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Greenberg

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[54] **SELF-TEST ARRANGEMENT FOR AN ENTERTAINMENT-SERVICE SYSTEM**

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[21] Appl. No.: **376,982**

Related U.S. Application Data

[60] Continuation of Ser. No. 152,645, June 14, 1971, abandoned, which is a division of Ser. No. 800,941, Feb. 20, 1969.

[52] **U.S. Cl.** ..... **179/175,** 340/171 R

[51] **Int. Cl.** **H04r 29/00**

[58] **Field of Search** ..... 179/175.3 R, 175.31 R, 179/2 A, 175; 340/213.1, 408, 156, 163, 179/171 R, 331, 324 R

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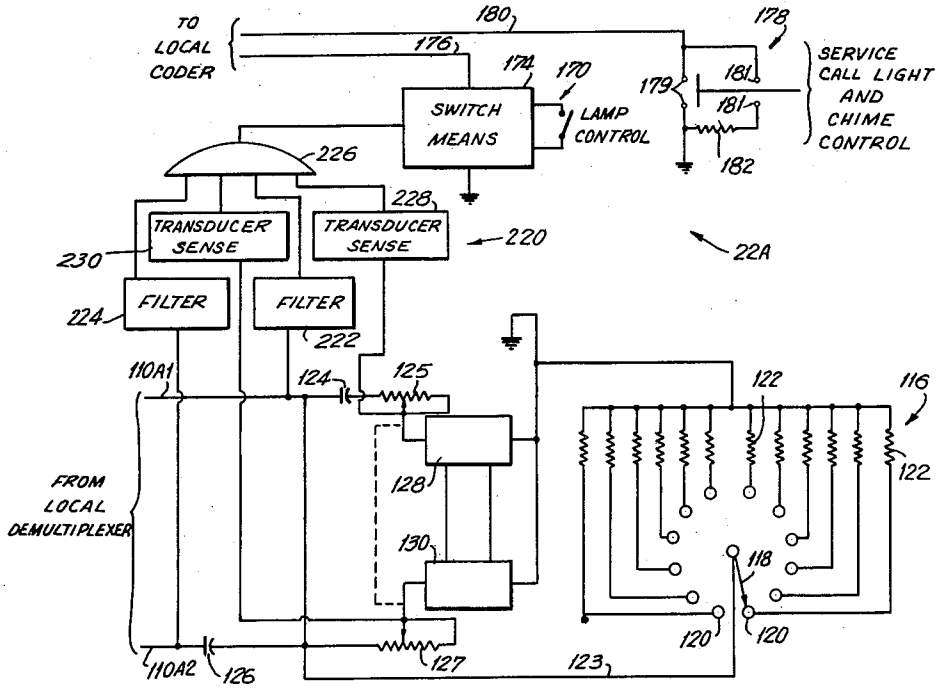
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Attorney, Agent, or Firm—Blum, Moscovitz, Friedman & Kaplan

[57] **ABSTRACT**

In an entertainment-service system for permitting each of a plurality of local stations to select one or more of a plurality of channels of audio signals and to control one or more utilization circuits associated with each local station or group of such stations through the application of multiplexing techniques, the improvement consisting of a self-test arrangement whereby a test signal of predetermined characteristics is applied to each input channel of the multiplexing means and a self-test circuit means is provided at each station to detect said test signal and to override the control for said utilization circuit to activate said utilization circuit in a unique mode.

5 Claims, 8 Drawing Figures



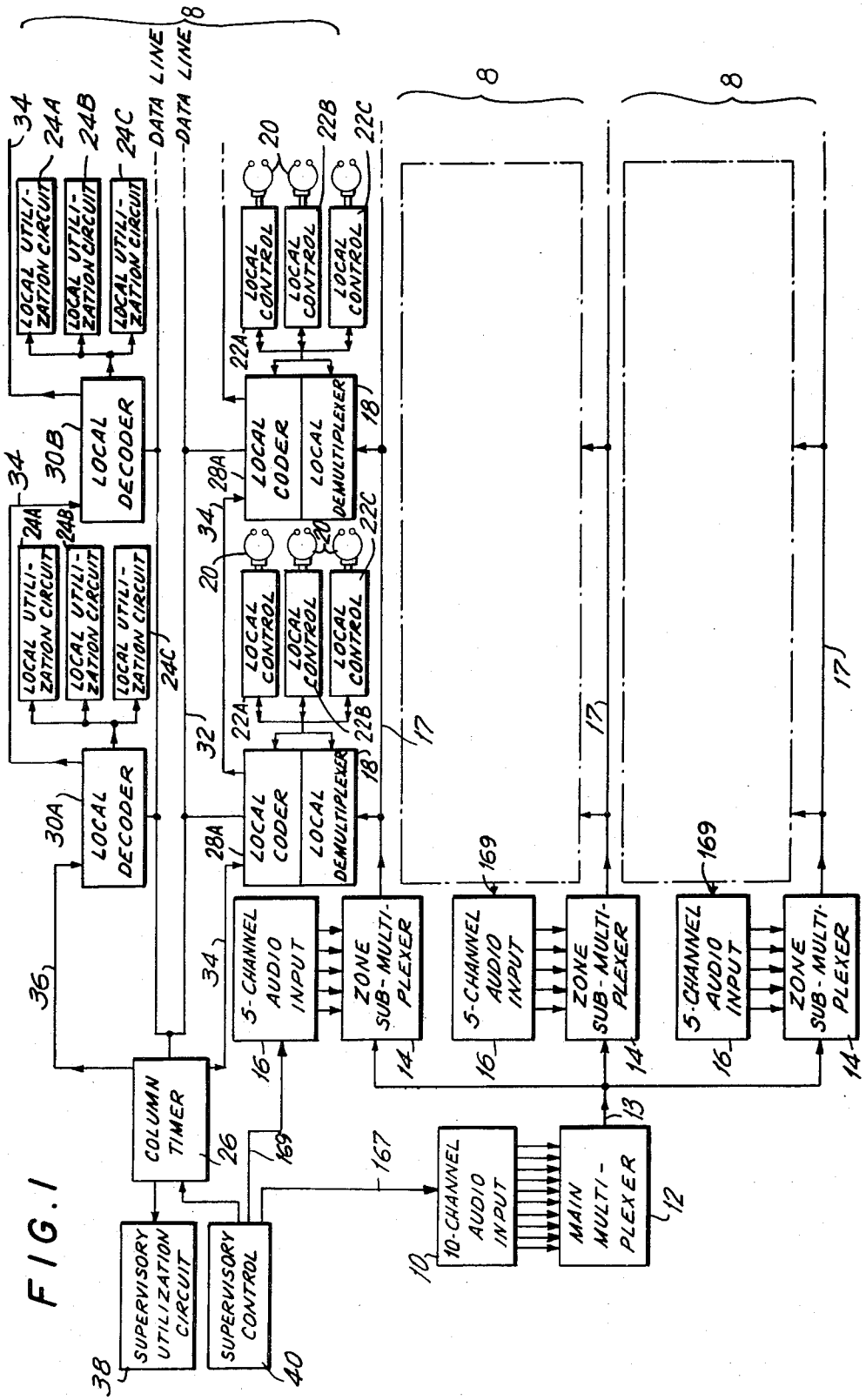

DATA LINE
8
34
24A
24B
24C
LOCAL UTILIZATION CIRCUIT
LOCAL DECODER
30A
30B
LOCAL CODER
LOCAL DEMULTIPLEXER
28A
32
18
22A
22B
22C
LOCAL CONTROL
20
17
169
5-CHANNEL AUDIO INPUT
ZONE SUB-MULTIPLEXER
14
16
36
COLUMN TIMER
26
167
SUPERVISORY UTILIZATION CIRCUIT
38
SUPERVISORY CONTROL
40
10-CHANNEL AUDIO INPUT
10
MAIN MULTIPLEXER
12
13

