered operative to couple a predetermined portion of the inductor **106** in circuit with the rest of the oscillator **100,** thereby to select the frequency of the control tone produced by the variable frequency oscillator **100.** Each position of the movable arm **81,** therefore, corresponds to a difference control tone.

The details of the tone substitution system will now be described. There is provided a rotary selector switch **110** having a movable contact **111** and ten stationary contacts **112.1–0.10.** The contact **112.2** is coupled to the junction of the resistors **61** and **63** in the electronic switch **60.2,** and the contact **112.9** is coupled to the junction of the resistors **61** and **63** in the electronic switch **60.9.** Although not shown, it is to be understood that the rest of the stationary contacts **112.1–0.10** are coupled respectively to the junction of the resistors **61** and **63** respectively in the electronic switches **60.1–0.10.** The movable contact **111** of the rotary selector switch **110** is coupled to a first AND circuit **120.** The AND circuit **120** includes a first NPN transistor **121** having its emitter coupled to the collector of a second NPN transistor **122,** the emitter of which is coupled to ground reference potential. The collector and base of the transistor **121** are connected together and to the movable contact **111** of the selector switch **110.** Alternatively, a simple diode could be used in place of the transistor **121.** The base of the transistor **121** provides a first input to the AND circuit **120** and is cou-

pled to the movable contact **111.** There is provided another rotary selector switch **130** having a movable contact **131** and 10 stationary contacts **132.1–0.10.**

The movable contact **131** is coupled to a second AND circuit **140** which includes a first NPN transistor **141** having its emitter coupled to the collector of a second NPN transistor **142,** the emitter of which is grounded. The base of the transistor **142** is coupled through a resistor **143** back to the movable contact **111** of the selector switch **110,** and provides a first input to the AND circuit **140.** The base of the transistor **141** is connected to the movable contact **131** of the rotary switch **130** and therefore provides a second input to the AND circuit **140.** A second input to the AND circuit **120** is provided by the connection provided by the conductor **145** from the contact **131** to the base of the transistor **122.** The collector of the transistor **141** is coupled to an electronic switch **150** which includes a PNP transistor **151,** the base of which is coupled through a resistor **152** to the collector of the transistor **141** in the AND circuit **140.** The emitter of the transistor **151** is coupled to the B+ supply voltage and is also coupled through a resistor **153** back to the collector of the transistor **141.** The collector of the transistor **151** is coupled to the junction of a pair of resistors **154** and **155.**

The resistor **154** in turn coupled to the movable contact **161** of a rotary selector switch **160,** which rotary selector switch **160** includes ten fixed contacts **162.1–0.10,** that are connected to the junction of the diode **64** and the resistor **65** respectively in the ten electronic switches **60.1–0.10.** The resistor **155** is coupled to the movable contact **171** of another rotary selector switch **170,** which also includes 10 fixed contacts **172.1–0.10** that are connected to the junction of the diode **94** and the resistor **95** respectively in the ten electronic switches **90.1–0.10.**

In the following description of the manner in which the tone substitution system operates, a sequence of tones identified by the number "**97**" means that the first tone is represented by position **9** and the second tone is represented by position **7.** It is to be understood that a sequence of tones such as **97** means that the first tone is produced by the first oscillator **70** when the portion of the inductor "above" the tap **76.9** is in circuit, and that the second tone is produced by the second oscillator **100** when the portion of the inductor "above" the tap **106.7** is in circuit. If the operator wants to send sequence **48,** he will adjust the selector switch **110** such that the movable contact **51** engages the fixed contact **52.4** (representing the first tone **4**) and will set the movable contact **81** of the selector switch **80** to engage the fixed contact **82.8** (the second tone **8**). Suppose, however, that the receiver to respond to sequence **97** was faulty and has been replaced with a receiver that will respond to sequence **24.** The tone substitution system is programed such that, if the caller selects sequence **97,** sequence **24** will be sent instead. To effect this programing, the transmitter operator adjusts the movable contact **111** of the selector switch **110** to engage the fixed contact **112.9** to match the first tone to be substituted (**9**); and adjusts the movable contact **131** of the selector switch **130** to engage the contact **132.7,** which represents the second tone to be substituted (**7**). The selector switches **110** and **130** are thus adjusted to represent the sequence of tones that is to be replaced, that is, **97.** The selector switch **160** is adjusted such that the movable arm **161** engages the contact **162.2** and the movable arm **171** of the selector switch **170** is moved to engage the fixed contact **172.4.** Thus, the selector switches **160** and **170** are adjusted to represent the sequence of tones to be substituted, that is, sequence **24.** Now the tone substitution system is properly programed.

If the operator sets the selector switches **50** and **80** to transmit sequence **97,** he will place contacts **51** and **81** in the positions shown. The B+ supply voltage is applied to the base of the transistor **121** as one input to the AND circuit **120** by virtue of the path defined by the contacts **51** and **52.9** of the selector switch **50,** the conductor **113,** and the contacts **112.9** and **111.** There is also provided a path along the conductor **144** to apply the B+ supply voltage to the base of the transistor **142,** as a first input to the second AND circuit **140.** Similarly, there is provided a path through the contacts **81** and **82.7,** the resistor **91** in the electronic switch **90.7,** the conductor **133,** and the contacts **132.7** and **131** of the selector switch **130,** to enable the B+ voltage to be applied to the base of the transistor **141** as a second input to the AND circuit **140.** The B+ supply voltage also is applied along the conductor **145** by the resistor **123** to the base of the transistor **122** as a second input to the first AND circuit **120.**

The concurrence of the B+ supply voltages, which may be considered enabling signals, at the two inputs of the AND circuit **120,** causes both transistors **121** and **122** to conduct, thereby effectively grounding the movable contact **111** (except for the saturation of voltage of each of the transistors which is 0.2 volts each or about 0.4 volts all together). This diverts the current from the transistors **62** and **66** in the electronic switch **60.9** and through the transistors **121** and **122.** In this regard, it should be noted that about 0.4 volts is necessary between the contact **111** and ground before the transistors **121** and **122** conduct, whereas the transistors in the electronic switch **60.9** will not conduct until the voltage is about 1.8 volts (0.6 volts for each of the transistors **62** and **66** and for the diode **64**), whereby the transistors **62** and **66** will not conduct if the contacts **111** and **112.9** are engaged. Accordingly, the tap **76.9** on the inductor **76** in the oscillator **70** will not become grounded despite the placement of the selector switch **50** in its number **9** position.