FIG. 1

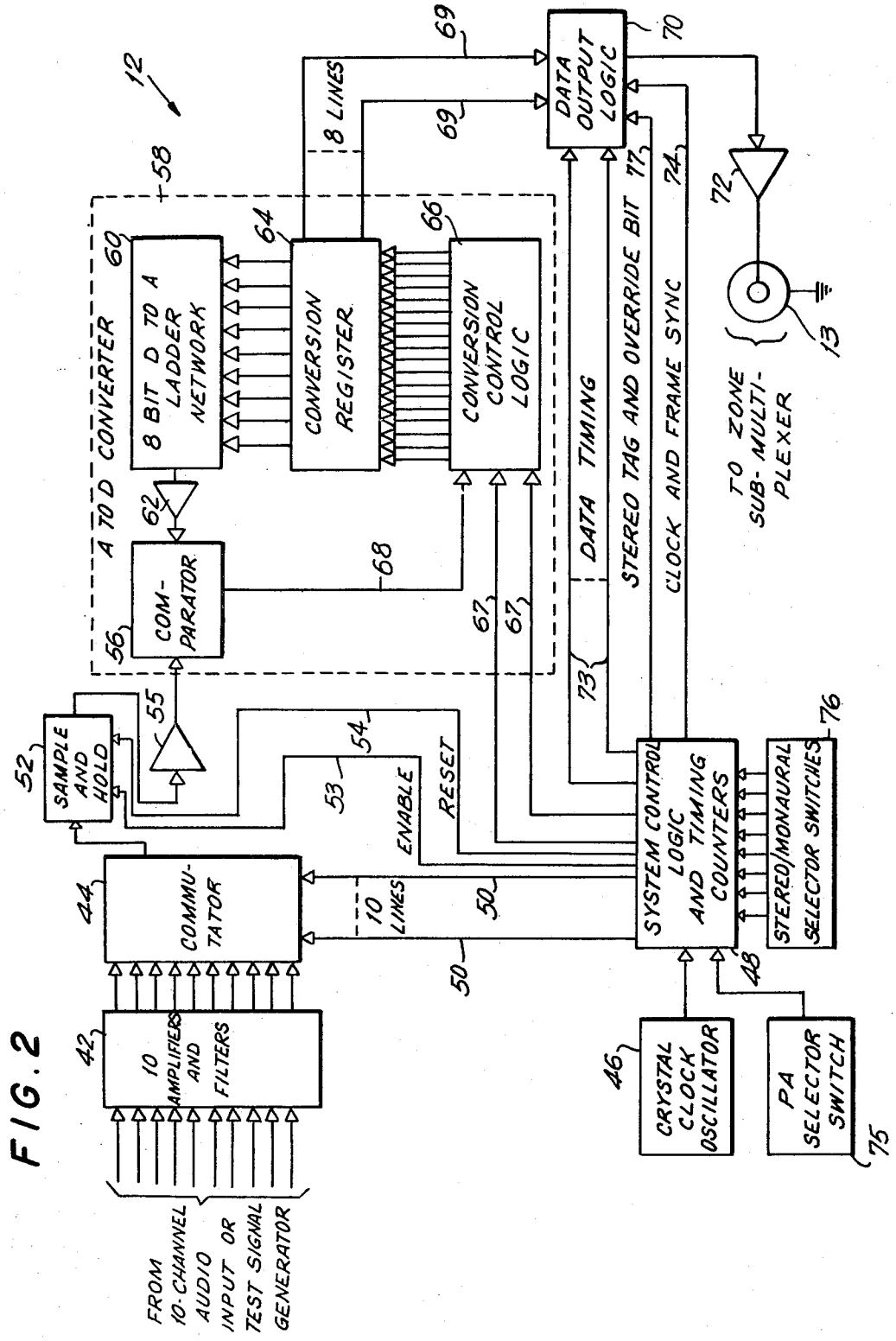

12
58
A TO D CONVERTER
8 BIT D TO A LADDER NETWORK
60
CONVERSION REGISTER
64
CONVERSION CONTROL LOGIC
66
8 LINES
69
DATA OUTPUT LOGIC
70
72
13
TO ZONE SUB-MULTI-PLEXER
DATA TIMING
STEREO TAG AND OVERRIDE BIT
77
CLOCK AND FRAME SYNC
74
COM-PARATOR
56
62
68
67
73
SAMPLE AND HOLD
52
55
54
53
ENABLE
RESET
SYSTEM CONTROL LOGIC AND TIMING COUNTERS
48
STERED/MONAURAL SELECTOR SWITCHES
76
COMMU-TATOR
44
10 LINES
50
10 AMPLIFIERS AND FILTERS
42
CRYSTAL CLOCK OSCILLATOR
46
PA SELECTOR SWITCH
75
FROM 10-CHANNEL AUDIO INPUT OR TEST SIGNAL GENERATOR

FIG. 2

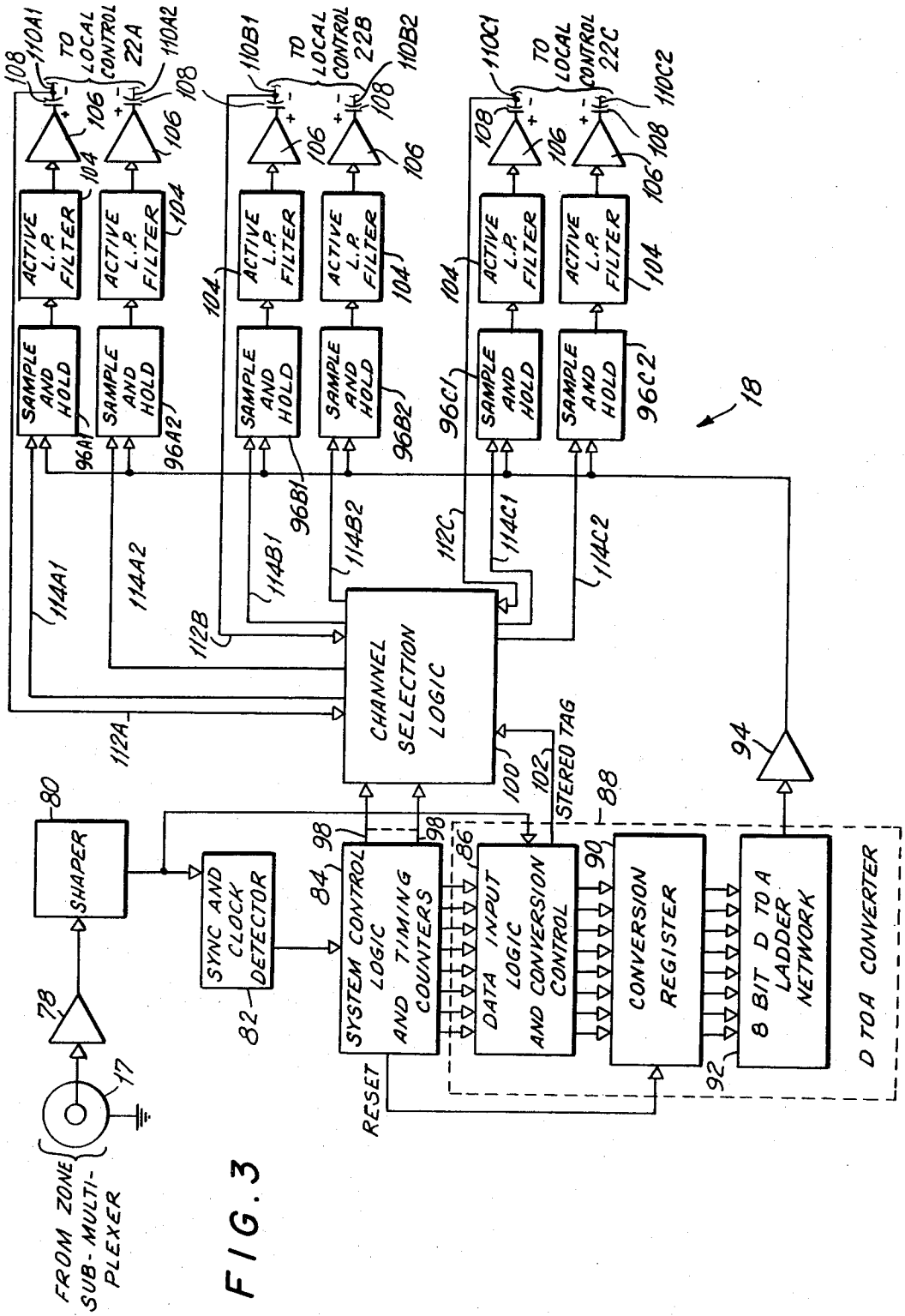

FROM ZONE SUB-MULTI-PLEXER
17
78
SHAPER
80
SYNC AND CLOCK DETECTOR
82
SYSTEM CONTROL LOGIC AND TIMING COUNTERS
84
DATA INPUT LOGIC AND CONVERSION CONTROL
86
CONVERSION REGISTER
90
8 BIT D TO A LADDER NETWORK
92
D TO A CONVERTER
94
RESET
98
CHANNEL SELECTION LOGIC
100
STERED TAG
102
88
112A
112B
112C
114A1
114A2
114B1
114B2
114C1
114C2
96A1
96A2
96B1
96B2
96C1
96C2
SAMPLE AND HOLD
ACTIVE L.P. FILTER
104
106
108
110A1
110A2
110B1
110B2
110C1
110C2
TO LOCAL CONTROL 22A
TO LOCAL CONTROL 22B
TO LOCAL CONTROL 22C
18