Also, the concurrence of the B+ enabling signals, at the two inputs of the AND circuit **140,** causes both transistors **141** and **142** to conduct, thereby effectively grounding the movable contact **131** (except for the saturation of the voltage of the transistors which is about 0.4 volt). This diverts the current from the transistors **92** and **96** in the electronic switch **90.7** and through the transistors **141** and **142.** In this regard, 0.4 volt is necessary between the contact **131** and ground before both the transistors **141** and **142** conduct, whereas the transistors in the electronic switch **90.7** will not conduct until the voltage is about 1.8 volts (0.6 volt for each of the transistors **92** and **96** and for the diode **94**), whereby the transistors **92** and **96** will not conduct if the contacts **131** and **132.7** are engaged. Accordingly, the tap **106.7** on the inductor **106** in the oscillator **100** will not become grounded despite the placement of the selector switch **80** in its number **7** position.

Also, the conduction of the transistors **141** and **142** provides a path for current flow from the B+ supply through the base-emitter junction of the transistor **151**

in the electronic switch **150** and through the resistor **152,** thereby to "close" the electronic switch **150** and enable current to flow through the emitter-collector of the transistor **151,** through the resistor **154,** the movable contact **161** of the selector switch **160,** the stationary contact **162.2** along the conductor **163,** through the resistor **65** in the electronic switch **60.2,** through the base-emitter junction of the transistor **66,** thereby causing the latter to conduct. This effectively grounds the tap **76.2** on the inductor **76** and places the portion "above" the tap in parallel with the capacitors **74** and **75,** so that the control tone developed by the oscillator **70** would be the number **2** tone, despite the number **9** selection made on the selector switch **50.**

In addition, current flows from the B+ supply through the transistor **151** in the electronic switch **150,** through the resistor **155,** through the contacts **171** and **172.4,** along the conductor **173,** through the resistor **95** in the electronic switch **90.4,** and through the base-emitter junction of the transistor **96,** thereby to render it conductive. Conduction of the transistor **96** effectively grounds the tap **106.4** of the inductor **106** causing the oscillator **100** to oscillate and produce the number **4** tone, despite the fact that the selector switch **80** was set to cause the oscillator **100** to produce the number **7** tone.

Thus, by setting the selector switches **110** and **130** on the sequence of tones to be replaced (sequence **97**) and by setting the selector switches **160** and **170** on the sequence of tones to be substituted (**24**), the tone sequence **24** will be produced when the selector switches **50** and **80** are adjusted to produce the sequence **97.**

Turning now to FIG. **3,** an alternative form of the invention is shown, wherein parts thereof corresponding to parts in the system shown in FIG. **2** are labeled with the same reference numerals with a factor **200** added thereto. There is provided a rotary selector switch **250** having a movable contact **251** and ten stationary contacts **252.1–0.10,** which contacts are respectively coupled to ten electronic switches **260.1–0.10.** Each electronic switch includes a resistor **261** coupled between the associated stationary contacts of the switch **250** and the base of an NPN transistor **262,** the collector of which is coupled to the B+ supply voltage. A resistor **263** is coupled between the base of the transistor **262** and ground reference potential. A diode **264** and a resistor **265** are coupled in series between the emitter of the transistor **262** and the base of a second NPN transistor **266,** the emitter of which is grounded and the collector of which is coupled to an associated tap on the inductor **276.** The inductor **276** corresponds to the inductor **76** shown in FIG. **2,** and is part of an oscillator (not shown) corresponding to the oscillator **70.** Coupled to the associated tap is the collector of a third NPN transistor **267,** the emitter of which is grounded. Also shown in FIG. **3** is a selector switch **360** corresponding to the switch **160** in FIG. **2,** and having a movable contact **361** and a set of ten stationary contacts **362.1–0.10.** The bases of the transistors **267** in the electronic switches **260.1–0.10** are respectively coupled to the stationary contacts **362.1–0.10.** It is understood that AND circuits such as the AND circuits **120** and **140,** an electronic switch such as the electronic switch **150,** ana selector switch such as the selector switch **170,** are also provided and connected in a similar manner. In addition, there are provided a selector switch corresponding to the selector switch **80,** and electronic switches corresponding to the electronic switches **90.1–0.10,** each modified by the addition of a transistor corresponding to the transistor **267.** Finally, a second oscillator, such as the oscillator **100,** is provided.

In operation, when the movable arm **251** is placed in the position shown, current will flow to the transitors **262** and **266** in the electronic switch **260.9,** thereby to ground the tap **276.9,** all in the manner previously described with respect to the embodiment of FIG. **2.** However, assuming the selector switches **110, 130,** and **80** are in the positions shown in FIG. **2,** the current will be diverted away from the electronic switch **260.9** and, instead, current will flow through the contacts **361** and **362.2** of the selector switch **360** to render conductive and transistor **267,** thereby effectively grounding the tap **276.2** on the inductor **276.** A similar mode of operation would hold true for the channel which controls the second tone. Thus, what has been provided is a pair of cascaded transistors for selectively grounding the taps on the inductor **276** (or any other impedance capable of controlling the frequency of oscillator) plus a third transistor for controlling the selective grounding of the taps when the tone substitution system is programed to substitute a sequence of tones.

Turning now to FIGS. **4** and **5,** the details of a tone substitution system permitting the substitution of more than one tone or sequence of tones will be described. There is provided a rotary selector switch **400** having a movable contact **401** and five fixed contacts **402.1–0.5,** which fixed contacts are respectively connected to conductors **403.1–0.5.** In the specific example being described, the first tone in the sequence of tones may have one of five difference frequencies. However, it is to be understood that the invention includes a system capable of selecting ten frequencies such as is achieved by the system disclosed in FIG. **2** by the use of a ten-position selector switch or, in fact, a system capable of selecting any number of frequencies. Five electronic switches (ES) **404.1–0.5** respectively have the inputs thereof coupled to the conductors **403.1–0.5.** Each electronic switch **404.1–0.5** may be of the same basic construction as the electronic switch **60.2** shown in FIG. **2.** There is provided a variable frequency oscillator **407** having five frequency determining elements **407.1–0.5,** which elements may correspond to the portions of the inductor **76** defined by the various taps **76.1–0.10** in the oscillator **70** of FIG. **2.** Conductors **405.1–0.5** respectively couple the outputs of the electronic switches **404.1–0.5** to the frequency determining elements **407.1–0.5** in a fashion similar to that described with respect to the system of FIG. **2.** Energization of one of the electronic switches **404.1–0.5** produces an output signal on the associated conductor **405.1–0.5** to couple the associated frequency determining element **407.1–0.5** into the oscillator **407.**

There is also provided a rotary selector switch **410** having a movable contact **411** and five fixed contacts **412.1–0.5,** which fixed contacts are respectively connected to conductors **413.1–0.5.** In this instance, the second tone also has one of five different frequencies. However, it is to be understood that any number of frequencies is contemplated. Five electronic switches (ES) **414.1–0.5** respectively have the inputs thereof coupled to the conductors **413.1–0.5.** Each electronic switch **414.1–0.5** is of the same basic construction such as electronic switch **90.4** shown in FIG. **2.** There is pro-

vided a variable frequency oscillator **417** having five frequency determining elements **417.1–0.5**, which elements may correspond to the portions of the inductor **106** defined by the various taps **106.1–0.10** in the oscillator **100** of FIG. **2.** Conductors **415.1–0.5** respectively couple the outputs of the electronic switches **414.1–0.5** to the frequency determining elements **417.1–0.5** in a fashion similar to that described with respect to the system of FIG. **2.** Energization of one of the electronic switches **414.1–0.5** produces an output signal on the associated conductor **415.1–0.5** to couple the associated frequency determining element **417.1–0.5** into the oscillator **417.**

In operation, the user sets up the switches **400** and **410** to produce the desired sequence of control tones, in this case the sequence being **13.** A path for current flow is provided from the B+ supply voltage through the contacts **401** and **402.1,** the conductor **403.1** to the electronic switch **404.1** which is thereby energized to provide an output signal. The output signal is produced on the conductor **405.1** and connects the frequency determining element **407.1** in the oscillator **407.** Similarly, a path is provided from the B+ supply voltage through the contacts **411** and **412.3** through the conductor **413.3** into the electronic switch **414.3,** which is thereby energized to provide an output signal. The output signal which appears on the conductor **415.3** connects the frequency determining element **417.3** into the oscillator **417** to cause the same to produce a corresponding control tone. The tones produced by the two oscillators **407** and **417** may then be coupled to gated amplifiers such as those shown labeled **33** and **34** in FIG. **1.**

A rotary selector switch **420** has a movable contact **421** and a set of five stationary contacts **422.1–0.5,** which stationary contacts are coupled respectively to the conductors **403.1–0.5.** Similarly, the rotary selector switch **430** has a movable contact **431** and a set of five stationary contacts **432.1–0.5** respectively connected to the conductors **413.1–0.5.** The contacts **421** and **431** are both coupled to a pair of AND circuits **423** and **433,** which AND circuits may be respectively constructed like the AND circuits **120** and **140** in FIG. **2.** The output of the AND circuit **433** is coupled to an electronic switch, which in turn is coupled to the movable contacts **441** and **451** respectively of a pair of rotary selector switches **440** and **450.** The rotary selector switch **440** has a set of five stationary contacts **441.1–0.5** respectively connected to the conductors **408.1–0.5** which in turn are coupled respectively to a second input of the electronic switches **404.1–0.5.**

The selector switch **450** also has a set of five stationary contacts **452.1–0.5** respectively connected to conductors **418.1–0.5** which in turn are coupled to a second input respectively of the electronic switches **418.1–0.5.** The switches **420, 430, 440,** and **450,** the AND circuits **423** and **433,** and the electronic switch **434** define a first tone substitution network **425,** which is capable of substituting one sequence of tones for a sequence set up on the selector switches **400** and **410.**

Specifically, since the contact **421** of the selector switch **420** engages the contact **422.1,** a path for current flow is defined by the contacts **401** and **402.1** of the selector switch **400,** the conductor **403.1** and the contacts **422.1** and **421** of the selector switch **420,** and is applied as a first input to the AND circuit **423** and also is applied as a first input to the AND circuit **433.** Similarly, since the contact **431** of the selector switch **430** engages the contact **432.3,** a path for current flow is defined by the contacts **411** and **412.3** of the selector switch **410,** the conductor **413.3** and the contacts **432.3** and **431** of the selector switch **430** and is applied as a second input to the AND circuit **423** and also is applied as a second input to the AND circuit **433.**

The AND circuit **423,** in a fashion similar to the mode of operation of the AND circuit **120** of FIG. **2** defines a path to divert the current flow from the electronic switch **404.1,** thereby to render the same inoperative. Similarly, the AND circuit **433** provides a path to divert current flow from the electronic switch **414.3,** thereby rendering the same inoperative. The output of the AND circuit **433** is applied to the electronic switch **434** to render the same operative to couple the B+ supply voltage through the contacts **441** and **442.3** of the selector switch **440,** along the conductor **408.3,** as an input to the electronic switch **404.3.** The electronic switch is thereby rendered operative to couple the frequency determining element **407.3** into the oscillator **407.** The frequency of the control tone by the oscillator **407** will be determined by the value of the frequency determining element **407.3.** Similarly, the B+ supply voltage is coupled through the contacts **451** and **452.2** of the selector switch **450,** along the conductor **418.2,** as an input to the electronic switch **414.2.** The electronic switch is thereby rendered operative to couple the frequency determining element **417.2** into the oscillating **417.** The frequency of the control tone produced by the oscillator **417** will be determined by the value of the frequency determining element **417.2.**

Thus, the selector switches **420** and **430** are set up to correspond to the tone sequence **13** to be replaced and the selector switches **440** and **450** are set up on the sequence **32** to be substituted. Now, if the selector switches **400** and **410** are set up to transmit tone sequence **13,** tone sequence **32** will be sent instead.