FIG. 3

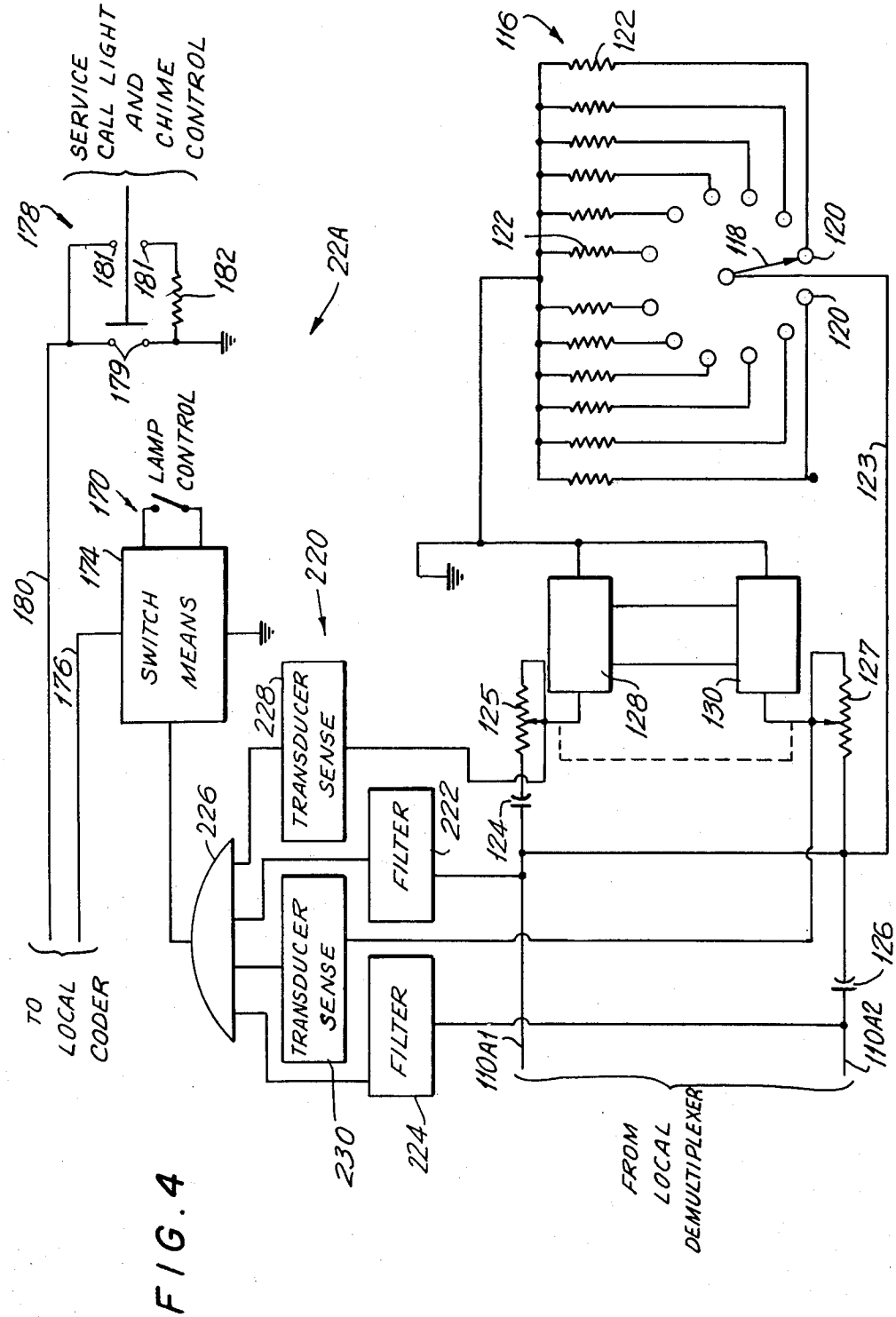

SERVICE CALL LIGHT AND CHIME CONTROL
178
181
181
182
179
LAMP CONTROL
170
174
SWITCH MEANS
180
176
TO LOCAL CODER
220
228
TRANSDUCER SENSE
226
222
FILTER
230
224
116
122
118
120
123
125
128
130
127
124
126
110A1
110A2
FROM LOCAL DEMULTIPLEXER

FIG. 4

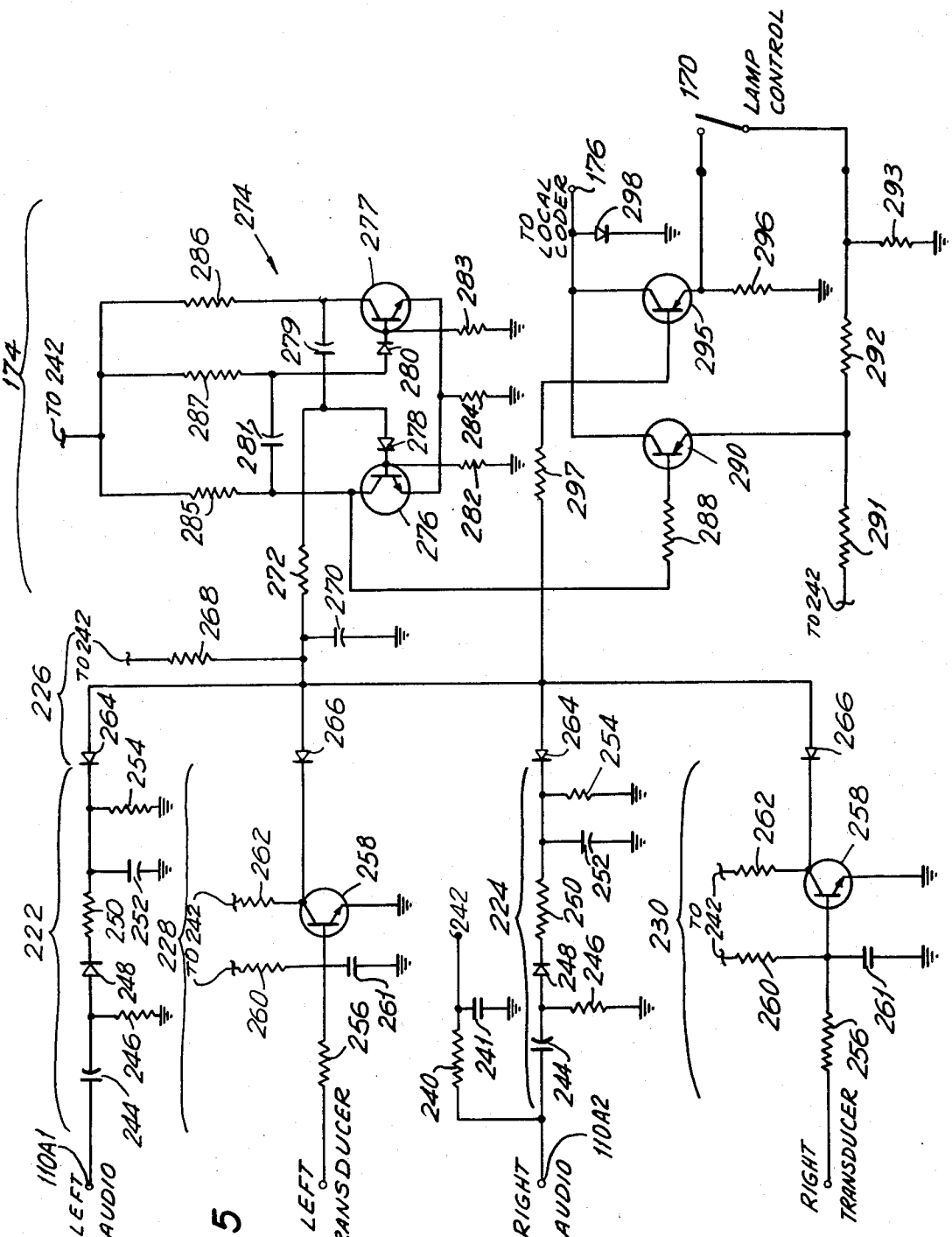
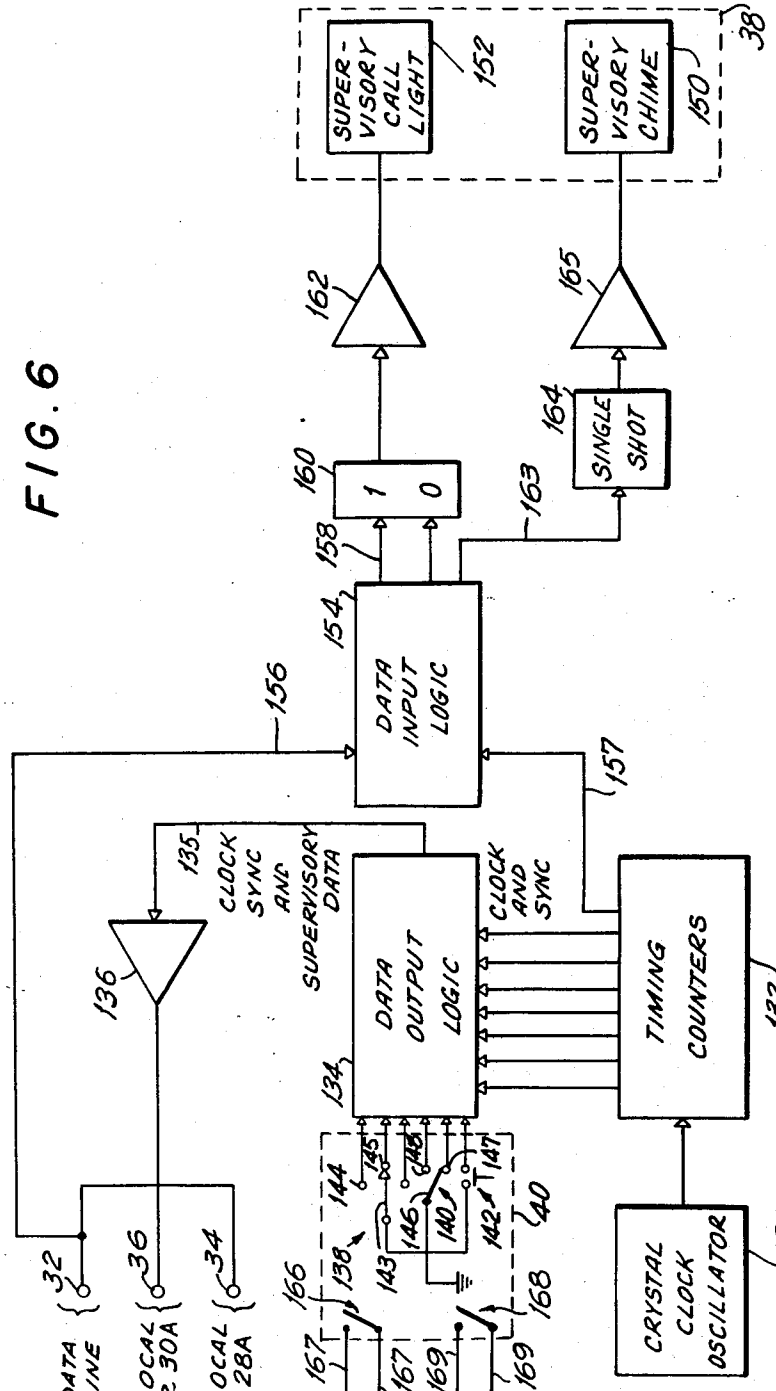

174
TO 242
286
274
277
283
279
280
287
278
284
281
285
276
282
272
270
268
226
264
254
222
250
252
228
248
246
244
110A1
LEFT AUDIO
262
258
260
256
261
LEFT TRANSDUCER
266
242
224
240
241
244
RIGHT AUDIO
110A2
230
RIGHT TRANSDUCER
TO LOCAL CODER
176
298
170
LAMP CONTROL
296
293
295
292
297
290
288
291

FIG. 5

FIG. 6


SUPER-VISORY CALL LIGHT
152
SUPER-VISORY CHIME
150
38
162
165
164
SINGLE SHOT
160
1
0
158
163
154
DATA INPUT LOGIC
156
157
135
CLOCK SYNC AND SUPERVISORY DATA
136
DATA OUTPUT LOGIC
134
CLOCK AND SYNC
TIMING COUNTERS
132
CRYSTAL CLOCK OSCILLATOR
130
144
145
146
143
140
142
141
40
166
167
136
167
168
169
169
32
36
34
DATA LINE
TO FIRST LOCAL DECODER 30A
TO FIRST LOCAL CODER 28A
TO MAIN MULTIPLEXER
TO ZONE SUB-MULTI-PLEXER