Turning specifically to FIG. **5,** there is provided a second tone substitution **485** which has the same basic construction as the network **425,** whereby corresponding elements are labeled with the same reference numerals but with the factor of **60** added thereto. Specifically, there is provided a rotary selector switch **480** which has a movable contact **481** and a set of five stationary contacts **482.1–0.5** which stationary contacts are coupled respectively to the conductors **403.1–0.5.** There is also provided a rotary selector switch **390** which has a movable contact **491** and a set of five stationary contacts **492.1–0.5** respectively connected to the conductors **413.1–0.5.** The contacts **481** and **491** are both coupled to AND circuits **483** and **493,** which AND circuits may be respectively constructed like the AND circuits **120** and **140** in FIG. **2.** The output of the AND circuit **493** is coupled to an electronic switch **494,** which in turn is coupled to the movable contacts **501** and **511** respectively of a pair of rotary selector switches **500** and **510.** The switch **500** has stationary contacts **502.1–0.5** respectively connected to the conductors **408.1–0.5** which in turn are coupled respectively to a second input of the electronic switches **404.1–0.5.** The selector switch **510** also has a set of five stationary contacts **512.1–0.5** respectively connected to conductors **418.1–0.5** which in turn are coupled to a second input respectively of the electronic switches **414.1–0.5.** The second tone substitution network **485**

is capable of substituting a sequence of tones for a second sequence set up on the selector switches **400** and **410.**

In the system shown, there is provided a third tone substitution network **535** having the same construction as the network **425,** and, accordingly, the elements are labeled with corresponding numerals with a factor of **110** added thereto. Specifically, a rotary selector switch **530** has a movable contact **531** and a set of five stationary contacts **531.1–0.5,** which stationary contacts are coupled respectively to the conductors **403.1–0.5.** Similarly, the rotary selector switch **540** has a movable contact **541** and a set of five stationary contacts **542.1–0.5** respectively connected to the conductors **413.1–0.5.** The contacts **531** and **541** are both coupled to a pair of AND circuits **533** and **543,** which AND circuits may be respectively constructed like the AND circuits **120** and **140** in FIG. **2.** The output of the AND circuits **543** is coupled to an electronic switch **544,** which in turn is coupled to the movable contacts **551** and **561** respectively of a pair of rotary selector switches **550** and **560.** The rotary selector switch **550** has a set of five stationary contacts **552.1–0.5** respectively connected to the conductors **408.1–0.5** which in turn are coupled respectively to a second input of the electronic switches **404.1–0.5.** The selector switch **560** also has a set of five stationary contacts **562.1–0.5** respectively connected to conductors **418.1–0.5** which in turn are coupled to the second input respectively of the electronic switches **414.1–0.5.**

Considering now the operation of the network **485,** the selector switches **480** and **490** have been set on a tone sequence **44** and the switches **500** and **510** have been set on the tone sequence **24.** Accordingly, placement of the selector switches **400** and **410** to transmit a tone sequence **44,** that is, in positions corresponding to the positions of the selector switches **480** and **490,** the tone sequence **24** would be sent instead, which represents the positions of the selector switches **500** and **510.** It should be noted that with the selector switches **400** and **410** in the positions shown, that is, to transmit tone sequence **13,** the network **485** will have no effect since the selector switches **480** and **490** are set on the tone sequence **44.** As explained previously, in order for the tones set up on the selector switches **500** and **510** to be substituted, the tone sequence on the selector switches **480** and **490** must match the tone sequence on the selector switches **400** and **410.**

Similarly, the selector switches **530** and **540** have been set on a tone sequence **15** and the switches **550** and **560** have been set on the tone sequence **43.** Accordingly, placement of the selector switches **400** and **410** to transmit the tone sequence **15,** that is, in positions corresponding to the positions of the selector switches **530** and **540,** the tone sequence **43** would be sent instead, which represents the positions of the selector switches **550** and **560.** It should be noted that with the selector switches **400** and **410** in the positions shown, that is, in tone sequence **13,** the network **535** will have no effect since the selector switches **530** and **540** are set on the tone sequence **15.** In order for the tones set up on the selector switches **550** and **560** to be substituted, the tone sequence on the selector switches **530** and **540** must match the tone sequence on the selector switches **400** and **410.**

The dashed conductors between the networks **485** and **535** indicate the fact that any number of such networks may be utilized. In this embodiment, three such networks **425, 485,** and **535** have been shown, whereby the transmitter would be capable of substituting three tone sequences. In other words, if the operator were to select tone sequence **13,** then tone sequence **32** would be sent automatically by virtue of the setup of the first network **425;** if the operator were to select tone sequence **44,** then tone sequence **24** would be sent automatically by virtue of the arrangement of the second network **485;** and, if the operator were to set up the selector switches **400** and **410** to transmit the tone sequence **15,** then the tone sequence **43** would be send instead, in accordance with the setup in the third network **535.**

With five available frequencies for the first control tone and five available frequencies for the second control tone, 25 different tone sequences are available. If it is desired that the transmitter be completely versatile and capable of simultaneously substituting all sequences, 25 substitution networks, such as the network **425,** would be needed.

The system above described has a variety of advantageous features. First, substitution of one sequence for another sequence of tones involves merely setting several rotary selector switches which may be mounted on the front of the transmitter so as to be easily accessible to the operator. No patch cords or the like are needed to make the change to provide for substitution. Also, no sequences need be placed aside for use as spares as is required in other presently available systems. In other words, in a system having 100 available tone sequences (10 first tones and 10 second tones), 10 were put aside as spares so that, when a receiver became faulty, it would be turned in and the owner would be given one of the spare receivers. If all the spares were being used at the time so that no spare was available, although several day-to-day receivers were available, the individual could not be given a receiver. On the other hand, in the system as above described, there are no particular spares set aside, but rather any of the 100 tone sequences may be utilized either for a spare or for a continuous-operation receiver.

When a receiver which is faulty has been turned in for repair by an individual, and he is given a replacement receiver, the transmitter is programed to transmit the tone sequence corresponding to his new receiver in response to dialing a tone sequence corresponding to his old number. There is no need to return the receiver to the individual when it is repaired, which saves the individual a trip back to the repair shop. The faulty receiver which has been repaired is then usable itself as a spare. Accordingly, a receiver, for example, responsive to the sequence **12** which becomes faulty, may be turned in for repairs. The user is given a receiver responsive to the sequence, for example, **28.** After the operator sets up the selector switches in any one of the unused networks **425, 485, 435,** etc., persons wanting to call the individual can call his old number **12,** yet be connected to him through his new number **28.**

If such a system finds particular use in a hospital, where Dr. Jones has, for example, No. **15,** and Dr. Smith has No. **18,** Dr. Smith could transfer his calls to Dr. Jones without apprising would-be callers, by having one of the substitution networks set up to substitute sequence **15** for sequence **18.** Thus, callers desirous of getting in touch with Dr. Smith would dial sequence **18,** but, by virute of the tone substitution system, the trans-

mitter would automatically send sequence 15. Also, Dr. White, who has, say, No. 28, could have his calls transferred to Dr. Jones. By virtue of the present system, any number of calls may be rerouted to Dr. Jones, without affecting Dr. Jone's ability to receive calls specifically directed to him. This latter feature results from the fact that the No. 15 sequence has not been programed into the appropriate selector switches in any one of the networks.

What has been described, therefore, is an improved tone substitution system for use in a transmitter of a selective calling communication system. Although preferred embodiments of the invention have been described, it is understood that various changes and modifications can be made therein without departing from the spirit and scope of the invention, and it is intended that all such changes and modifications be covered as fall within the scope of the appended claims.

What is claimed is:

1. A tone substitution system for use in a transmitter including at least one oscillator with frequency determining means therein for generating a control tone, said tone substitution system comprising a plurality of electronic switches for coupling selected portions of the frequency determining means in circuit in the oscillator, a first selector switch having a first contact coupled to an enabling signal and a plurality of second contacts respectively coupled to said electronic switches, said first selector switch being movable to a selected position to couple the enabling signal to the associated electronic switch, thereby to render said last-mentioned electronic switch operative to couple the associated portion of the frequency determining means in circuit in the oscillator, a second selector switch having a first contact and a plurality of second contacts individually coupled to the second contacts of said first selector switch, a third selector switch having a first contact coupled to the first contact of said second selector switch and a plurality of second contacts respectively coupled back to said electronic switches, said first selector switch being movable to a position corresponding to a preselected position of said second selector switch to complete a path for the enabling signal through said second and third selector switches to the one of said electronic switches corresponding to the position of said third electronic switch, thereby to render said last-mentioned electronic switch operative to couple the associated portion of the frequency determining means in circuit in the oscillator, means responsive to said first and second selector switches being in corresponding positions to divert the enabling signal away from the electronic switch associated with the selected position of said first selector switch.

2. The tone substitution system set forth in claim 1, wherein the frequency determining means includes an inductor having a plurality of taps thereon, said electronic switches being respectively coupled to said taps.

3. The tone substitution system set forth in claim 1, and further comprising an additional electronic switch coupled between said second and third selector switches, said additional electronic switch being responsive to said first and second selector switches being in corresponding positions to couple an enabling signal through said third selector switch to the electronic switch associated therewith.

4. The tone substitution system set forth in claim 1, wherein each of said electronic switches includes a pair of cascaded transistors.

5. The tone substitution system set forth in claim 4, wherein the second contacts of said third selector switch are coupled to the junction of the transistors respectively in said electronic switches.

6. The tone substitution system set forth in claim 4, wherein said electronic switches respectively include third transistors respectively coupled to the associated portions of the frequency determining means, the second contacts of said third selector switch being respectively coupled to said third transistors for controlling the conduction thereof.

7. The tone substitution system set forth in claim 1, wherein the enabling signal is a DC voltage used in supplying power to the transmitter.

8. The tone substitution system set forth in claim 1, wherein each of said selector switches is a rotary switch having a plurality of second contacts which are stationary and a first contact which is movable.

9. A tone substitution system for use in a transmitter including first and second oscillators respectively generating two control tones and respectively including first and second impedance networks therein, said tone substitution system comprising a plurality of first electronic switches for coupling selected portions of the first impedance network in circuit in the first oscillator, a first selector switch having a first contact coupled to an enabling signal and a plurality of second contacts respectively coupled to said first electronic switches, said first selector switch being placeable in a selected condition to couple the enabling signal to the associated first electronic switch, thereby to render said last-mentioned electronic switch operative to couple the associated portion of the first impedance network to the first oscillator, a plurality of second electronic switches coupling selected portions of the second impedance network in circuit in the second oscillator, a second selector switch having a first contact coupled to an enabling signal and a plurality of second contacts respectively coupled to said second electronic switches, said second selector switch being placeable in a selected condition to couple the enabling signal to the associated second electronic switch, thereby to render said last-mentioned electronic switch operative to couple the associated impedance portion in the second oscillator, a third selector switch having a first contact and a plurality of second contacts individually coupled to the second contacts of said first selector switch, a fourth selector switch having a first contact and a plurality of second contacts respectively coupled to the second contacts of said second selector switch, an AND circuit having a pair of inputs respectively coupled to the first contacts of said third and fourth selector switches, said first selector switch being placeable in a condition corresponding to a preselected condition of said third selector switch to complete a path for the enabling signal through said third selector switch to said AND circuit, said second selector switch being placeable in a condition corresponding to a preselected condition of said fourth selector switch to complete a path for the enabling signal through said fourth selector switch to said AND circuit, said AND circuit being responsive to the application thereto of enabling signals from said third and fourth selector switches to provide an output signal, a fifth selector switch having a first