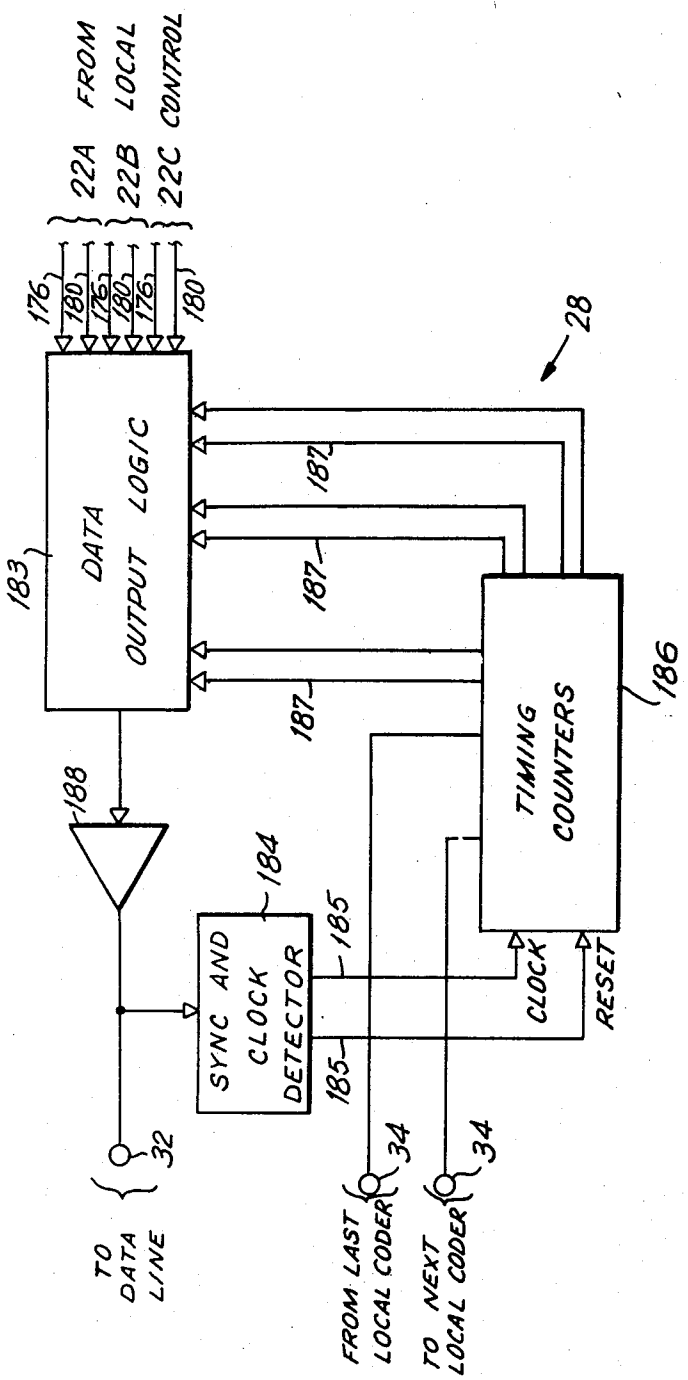

22A FROM LOCAL
22B
22C CONTROL
176
180
28
DATA OUTPUT LOGIC
183
187
188
184
SYNC AND CLOCK DETECTOR
185
TIMING COUNTERS
186
CLOCK
RESET
32
TO DATA LINE
34
FROM LAST LOCAL CODER
TO NEXT LOCAL CODER

FIG. 7

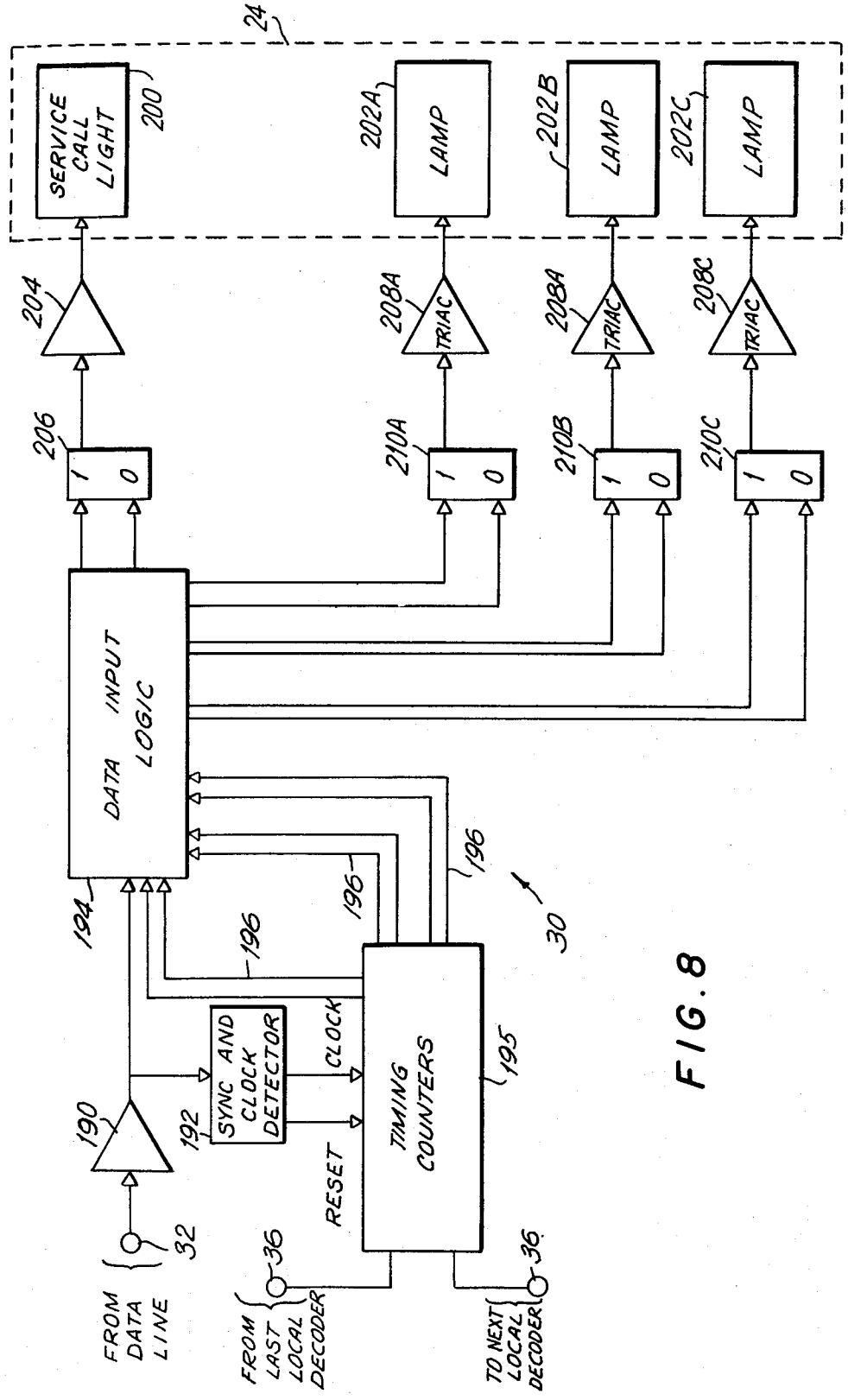

24
SERVICE CALL LIGHT
200
202A
LAMP
202B
LAMP
202C
LAMP
204
208A
TRIAC
208B
TRIAC
208C
TRIAC
206
210A
210B
210C
1
0
DATA INPUT LOGIC
194
196
30
190
192
SYNC AND CLOCK DETECTOR
CLOCK
RESET
TIMING COUNTERS
195
32
36
FROM DATA LINE
FROM LAST LOCAL DECODER
TO NEXT LOCAL DECODER

FIG. 8

SELF-TEST ARRANGEMENT FOR AN ENTERTAINMENT-SERVICE SYSTEM

This is a continuation, of now abandoned application Ser. No. 152,645, filed June 14, 1971 which is a divisional of application Ser. No. 800,941 filed Feb. 20, 1969.

BACKGROUND OF THE INVENTION

This invention relates generally to entertainment-service systems of the type applicable to a plurality of remote stations such as might be found in aircraft. The testing of such systems generally requires the separate operation of each component. Thus, if the system included a plurality of demultiplexers each servicing a group of remote stations, each of said stations being provided with a separate headset, the prior art method of testing such a system would consist of individually listening at each headset to detect an audio input. Substantially all of the entertainment portion of such a system would be tested in this manner provided that at least one of the channel selection means in the system is set to each of the channels. To test the service portion of such a system, it would be necessary to individually operate the utilization control means at each station and detect the results at the corresponding utilization circuit.

The above described testing method is extremely time consuming, a factor which is of particular importance where the conduct of a lengthy test would substantially increase the down time of an otherwise available aircraft.

SUMMARY OF THE INVENTION

Generally speaking, in accordance with the invention, a self-test arrangement for an entertainment-service system is provided. The entertainment-service system to which the self-test arrangement according to the invention is to be applied includes an entertainment portion wherein a plurality of channels of input are multiplexed and transmitted as a single signal to a plurality of remotely located demultiplexer means which reconstruct the content of the input channels selected by a channel selector means associated therewith and transmit said reconstructed signal to a corresponding transducer means. The service portion of the system to be tested includes a plurality of remotely located utilization circuits, at least one utilization control means associated with each of said utilization circuits and means for placing each of said utilization circuits in a state responsive to the state of its corresponding utilization control means. The self-test arrangement consists of a multi-channel test signal generator connected to the multiplexing means to apply a test signal of a predetermined characteristic to each input channel and at least one self-test circuit means connected to the output of each demultiplexer means to detect the presence of said test signal and to override, in response to said detector test signal, at least one utilization control means to produce a unique state indication at said utilization control means effective to operate the corresponding utilization circuit in a unique manner. The unique state indication may correspond to that which would be produced if the utilization control means were alternately turned on and off so so that the corresponding utilization circuits are alternately rendered operative and inoperative when said test signal is detected.