contact coupled to the output of said AND circuit and a plurality of second contacts respectively coupled back to said first electronic switches, said fifth selector switch being operative to conduct said output signal to the one of said first electronic switches corresponding to the condition of said fifth selector switch, thereby to render said last-mentioned electronic switch operative to couple the associated impedance portion to the first oscillator, a sixth selector switch having a first contact coupled to the output of said AND circuit and a plurality of second contacts respectively coupled back to said second electronic switches, said sixth selector switch being operative to conduct said output signal to the one of said second electronic switches corresponding to the condition of said sixth selector switch, thereby to render said last-mentioned electronic switch operative to couple the associated impedance portion to the second oscillator, means responsive to said first and third selector switches being in corresponding conditions and said second and fourth selector switches being in corresponding conditions to divert the enabling signals away from the electronic switches associated with the selected conditions of said first and second selector switches.

10. The tone substitution system set forth in claim **9,** wherein said AND circuit includes a pair of transistors connected in series, the first contact of said third selector switch being coupled to the input of one of said transistors and the first contact of said fourth selector switch being coupled to the input of the other of said transistors.

11. The tone substitution system set forth in claim **9,** wherein said AND circuit is operative to divert the enabling signal from the first electronic switches when said first and third selector switches are in corresponding conditions, and further comprising a second AND circuit for diverting the enabling signal from said second electronic switches when said second and fourth selector switches are in corresponding conditions.

12. A tone substitution system for use in a transmitter including first and second oscillators respectively generating two control tones and respectively including first and second impedance networks therein, said tone substitution system comprising a plurality of first electronic switches for coupling selected portions of the first impedance network in circuit in the first oscillator, a first selector switch having a first contact coupled to an enabling signal and a plurality of second contacts respectively coupled to said first electronic switches, said first selector switch being placeable in a selected condition to couple the enabling signal to the associated first electronic switch, thereby to render said last-mentioned electronic switch operative to couple the associated portion of the first impedance to the first oscillator, a plurality of second electronic switches respectively coupling selected portions of the second impedance network in circuit in the second oscillator, a second selector switch having a first contact coupled to an enabling signal and a plurality of second contacts respectively coupled to said second electronic switches, said second selector switch being placeable in a selected condition to couple the enabling signal to the associated second electronic switch, thereby to render said last-mentioned electronic switch operative to couple the associated impedance portion in the second oscillator, a third selector switch having a first contact and a plurality of second contacts individually coupled to the second contacts of said first selector switch, a fourth selector switch having a first contact and a plurality of second contacts respectively coupled to the second contacts of said second selector switch, a pair of AND circuits each having a pair of inputs respectively coupled to the first contacts of said third and fourth selector switches, said first selector switch being placeable in a condition corresponding to a preselected condition of said third selector switch to complete a path for the enabling signal through said third selector switch to said AND circuits, said second selector switch being placeable in a condition corresponding to a preselected condition of said fourth selector switch to complete a path for the enabling signal through said fourth selector switch to said AND circuits, one of said AND circuits being responsive to the application thereto of enabling signals from said third and fourth selector switches to provide an output signal, a fifth selector switch having a first contact coupled to the output of said one AND circuit and a plurality of second contacts respectively coupled back to said first electronic switches, said fifth selector switch being operative to conduct said output signal to the one of said first electronic switches corresponding to the condition of said fifth selector switch, thereby to render said last-mentioned electronic switch operative to couple the associated impedance portion to the first oscillator, a sixth selector switch having a first contact coupled to the output of said one AND circuit and a plurality of second contacts respectively coupled back to said second electronic switches, said sixth selector switch being operative to conduct said output signal to the one of said second electronic switches corresponding to the condition of said sixth selector switch, thereby to render said last-mentioned electronic switch operative to couple the associated impedance portion to the second oscillator, one of said AND circuits including means responsive to said first and third selector switches being in corresponding conditions to divert the enabling signals away from the electronic switch associated with the selected condition of said first selector switch, the other of said AND circuits including means responsive to said second and fourth selector switches being in corresponding conditions to divert the enabling signals away from the electronic switch associated with the selected conditions of said second selector switch.

13. A tone substitution system for use in a transmitter including at least one oscillator for generating a control tone and including an impedance network, said tone substitution system comprising a plurality of electronic switches for coupling selected portions of the impedance network in circuit in the oscillator, a first selector switch having a first contact coupled to an enabling signal and a plurality of second contacts respectively coupled to said electronic switches, said first selector switch being placeable in a selected condition to couple the enabling signal to the associated electronic switch, thereby to render said last-mentioned electronic switch operative to couple the associated frequency determining element to the oscillator, a plurality of second selector switches each having a first contact and a plurality of second contacts individually coupled to the second contacts of said first selector switch, a plurality of third switches each having a first contact coupled to the first contact of an associated second selector switch and a plurality of second contacts respectively coupled back to said electronic switches, said first selector

switch being placeable in a condition corresponding to a preselected condition of any of said second selector switches to complete a path for the enabling signal through said last-mentioned second selector switch and through the associated third selector switch to the one of said electronic switches corresponding to the condition of said last-mentioned third selector switch, thereby to render said last-mentioned electronic switch operative to couple the associated impedance portion to the oscillator, means responsive to said first and second selector switches being in corresponding conditions to divert the enabling signal away from the electronic switch associated with the selected condition of said first selector switch.

14. The tone substitution system set forth in claim **13,** wherein there are as many second selector switches and there are as many third selector switches as there are impedance portions, whereby any desired number of control tones may be substituted.