The self-test circuit includes filter means adapted to pass a signal of a frequency substantially identical to the frequency of the test signal, transducer sense means adapted to produce a further signal if the transducer means coils are intact, an "AND" gate to receive the signals of said filter means and transducer sense means and switch means to override the utilization control means in the manner described above.

Accordingly, it is an object of this invention to provide a test arrangement for an entertainment-service system which requires a minimum of additional test equipment and which permits the rapid testing of the system.

Another object of the invention is to provide a testing arrangement for an entertainment-service system which permits ready diagnosis of any defects therein.

A further object of the invention is to provide a testing arrangement which permits the testing of an entertainment-service system through the inclusion of a compact testing module within each local control of said system and appropriate signal test generators.

Another object of the invention is to provide a testing arrangement for an entertainment-service system which permits the simultaneous testing of substantially the entire system.

Still other objects and advantages of the invention will in part be obvious and will in part be apparent from the specification.

The invention accordingly comprises the features of construction, combination of elements and arrangement of parts which will be exemplified in the constructions hereinafter set forth, and the scope of the invention will be indicated in the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

For a fuller understanding of the invention, reference is had to the following description taken in connection with the accompanying drawings, in which:

FIG. **1** is a schematic representation of one type entertainment-service system according to the invention;

FIG. **2** is a schematic representation of the main multiplexer of said entertainment-service system;

FIG. **3** is a schematic representation of the local demultiplexer of said entertainment-service system;

FIG. **4** is a schematic representation of the local control of said entertainment-service system including the self-test circuit for said system;

FIG. **5** is a circuit diagram of one type of the self-test circuit of FIG. **4**;

FIG. **6** is a schematic representation of the column timer, supervisory utilization circuit and supervisory control of entertainment-service system;

FIG. **7** is a schematic representation of the local coder of said entertainment-service system; and

FIG. **8** is a schematic representation of the local decoder and local utilization circuits of said entertainment-service system.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIG. **1**, the entertainment-service system depicted utilizes multiplexing techniques, preferably of the pulse code modulation type, to permit a plurality of local stations to selectively receive one or more of a plurality of channels of audio signals and to control one or more utilization circuits associated with

each local station or a group of such stations. Pulse code modulation is a form of time division multiplexing wherein the time available to transmit a plurality of channels of information is divided into a plurality of discrete intervals or frames which are assigned successively to each of said channels. Each channel of information to be transmitted is successively sampled and the analog value thereof is converted to a digital pulse code. Each of said intervals or frames are in turn divided into time slots, one of said time slots being assigned to each bit of the digital code. Further time slots can be assigned for the transmission of other information, if desired. In this manner a plurality of channels of information may be transmitted over a single line and reconstructed at the receiver to produce the plurality of channels of information originally transmitted.

In particular, in the system according to the invention, an audio input **10,** for example having ten channels, feeds into a main multiplexer **12.** Said main multiplexer originates the basic system timing, multiplexes the input signals by sequentially sampling each of the channels and converting the analog signals to digital form, and transmits, along line **13,** the resulting digital data along with clock and synchronization sgiansl in the form of a train of pulses, to the zone submultiplexers **14.** In the embodiment shown in FIG. **1,** five further channels of audio input **16** are applied to each zone sub-multiplexer **14.** Each of said zone sub-multiplexers function in a similar manner to main multiplexer **12** to multiplex said five additional channels and to interleave the resulting digitized multiplexed signal in the appropriate frames of the main multiplexer output signal. The timing sampling arrangements of said main multiplexer are adapted to provide the additional frames required in each cycle to permit the addition of the further five channels of audio input by each zone sub-multiplexer **14.**

The output of each zone sub-multiplexer **14,** which consists of fifteen channels of multiplexed information is applied to a single line **17.** Reconstruction of the multiplexed signal for the remotely located stations is performed by a plurality of local demultiplexers **18,** each of which taps its respective line **17,** econstructs the multiplexed signal into its component channels of analog audio signals and transmits to its corresponding headsets **20** disposed at each remote station the particular channel selected by the local control **22** (**22A, 22B** or **22C**) associated therewith. In this manner, a plurality of audio channels are transmitted to a plurality of stations represented by local controls **22** and headsets **20** associated therewith. Each of said stations can be remotely located relative to the audio inputs **10** and **16,** main multiplexer **12** and zone sub-multiplexer **14,** while requiring only a single channel for information transmission, and therefore a minimum of wiring. Despite the use of a single channel for transmission, each local control **22** can select one or a pair of said channels (as in the case of stereo transmissions) to provide the user at the remote station with an accurate reproduction of the audio signal from the multi-channeled input **10** and **16.**

Local controls **22** are also adapted to permit each remote station to control, through the application of multiplexing techniques, a local utilization circuit **24** (**24A, 24B** or **24C**) associated therewith. Such local utilization circuit might include, for example, service call lights, other forms of attention-attracting alarm means, or lamps for general illumination or reading.

For this purpose, column timer **26,** a plurality of local coders **28** (**28A 28B, ... 28K**) and a corresponding number of local decoders **30** (**30A, 30B, . . . T 30K**) are provided. Column timer **26** is adapted to produce the basic timing for this portion of the system, transmitting a clock and synchronization signal alon data line **32** which interconnects said local coders.

Each cycle is divided into frames, one frame being alloted to each local coder-decoder pair. Each frame is in turn divided into time slots allocated to each function to be performed such as the state of the portion of local control **22A** which governs the service call light in local utilization circuit **24A** or the state of the portion of local control **22C** which governs the light in local utilization circuit **24C.** Data is transmitted in the form of a train of pulses, the presence or absence of a pulse in each time slot governing the corresponding function. Each of said local coders are identical and adapted, when activated, to detect the state of the local controls associated therewith and to transmit digital data identifying said state to data line **32** during predetermined time slots and frames. In like manner, each of said local decoders are identical and are adapted to query said data line during predetermined time slots and frames to detect the local control state data transmitted by the corresponding local coder, and to operate the local utilization circuits **24** associated therewith, so that they are disposed in accordance with the settings of local controls **22.**

Activation of local coder **28** and local decoders **30** in the appropriate time frames is accomplished in response to the clock and synchronization signal generated by column timer **26** which is also transmitted along shift lines **34** which connect said column time and local coders **28** in series and shift lines **36** which connects said column timer and local decoders **30** in series. The signal transmitted along shift lines **34** and **36** sequentially activates local coders **28** and local decoders **30** respectively so that for example, only local coder **28B** and its corresponding local decoder **30B** are activated during the second time frame, and therefore transmit and receive during that frame.

Column timer **26** may also be adapted to perform supervisory coder and decoder functions by querying data line **32** at a predetermined time slots to detect local control state data contained therein or the activation of a centrally located supervisory utilization circuit **38** and to transmit to said data line, during predetermined time slots, digital data representative of the state of a supervisory control **40.**

The embodiment of the entertainment-service system according to the invention shown in FIG. **1** incorporates zone sub-multiplexers **14** to introduce further channels of audio input **16.** Such further channels would be required if it were necessary to provide a number of channels of unique audio input at each zone, as would be the case where moves were being projected at each zone and synchronization between sound track and film required separate transmission of said sound track at each zone. However, where such separate transmission is not required, the audio input **16** and zone sub-multiplexers **14** may be dispensed with in the entertainment-service system according to the invention. In such embodiments, local demultiplexers **18**

would tap directly off line **13** to receive the output of main multiplexer **12.**

Further, in the embodiment of the system shown in FIG. **1,** one column timer **26** is provided for the group of local stations associated with each zone. However, depending on the number of local stations, the switching speed of the equipment, and the frequency with which each station must be scanned, a single column timer **26** may be utilized to control all of the local coders **28** and local decoders **30** in the system, without regard to the zone in which they may fall. In the alternative, more than one column timer might be utilized to control the local coders **28** and local decoders **30** in each zone, provided that each local coder and its corresponding local decoder are tied to only a single column timer. As shown by dashed lines **8,** each line **17** would be provided with a complete set of local demultiplexers **18,** local controls **22,** local coders **22,** a column timer **26,** etc.

Turning now to a more detailed discussion of the components of the entertainment-service system according to the invention, reference is had to FIG. **2** which shows a schematic representation of the main multiplexer **12.** The ten channels of audio input **10** are applied to ten amplifiers and filters **42,** the output of which is applied to an electronic commutator **44.** The timing for the audio portion of the system is obtained from crystal clock oscillator **46** which is applied to system control logic and timing counters **48.** Said system control logic and timing counters control the operation of the main multiplexer by providing the gating signals to insure proper synchronization and sequential timing of the components. Thus, ten lines **50** connects system control logic and timing counters **48** to commutator **44** to enable said commutator to sequentially sample each of the ten input channels during a predetermined time frame. Since the entire system, as shown in FIG. **1,** would include **15** channels, the system control logic and timing counters would actually divide a single cycle into fifteen time frames, only ten of which are utilized by the commutator **44** of the main multiplexer. The remaining five time frames are preserved for the five additional channels to be introduced by each zone submultiplexer **14.** The number of channels of the embodiment shown in the drawings is given by way of example and not by way of limitation, the actual number of channels in an entertainment-service system according to the invention being a matter of selection.

During the frame that each channel is being sampled, the sampled signal is applied to sample and hold circuit **52** which is also controlled by system control logic and timing counters **48** through an enable line **53** and a reset line **54.** The held sample is applied through a driver **55** to comparator **56** of analog to digital converter **58** of conventional design. The timing for analog to digital conversion is also controlled by system control logic and timing counters **48.** In the embodiment shown, analog to digital conversion is performed by an 8-bit ladder network **60** which generates a series of voltages for application to comparator **56** through a driver **62.** Said voltages are matched by said comparator to the sampled audio signal. The ladder network **60** is controlled by a conversion register **64** whose operation is in turn governed by a conversion control logic **66** responsive to system control logic and timing counters **48.** When comparator **56** detects a match between the audio signal and the voltage output of the ladder network **60,** a signal applied along line **68** to conversion control logic **66** causes conversion register **64** to transmit the digital code corresponding to the matched voltage along line **69** to data output logic **70.** Said data output logic assemblies the various components of the main multiplexer output signal with each bit in its assigned time slot and transmits said output signal through low impedance driver **72** to line **13,** shown as a coaxial cable, for transmission to the various zone sub-multiplexers **14.** Timing for data output logic **70** is also provided by system control logic and timing counters **48** through data timing lines **73.**

The output signal from main multiplexer **12** consists of a periodic clock and frame synchronization signal having the digital data representing the audio signal in each channel interleaved therein, and is in the form of a train of pulses. The clock and frame synchronization pulses are provided directly to data and input logic **70** by system control logic and timing counters **48** through clock and frame sync line **74.**

In some applications, it is desirable to provide a single channel of input, the activation of which overrides the other channels so that only the content of that channel is transmitted to headsets **20** irrespective of the channel selected by local control **22.** Thus, it would be desirable to have the channel set aside for a public address system function in this manner. To this end, an override bit is transmitted by system control logic and timing counters **48** in an appropriate time slot in each frame to data output logic **70,** along line **77** for interleaving in the output pulse train. Said override bit is generated in response to the activation of said predetermined channel as by P. A. selector switch **75.** Upon detection of such override bits, local demultiplexers **18** transmit only the channel assigned to the public address system.

Still a further feature of the main multiplexer accoding to the invention is the provision of stereo/monaural selector switches **76.** These selector switches introduce a stereo tag bit into a predetermined time slot of the frame assigned to the first of two adjacent channels carrying the left and right components of a stereo signal. When local demultiplexer **18** detects such a stereo tag, it will apply one of said pair of channels to the left and the other to the right side of headset **20,** treating said two adjacent channels as a single channel for the purpose of channel selection by local control **22.** This feature greatly increases the flexibility of the system since no channels are permanently dedicated to stereo transmission.

Each of the zone sub-multiplexers **14** operates in substantially the same manner as main multiplexer **12.** The frame synchronization and clock signal utilized to regulate the system control logic and timing counters of the zone sub-multiplexers is stripped from the signal on line **13,** although each of said zone sub-multiplexers can be provided with an auxiliary crystal clock oscillator, if desired, to provide a standby timing source in case of failure of the main multiplexer. In other respects, the zone sub-multiplexers preferably include system control logic and timing counters, commutator, sample and hold circuit, analog to digital converter and data output logic similar in function and structure to the corresponding components of the main multiplexer but adapted to interleave the digitized lots corresponding to the five channels of audio input **16** in the appropriate frames and time slots reserved therefore and to pass the

thus modified signal from line **13** to its respective zone line **17,** which is also preferably a coaxial cable.

The signal from each zone line **17** is tapped off by the corresponding local demultiplexers **18,** a schematic representation of one of which is shown in FIG. **3.** The signal tapped from line **17** is amplified by high impedance amplifier **78** and applied to shaper **80** adapted to eliminate any spurious signals. The frame synchronization and clock portions of the signal are detected by sync and clock detector **82** which applies these portions of the signal to the system control logic and timing counters **84** which control the timing and operation of the remaining components of the local demultiplexer. The clock signal drives the counters and logic while the frame synchronization is used to lock the system timing to that of zone sub-multiplexer **14** and main multiplexer **12.** The signal from shaper **80** is also applied to the data input logic and conversion control **86** of digital to analog converter **88.** This signal includes, sequentially, the digitized instantaneous value of each of the input channels ' audio signal plus stereo tag bits, if any. As each data bit is received, the corresponding flip-flop in the conversion register **90** is set to that data bit condition which in turn sets the **8**-bit digital to analog ladder network **92** to the original sample audio values. This ladder network analog voltage is applied through driver **94** to a plurality of sample and hold networks **96** (**96A–1, 96A–2, 96B–1, 96B–2, 96C–1, 96C–2**) One of said sample and hold networks are associated with each audio output circuit, two of said audio output circuits being provided for each station (headset **20** and local control **22**), whereby each station is provided with full stereo capability.

The system control logic and timing counters **84** provide timing signals through lines **98** to channel selection logic **100.** Said channel selection logic also receives the sterio tag, if any, from the data input logic and conversion control **86** along line **102** to determine whether a single channel of information should be applied to both audio output circuits associated with a single station or whether one of a pair of adjacent channels of information should be applied to each of said two audio output circuits to produce a stereo effect.

Each of said sample and hold circuits **96** drives an active low pass filter **104,** which drives into an amplifier **106** connected at its output to capacitor **108,** which in turn is connected to the audio output line **110.** Each pair of audio output lines **110A–1** and **110A–2, 110B–1** and **110B–2,** and **110C–1** and **110C–2,** are connected to one of said local controls **22** (**22A, 22B** and **22C** respectively) which contain channel selection means and headset **20** which is operated by the signal from said audio output lines.

Channel selection logic **100** detects the setting of each local control **22** by means of lines **112A, 112B** and **112C** connected respectively to audio output lines **110A–1, 110B–1** and **110C–1** in a manner to be described below. In response to the signal from said lines **112A, 112B** and **112C,** channel selection logic **100** gates each sample and hold circuit **96** into and out of operation during the time frame corresponding to the channel selected at the respective local control. This gating signal is sent along sample lines **114A–1, 114A–2, 114B–1, 114B–2, 114C–1** and **114C–2.** Thus, if local control **22A** were set to select a stereo program, that fact would be detected by channel selection logic **100** through line **112A.** Based on the system timing derived along lines **98,** said channel selection logic would gate sample and hold circuit **96A–1** to sample and hold the output of amplifier **94** during the time frame assigned to the first of the pair of stereo channels selected while sample and hold circuit **96A–2** would be gated to sample and hold during the time frame assigned to the second of said pair of stereo channels. If a monaural channel is selected at local control **22A,** sample and hold circuits **96A–1** and **96A–2** would be simultaneously gated to sample and hold the output of amplifier **94** during the same time frames, whereby the same audio signal is transmitted to both sides of headset **20.**

Filters **104** are selected to pass only audio frequencies and to have a sharp attenuation characteristic to produce an audio output. This audio output is applied along each audio output line **110** to its corresponding local control **22.**

A block diagram of one of local controls **22** is shown in FIG. **4.** The channel selection means **116** of said local control consists of a single pole multiple position rotary switch. Movable arm **118** of said switch selectively engages one of a plurality of fixed contacts **120** which are connected through resistors **122** to ground. Said movable arm is connected by means of line **123** to audio output line **110A–1,** and therefor to line **112A** of local demultiplexer **18,** which in turn is connected to channel selection logic **100** for the purpose of detecting the state of said channel selection means.

Audio output line **110A–1** is also connected to capacitor **124** which in turn is connected to the input of rheostat **125.** Audio output line **110A–2** is connected through capacitor **126** to the input of rheostat **127.** The left and right transducers, **128** and **130** respectively, shown schematically, are connected between the wipers of said rheostats **125** and **127,** respectively and ground. In this manner, the audio signal, whether stereo or monaural, is applied to the coils of transducers **128** and **130** which convert the electrical signal to sound for application to headsets **20.** Adjustment of the rheostats **125** and **127** adjusts the volume of the signal applied to said headsets. Channel selection means **116** is shown in FIG. **4** with a 12-position switch, in which case several of the **15** input channels of audio would be stereo pairs automatically selected by one position on said channel selection means.

Each of said resistors **122** are of a different value. The selected resistor serves as a part of a voltage divider located within channel selection logic **100** of local demultiplexer **18.** The output of said voltage divider is filtered to d-c within said channel selection logic which is prferably provided with a ramp sweep generator and comparator. When said comparator matches the output of said ramp sweep generator with the output of said voltage divider as determined by the setting of movable arm **118,** the comparator activates logic circuitry within channel selection logic **100** which, preferably through a digital code, identifies the selected circuit. As mentioned above, channel selection logic **100** is adapted to detect the stereo tag, if any, in which case two adjacent channels of stereo would be treated as a single program selected by a single position of selection switch **116.** The foregoing arrangement permits the seat selection function to share one of each pair of audio output lines **110,** thereby avoiding an additional cable extending between each local demultiplexer **18** and its corresponding local control **22.**

Turning now to the service portion of the system, an example of a column timer **26** and the supervisory utilization circuit **38** and supervisory control **40** associated therewith is shown in FIG. **6.** Basic timing for this portion of the system is obtained by crystal clock oscillator **130** which provides a stable frequency source which drives timing counters **132** to produce system clock and frame synchronization pulses and to govern the operation of data output logic **134.** Such clock and sync pulses are included in the train of pulses forming the output of data output logic **134** which is transmitted along line **135** to driver **136.** This output signal is applied to data line **32** and shift lines **34** and **36.** As discussed above, shift line **34** is connected to the first local coder **28A** while shift line **36** is connected to the first local decoder **30A.** This output signal is divided by the clock and sync pulses into a plurality of frames, each assigned to a particular local coder and its corresponding local decoder. Each of said frames is subdivided and time slots therein are assigned to each of the functions to be performed by the service system. The data in each time slot is generally applied by local coders **28** in response to the settings of the corresponding local controls **22.** However, it is sometimes desired to provide supervisory control functions at a contral location, in which case a supervisory control circuit **40** of the type shown in FIG. **6** might be connected to data output logic **134,** which would then interleave in the appropriate time slots, as governed by timing counters **132,** data responsive to the settings of said supervisory control.