15. A tone substitution system for use in a transmitter including a plurality of oscillators respectively generating a plurality of control tones and each having an impedance network, said tone substitution system comprising a plurality of sets of electronic switches respectively coupling portions of the impedance networks respectively to the oscillators, a plurality of first selector switches each having a first contact coupled to an enabling signal and a plurality of second contacts respectively coupled to the electronic switches in a set of electronic switches, each of said first selector switches being placeable in a selected condition to couple the enabling signal to the associated electronic switch, thereby to render said last-mentioned electronic switch operative to couple the associated impedance portion to the associated oscillator, a plurality of second selector switches each having a first contact and a plurality of second contacts respectively coupled to the second contacts of said first selector switches, an AND circuit having a plurality of inputs respectively coupled to the first contacts of said second selector switches, each of said first selector switches being placeable in a condition corresponding to a preselected condition of the associated second selector switch to complete a path for the enabling signal through the associated second selector switch to said AND circuit, a plurality of third selector switches each having a first contact coupled to the output of said AND circuit and a plurality of second contacts respectively coupled to the associated second electronic switches, each of said third selector switches being operative to conduct said output signal to the electronic switch corresponding to the condition of said third selector switch, thereby to render said last-mentioned electronic switch operative to couple the associated impedance portion in the associated oscillator, means responsive to associated first and second selector switches being in corresponding conditions to divert the enabling signals away from the electronic switches associated with the selected conditions of said first selector switches.

16. A tone substitution system for use in a transmitter and comprising tone signal producing means, first selector means coupled to said tone signal producing means and placeable in one of a plurality of conditions to cause the tone signal to have a selected one of a corresponding plurality of first characteristics, second selector means coupled to said tone signal producing means and placeable in one of a plurality of conditions to cause the tone signal to have a selected one of a corresponding plurality of second characteristics, and third selector means coupled to said first and second selector means and placeable in one of a plurality of conditions for rendering said first selector means or said second selector means operative to control the characteristics of the tone signal, the tone signal having the selected one of said first characteristics when the conditions of said first and third selector means do not correspond, the tone signal having the selected one of said second characteristics when the conditions of said first and third selector means correspond.

17. The tone substitution system set forth in claim **16,** wherein said tone signal producing means includes at least one variable frequency oscillator for providing a plurality of control tones respectively having frequencies corresponding to the plurality of conditions of said first selector means.

18. The tone substitution system set forth in claim **16,** wherein each of said selector means includes a manually operable multi-position selector switch.

19. The tone substitution system set forth in claim **16,** wherein said tone signal producing means includes at least two variable frequency oscillators for providing two control tones, the frequencies of said control tones being determined by the conditions of said selector means.

20. The tone substitution system set forth in claim **16,** wherein said tone signal producing means includes a variable frequency oscillator having an impedance network, portions of said network being adapted to be individually coupled in circuit in said oscillator, and further comprising electronic switching means coupled to said impedance network portions for respective switching thereof into and out of circuit in said oscillator, said first and second selector means being coupled to said electronic switching means for controlling the switching thereof.

21. The tone substitution system set forth in claim **16,** and further comprising a plurality of electronic switching means having inputs coupled to said first selector means and having outputs coupled to said second selector means and having outputs coupled to said tone signal producing means.

22. A tone substitution system for use in a transmitter and comprising a number of variable frequency oscillators for producing control tones, a number of first selector means respectively coupled to said oscillators and each being placeable in one of a plurality of conditions to cause the associated control tone to have a selected one of a corresponding plurality of first frequencies, a number of second selector means respectively coupled to said oscillators and each being placeable in one of a plurality of conditions to cause the associated control tone to have a selected one of a corresponding plurality of second frequencies, a number of third selector means respectively coupled to the associated pairs of said first and second selector means and being placeable in one of a plurality of conditions for causing the frequency of the associated control tone to be controlled by the associated first selector means or the associated second selector means, each control tone having the associated selected one of said first frequencies when the conditions of the associated first and third selector means do not correspond, each control tone having the associated selected one of said second frequen-

cies when the conditions of the associated first and third selector means correspond.

23. The tone substitution system set forth in claim **22,** and further comprising a number of AND circuits each having inputs respectively coupled to said third selector means and to said first selector means, each of said AND circuits being operative to produce an output signal only when each associated pair of first and third selector means is in corresponding conditions, each of said second selector means being respectively coupled to said AND circuit and responsive to said output signals to control the frequencies of the control tones produced by said oscillators.

24. The tone substitution system set forth in claim **22,** wherein each of said variable frequency oscillators includes impedance network portions which may individually be coupled in circuit in the associated oscillator, and further comprising a plurality of electronic switching means respectively coupled to said impedance network portions for respective switching thereof into and out of circuit with the associated oscillators, associated pairs of said first and second selector means being respectively coupled to the associated electronic switching means for controlling the switching thereof.

25. A tone substitution system for use in a transmitter and comprising at least two variable frequency oscillators for producing a pair of control tones, at least two first selector means respectively coupled to said oscillators and each being placeable in one of a plurality of conditions to cause the associated control tone to have a selected one of a corresponding plurality of first frequencies, at least two second selector means respectively coupled to said oscillators and each being placeable in one of a plurality of conditions to cause the associated control tone to have a selected one of a corresponding plurality of second frequencies, at least two third selector means respectively coupled to the associated pairs of said first and second selector means and being placeable in one of a plurality of conditions for causing the frequency of the associated control tone to be controlled by the associated first selector means or the associated second selector means, each control tone having the associated selected one of said first frequencies when the conditions of the associated first and third selector means do not correspond, each control tone having the associated selected one of said second frequencies when the conditions of the associated first and third selector means correspond.

26. The tone substitution system set forth in claim **25,** and further comprising an AND circuit having inputs coupled to each of said first selector means and to each of said third selector means and operative to produce an output signal only when each associated pair of first and third selector means is in corresponding conditions, each of said second selector means being coupled to said AND circuit and responsive to said output signals to control the frequencies of the control tones produced by said oscillators.