In the embodiment shown in the drawings, the service portion of the system is adapted by way of example, to perform two functions, namely to activate a lamp associated with each local control and to activate a service call light associated with each group of three local controls. The supervisory control shown in FIG. **6** serves both a test and a functional purpose and consists of a three-position lamp test switch **138,** a two-position service call light test switch **140** and a service call light reset switch **142.** Lamp test switch **138** consists of movable arm **143** adapted to engage any one of three contacts **144, 145** and **146.** When first contact **144** is engaged, data output logic **134** transmits the data required to turn all lamps in all local utilization circuits **24** on. When second contact **145** is engaged, data output logic **134** interleaves the data in the appropriate time slots of the output signal directing all lamps in all utilization circuits to be turned off, third contact **145** being a neutral position.

Service call light test switch **140** includes a movable arm **146** normally engaged to neutral fixed contact **147,** but displaceable into engagement with the other fixed contact **148,** in which case data output logic **134** will interleave into the pulse stream, the appropriate data necessary to activate all service call lights of all of said local utilization circuits. Reset call light switch **142,** when depressed, causes data output logic **134** to interleave into the data stream in the appropriate time slots the data necessary to reset all of the service call lamps of all of said local utilization circuits. Also included are switches **166** and **168** which control the test signal generators utilized in the self-test feature of the system in a manner to be described below.

The embodiment of the system shown in the drawings also includes a supervisory utilization circuit **38,** which is shown in FIG. **6** to include a supervisory chime **150** and a supervisory call light **152.** To this end, column timer **26** is preferably provided with data input logic **154** which taps data line **32** by means of line **156.** The timing of said data input logic is governed by timing counters **132** through line **157.** If data input logic **154** detects that any one of the local controls **22** is set to enable its corresponding call light in its corresponding utilization circuit to light, a signal is passed along lines **158** to flip-flop **160,** the output of which is connected to supervisory call light **152** through amplifier **162.** Flip-flop **160** serves to latch the supervisory call light in the on position until all of the call light controls in all of the local controls **22** are reset. The affirmative act of resetting is required to insure that appropriate action is taken in response to each service call light. As a further alarm means in connection with the service call light, the activation of the service call light control at a local control **22** also results in the transmission by the local coder in the appropriate time slot of a pulse directing the ringing of supervisory chime **150.** This pulse is detected by data input logic **154** to pass a signal along line **163** to single shot multivibrator **164** the output of which is connected to said supervisory chime through amplifier **165.** The frequency and duty cycle of said single shot multivibrator **164** is selected to limit the frequency with which the chime rings.

As shown in FIG. **4,** each local control **22** includes a manual lamp control **170** operative through switch means **174** to impress a signal on line **176,** which in turn in connected to its corresponding local coder **28.** Similarly, each local control **22** is provided with service call light and chime control **178,** which, when depressed, closes contacts **179** to pass first signal along line **180** to said corresponding local coder, and when raised, closes contacts **181** connected in series with resistance **182** to pass a second, different, signal on line **180.** Preferably, said first signal represents a command to light the corresponding service call light and ring the supervisory chime, while said second signal directs the resetting of said corresponding service call light.

As seen in FIG. **7,** which schematically represents one example of a local coder **28** according to the invention, lines **176** and **180** from the lamp control **170** and service call light and chime control **178** respectively of each local control **22A, 22B, 22C** are applied to the date output logic **183** thereof. Timing for local coders **28** is obtained by means of sync and clock detector **184,** preferably a chain of single shot multivibrators, which taps off data line **32** and strips the clock pulses from the pulse train. The clock and frame synchronization pulses are passed to timing counters **186** along clock and reset lines **185.** Said timing counters control the functioning of data output logic **183** through lines **187** but are inhibited from driving said data output logic until a shift-in command is received from shift line **34** connected to the last local coder, or in the case of the first local coder **28A,** connected to the column timer **26.** This shift command consists merely of the sync and clock pulse and operates as follows. The frame synchronization pulse resets all of the timing counters **186** in all of the local coders **28A, 28B,** . . . , **28K,** enabling the timing counters on the first local coder to respond to the clock pulses received from column timer **26** along shift line **34.** When the timing counters **186** of said first local coder **28A** have completed their cycle and directed data output logic **183** thereof to transmit the state data of the corresponding

local controls **22**, a shift-out command is generated by said timing counters and passed along shift line **34** to the timing counters of the second local coder **28B** which is then activated to function as described above. This sequential activation of the local coders continues until the last local coder **22K** has completed its cycle, at which time a frame synchronization pulse resets the entire portion of the system and a new cycle is commenced.

During the period that each local coder is activated, data output logic **183** detects the states of local controls **22A**, **22B** and **22C** and, during appropriate time slots, transmits data representative of said states through low impedance driver **188** to data line **32.** The sequential activation of said local coders insures that the data is interleaved into the proper frame for detection by the corresponding local decoder **30.**

Local coders **30,** a schematic representation of one example of which is shown in FIG. **8,** are designed to be sequentially activated in the same manner as said local coders. Thus, the pulse train is tapped off data line **32** and applied through driver **190,** to sync and clock detector **192** and data input logic **194.** Reset and clock pulses are applied from said sync and clock detector to timing counters **195** which are governed by shift commands from shift lines **36.** Sync and clock detector **192,** timing counters **195,** and shift lines **36** function in the same manner as sync and clock detector **184,** timing counters **186** and shift lines **34** of local coders **22,** and a detailed description of their operation will not be repeated at this point. The operation of data input logic **194** is governed by timing signals obtained from timing counters **195** along lines **196.**

In the embodiment shown in FIG. **8,** the local utilization curcuits **24A**, **24B** and **24C**, have, in part, been combined to provide only a single service call light **200** for the three stations controlled by each local decoder **30.** Of course, this system according to the invention can include separate service call lights for each station, if desired. Further, said local utilization circuits include a lamp **202** (**202A**, **202B** and **202C**) for each station. Service call light **200** is driven through driver **204** and flip-flop **206** by data input logic **194.** In like manner, each lamp **202** is driven through a bi-directional gate-controlled thyristor which completes the A-C path for said reading lamp when gated on, said gating signal being derived from flip-flop **210** controlled by data input logic **194.** The data input logic **194** of each local decoder is activated in its proper time frame, detects the state data stored in each time slot of that frame and transmits a signal to the specific service call light on lamp of its utilization circuit **24** associated with said time slot to set the state of said call light or lamp. The group of local coders and the group of decoders are each in series connection for the purposes of sequential shifting. The correct local code and decoder are simultaneously activated during each frame, for example, local coder **28B** and local decoder **30B.**

The above-described arrangement permits both the local coders and local decoders to be interchangeable among themselves since special circuitry is not required for each station to identify the local control or utilization circuit associated with that station, while full multiplexing is accomplished. This feature offers substantial advantages in terms of the number of types of equipment that must be maintained on inventory and convenience of maintenance. Said local coders and decoders are preferably adapted to be bidirectional by providing appropriate gating in timing counters **186** and **194** so that the system is operative if the column timer **26** were connected at the other end of the series connection of said local coders and decoders. If the system also incorporates supervisory control **40,** the system timing is adjusted so that the data representative of the test functions and the supervisory call reset are detected after the data from each local coder **28** is latched so that the supervisory inputs would override the local control state date in all cases. In view of the switching speeds contemplated, the time gap between a particular data bit from the local coder and the overriding data bit from the supervisory control would be so slight as to be imperceptible.

While the supervisory control **40** provides some element of test capability to the system, a device for testing substantially the entire entertainment-service system would offer substantial advantages. To this end, a self-test circuit **220** is provided in each local control **22** as exemplified in FIG. **4,** a ten-channel test signal generator is substituted for audio input **10** and a five-channel test signal is substituted for audio input **16.** Said test signal generators are adapted to produce over each of the system audio channels a test signal of predetermined characteristics not normally present in the audio input signal. The test signal is preferably a tone of a frequency within the audio frequency range to pass filters **104** and of sufficient strength to operate self-test circuit **220.** The test signal generator may take any of the forms well known in the art and may be built into audio inputs **10** and **16.** In such case, as shown in FIGS. **1** and **6,** supervisory control **40** could be provided with switch **166** to remotely activate the ten channel test signal generator in audio input **10** by means of lines **167** and switch **168** to remotely activate the corresponding five channel test signal generator in audio input **16** by means of lines **169.** The supervisory control incorporated in each of the other assemblies **8** would only incorporate switch **166** to control the test generator incorporated therein.

In its simplest form, said self test circuit **220** is provided with a filter **222** connected to audio output line **110A–1** and filter **224** connected to audio output line **110A–2.** These filters are selected to pass only the frequency generated by said test signal generators and are connected to "AND" gate **226** the output of which is connected to switch means **174.** In the embodiment shown, switch means **174** is connected to manual lamp control **170** and adapted, in response to an output by "AND" gate **226,** to override said lamp control to produce a unique indication on line **176** equivalent to the repetitive opening and closing of said lamp control. If the entire system were operating properly, every lamp **202** in the system would blink in response to the signal so generated. To further extend the scope of the test on the system, self-test circuit **220** preferably includes a first transducer sense means **228** connected to the input side of transducer **128** and a second transducer sense means **230** connected to the input side of transducer **130.** Each of said transducer sense means is adapted to provide an output to gate **226** when the coil of its corresponding transducer **128** and **130** is intact, and therefore provides a low impedance to ground. However, if one or the other of said coils is broken, the resulting high impedance is sufficient to cut off the output of the corresponding transducer sense circuit so

that the "AND" gate **226** for that particular local control is not actuated and the corresponding lamp **202** does not blink.

If steps are taken to insure that at least one of each of the channel selector means **116** is set to each of the possible channels, the blinking or failure to blink of lamps **202** provides a test of substantially all of the system.