27. A tone substitution system for use in a transmitter and comprising tone signal producing means, first selector means coupled to said tone signal producing means and being placeable in one of a plurality of conditions to cause the tone signal to have a selected one of a corresponding plurality of first characteristics, a plurality of second selector means coupled to said tone signal producing means and each being placeable in one of a plurality of conditions to cause the tone signal to have a selected one of a corresponding plurality of second characteristics, and a plurality of third selector means coupled to said first selector means and respectively coupled to said plurality of second selector means, each of said third selector means being placeable in one of a plurality of conditions for rendering said first selector means or the associated one of said second selector means operative to control the characteristics of the tone signal, when the condition of none of said third selector means corresponds to the condition of said first selector means the tone signal has the selected one of said first characteristics, when the condition of one of said third selector means corresponds to the condition of said first selector means the tone signal has the one of said second characteristics associated with the one of said second selector means coupled to said one third selector means.

28. The tone substitution system set forth in claim **27,** wherein the number of second selector means equals the number of third selector means.

29. The tone substitution system set forth in claim **27,** wherein the number of second selector means is the same as the number of third selector means and is no less than the number of said first characteristics.

30. The tone substitution system set forth in claim **27,** wherein said tone signal producing means includes at least two variable frequency oscillators for providing two control tones, the frequencies of said control tones being determined by the conditions of said selector means.

31. The tone substitution system set forth in claim **27,** and further comprising a plurality of electronic switching means having inputs coupled to said first selector means, having inputs coupled to said plurality of second selector means and having outputs coupled to said tone signal producing means.

32. A signal substitution system for use in a transmitter including a tone generator for generating at least one tone having a frequency selected from a plurality of possible frequencies, and comprising primary-tone selecting means coupled to the tone generator and placeable in a plurality of conditions to cause the tone produced by the tone generator to have a given frequency, substituting means coupled to said primary-tone selecting means and being placeable in a plurality of conditions corresponding to the conditions of at least some of the conditions of said primary-tone selecting means, said substituting means providing an output when the condition thereof corresponds to the condition of said primary-tone selecting means, and substitute-tone selecting means coupled to the tone generator and placeable in a plurality of conditions to cause the tone produced by the tone generator to have a different frequency, said substitute-tone selecting means being coupled to said substituting means and responsive to the output therefrom to cause the tone generator to produce the tone having said different frequency instead of the tone having said given frequency.

33. The signal substitution system set forth in claim **32,** and further comprising electronic switching means coupled between said primary-tone selecting means and the tone generator and being operative to cause the tone generator to produce a tone having said given frequency in accordance with the condition of said primary-tone selecting means, said substitute-tone selecting means being coupled to said electronic switching

means and being operative to cause the tone generator to produce a tone having said difference frequency in accordance with the condition of said substitute-tone selecting means.

34. The signal substitution system set forth in claim **32,** wherein said primary-tone selecting means includes a multiposition manual switch.

35. A signal substitution system for use in a transmitter including a tone generator for generating a plurality of tones respectively having frequencies selected from a plurality of possible frequencies, and comprising a plurality of primary-tone selecting means coupled to the tone generator and each placeable in a plurality of conditions to cause the tones produced by the tone generator respectively to have given frequencies, a plurality of substituting means respectively coupled to said plurality of primary-tone selecting means and each placeable in a plurality of conditions corresponding to the conditions of at least some of the conditions of the associated primary-tone selecting means, each of said substituting means providing a signal when the condition thereof corresponds to the condition of the associated one of said primary-tone selecting means, AND circuit means coupled to said plurality of substituting means and responsive to the concurrence of a signal from each of said substituting means to provide an output, and a plurality of substitute-tone selecting means coupled to the tone generator and each placeable in a plurality of conditions to cause the tones produced by the tone generator respectively to have different frequencies, each of said substitute-tone selecting means being coupled to said AND circuit means and responsive to the output therefrom to cause the tone generator to produce the tones having said different frequencies instead of the tones having said given frequencies.

36. A signal substitution system for use in a transmitter including a tone generator for generating at least one tone having a frequency selected from a plurality of possible frequencies, and a primary-tone selector placeable in a plurality of conditions to cause the tone produced by the tone generator to have a given frequency, said signal substitution system comprising substituting means for coupling to the primary-tone selector and being placeable in a plurality of conditions corresponding to the conditions of at least some of the conditions of the primary-tone selector, said substituting means providing an output when the condition thereof corresponds to the condition of the primary-tone selector, and substitute-tone selecting means for operating the tone generator and placeable in a plurality of conditions to cause the tone produced by the tone generator to have a different frequency, said substitute-tone selecting means being coupled to said substituting means and responsive to the output therefrom to cause the tone generator to produce the tone having said different frequency instead of the tone having said given frequency.

37. The signal substitution system set forth in claim **36,** and further comprising electronic switching means for coupling between the primary-tone selector and the tone generator and being operative to cause the tone generator to produce a tone having the given frequency in accordance with the condition of the primary-tone selector, said substitute-tone selecting means being coupled to said electronic switching means and being operative to cause the tone generator to produce a tone having said different frequency in accordance with the condition of said substitute-tone selecting means.

38. a signal substitution system for use in a transmitter including a tone generator for generating a plurality of tones respectively having frequencies selected from a plurality of possible frequencies and a plurality of primary-tone selectors each placeable in a plurality of conditions to cause the tones produced by the tone generator respectively to have given frequencies, said signal substitution system comprising a plurality of substituting means for respectively coupling to the primary-tone selectors and each placeable in a plurality of conditions corresponding to the conditions of at least some of the conditions of the associated primary-tone selectors, each of said substituting means providing a signal when the condition thereof corresponds to the condition of the associated one of the primary-tone selectors, AND circuit means coupled to said plurality of substituting means and responsive to the concurrence of a signal from each of said substituting means to provide an output, and a plurality of substitute-tone selecting means for coupling to the tone generator and each placeable in a plurality of conditions to cause the tones produced by the tone generator respectively to have difference frequenceis, each of said substitute-tone selecting means being coupled to said AND circuit means and responsive to the output therefrom to cause the tone generator to produce the tones having said different frequencies instead of the tones having said given frequencies.

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