Thus, since each "AND" gate **226** requires the proper functioning of the two audio input channels and the two transducer coils associated therewith, it is apparent that substantially all of the entertainment portion of the system, including the entire main multiplexer and zone sub-multiplexer and substantially all of the local demultiplexers are tested. Further, since the output of the gate is connected to the service portion of the system, substantially all of the column timers, local coders, and local decoders are also tested. In this connection, it is noted that the lamps **202** are also tested and that the balance of supervisory utilization circuit **38** and service call light **200** would be tested by the activation of the call light test switch **140** in supervisory control **40.** Thus, by merely substituting test generators for audio inputs **10** and **16** the system performs an automatic self test. This self test results in substantial savings in time and labor and also provides a ready indication of the nature of any faults in the system through an analysis of the particular lamps **202** which fail to blink.

Turning now to FIG. **5,** a detailed circuit diagram of self-test circuit **220** is shown. The power supply for said self-test circuit is provided by tapping off audio output line **110A–2** and filtering the d-C component from that output by means of resistor **240** and capacitor **241.** A rectifying arrangement tapping off the audio output line can also be utilized. A positive voltage thus appears at terminal **242** and the bias voltages for the remainder of the circuit are obtained by connecting to said terminal. Filters **222** and **224** are substantially identical, consisting of series connected capacitors **244** shunted to ground by resistors **246** to define a first filtering stage and diodes **248** and resistors **250** shunted to ground by capacitors **252** and resistors **256** to define a second filtering stage. Transducer sense means **228** and **230** are defined by series connected resistors **256** connected to the base of transistors **258.** The bases of said transistors are also connected through resistors **260** to bias voltage terminal **242** and to ground through capacitors **261.** The collectors of said transistors are connected through resistors **262** to said bias voltage terminal while the emitters thereof are connected to ground. Transistors **258** are normally biased off. However, if a transducer coil is broken and a high impedance to ground appears at the input to transducer sense means **228** or **230,** then the transistor **258** of that transducer sense means will be forced into conduction to close "AND" gate **226.**

Said "AND" gate consists of diodes **264** connected respectively at their cathodes to the output of transducer sense means **228** and **230** (the collector of transistors **258**), and resistor **270** connected at one end to the anodes of diodes **264** and **266** and, at its other end, to the bias voltage terminal **242.** The output of "AND" gate **226** is connected to the input of switch means **174** represented by capacitor **270** shunted to ground and series connected resistor **272,** which in turn is connected to the input of astable multivibrator **274.** Capacitor **270** provides a delay means for distinguishing the test signal from a portion of the regular audio input signal which might be of the test signal frequency. Said test signal frequency is preferably chosen from among those frequencies least likely to be present in normal audio programming. The test signal must be present for sufficient time to charge capacitor **270** to the triggering voltage of multivibrator **274,** preferably about fifteen seconds. Said triggering voltage provides still a further distinguishing characteristic of the test signal since a weak signal will be insufficient to trigger the multivibrator, and therefore to override the manual control of the corresponding lamp **202.**

Said astable multivibrator includes transistors **276** and **277.** The base of transistor **276** is connected to the cathode of diode **278,** the base of which is connected through capacitor **279** to the collector of transistor **277.** In like manner, the base of transistor **277** is connected to the cathode of diode **280** which in turn is connected to the collector of transistor **276** through capacitor **281.** The base of transistors **276** and **277** are connected respectively through resistors **282** and **283** to ground. The emitters of said transistors are connected together, said common connection being connected through resistor **284** to ground. The collectors of said transistors are each connected through a resistor **285** and **286,** respectively, to bias voltage terminal **242.** The anode of diode **280** is connected to said bias voltage terminal through resistor **287,** while the anode of diode **278** serves as the input to said multivibrator. The output of said multivibrator is taken at the collector of transistor **276** and is connected through resistor **288** to transistor **290.**

The collector of transistor **290** is connected to output line **176** leading to the corresponding local coder. The emitter of said transistor is connected through resistor **291** to bias voltage terminal **242** and through resistor **292** to the movable arm of lamp control **170.** Said movable arm is shunted to ground by means of resistor **293.** The fixed terminal of lamp control **170** is connected to the emitter of transistor **295,** said emitter also being connected to ground through resistor **296.** The base of transistor **295** is connected through resistor **297** to the output of gate **226.** The collector of said transistor is connected to the aforementioned line **176** which is shunted to ground by means of diode **298.**

Switch means **174** operates as follows. When no test signal is detected, and the normal audio inputs **10** and **16** are applied, the manual closing of lamp control **170** turns on transistor **295** to present the appropriate signal to line **176,** and therefore to the local coder. If said lamp control is open, transistor **295** is turned off, also giving the appropriate indication to said local coder. Transistor **290** is in the off condition during this mode since its base is returned to transistor **276** of astable multivibrator **274** which is normally off.

If a test signal is applied by means of a test signal generator, the detection of said test signal by the "AND" gate, assuming all components of the system are functioning properly, produces a d-c level at capacitor **270** proportional to the amplitude of said test signal. This positive level is coupled through resistor **297** to the base of transistor **295** to maintain said transistor in reverse biased condition for the duration of the test signal detection. This in effect disables the control function of lamp control **170,** the signal passed along line **176** now being under the control of transistor **290** alone. This

transistor follows the voltage levels of transistor **276** of multivibrator **274,** alternating conduction and non-conduction with transistor **277** in the known manner. Accordingly, the signal at line **176** is an alternating signal which produces a blinking lamp in the corresponding utilization circuit to indicate a successful test. If a test signal is not detected, indicating some failure, the voltage of capacitor **270** is very nearly zero and the return path for the base of transistor **290** is through diodes **264** and **266** and the resistive path upstream thereof. In the latter case, the state of the lamp would be governed by lamp control **170** and would be steady.

If the entertainment-service system includes the special channel governed by P. A. selector switch **75,** the activation of which overrides all other channels to apply the contents of said special channel to all of the headsets **20** without regard to the setting of channel selector switches **116,** said special channel can be readily tested using the arrangement according to the invention. Testing can be accomplished by adapting the test signal generator to selectively apply a test signal different from the normal test signal to said channel while the normal test signal is applied to the balance of the channels. If the lamps **202** stop blinking and return to their normal state, the override feature of the special channel is operating properly. This results from the fact that the signal on the special channel is applied to all of the audio output lines instead of the normal test signal. Said special test signal can be of a different frequency which is not passed by filters **222** and **224** or of insufficient strength to trigger multivibrator **274.** A separate switch can be provided in supevisory control **40** to apply the special test signal to the special channel after switches **166** and **168** are closed.

Self-test circuit **220** is shown disposed in local control **22** but could be disposed in either local coder **28** or local demultiplexer **18.** While in the embodiment shown, the self-test circuit is connected to override lamp **202,** this is merely shown by way of example and not limitation and any utilization circuit capable of indicating a successful test could be used for this purpose. Thus, service call lights **200** could be used as the alarm. Further, the unique test state of the utilization circuit providing test indication need not be the blinking state used in the embodiment shown. For example, if service call lights **200** are used and reset button **142** of supervisory control **40** is depressed before test, the lighting of said service call lights could provide the test indication.

The entertainment-service system according to the invention has many applications. For example, the system can be applied to an aircraft or other means of transportation where it is necessary for each seat to individually control entertainment functions by selectively choosing a plurality of channels and service functions such as reading lamps and service call lights to attract the attention of stewardesses. In such an application, the zone sub-multiplexers **14** might represent a compartment on the aircraft, each local decoder, each local coder and local demultiplexer being associated with a row of seats within that compartment, and each local utilization circuit and local control being associated with a particular seat within that row. The entertainment-service system according to the invention is particularly advantageous for use in aircraft where weight considerations are of critical importance, since the multiplexing techniques used herein result in substantial savings in weight. Further, the self test circuit expedites servicing time, therefore minimizing the down-time of an extremely valuable aircraft. Still other applications of the system according to the invention include, but are not limited to use in hospitals, intercom systems in buildings and all other circumstances wherein a plurality of remote stations are to be tied to a single entertainment-service system.

It will thus be seen that the objects set forth above, among those made apparent from the preceding description are efficiently obtained, and, since certain changes may be made in the above constructions without departing from the spirit and scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

It is also to be understood that the following claims are intended to cover all of the generic and specific features of the invention herein described, and all statements of the scope of the invention, which, as a matter of language, might be said to fall therebetween.

What is claimed is:

1. A self-test arrangement for connection in a system having an output, an input, lamp means normally in an illumination mode in which said lamp means can provide illumination independent of any test function and capable of serving as a test-result indicator when disposed in a predetermined test state, manual switch means for selectively controlling said lamp means when said lamp means is in its illumination mode by providing signals for turning said lamp means on and off, and signal transmission means interconnecting said input, output and lamp means for transmitting at least said signals for turning said lamp means on and off when said lamp means is in said illumination mode comprising, means for selectively applying a test signal to said system input for transmission through said signal transmission means to said output, filter means connected to said system output for passing only an output signal substantially equal to the frequency of said test signal applied to said system input, and second switch means connected to said lamp means through said signal transmission means and to said filter means for disposing said lamp means in said predetermined test state without regard to the state of said manual switch means in response to said output signal from said filter means.

2. An arrangement as recited in claim **1,** wherein said predetermined alarm state of said lamp means is a blinking state, said switch means including lamp blinking circuit means.

3. An arrangement as recited in claim **1,** wherein said system includes audio transducer means having at least one transducer coil and said self-test arrangement includes AND gate means connected intermediate said filter means and switch means to receive the output signal of said filter means, transducer sense means connected to said transducer coil and adapted to produce a signal if said coil is unbroken, said transducer sense means being connected as a further input to said "AND" gate means.

4. An arrangement as recited in claim **1,** wherein said second switch means is adapted to dispose said utilization circuit in said predetermined state only if a prede-

termined period passes during which said filter means output is applied thereto.

5. A self-test arrangement for connection to a system having a central station and a plurality of local stations, lamp means at each of said local stations each normally in an illumination mode in which said lamp means can provide illumination independent of any test function and capable of serving as a test-result indicator when disposed in a predetermined test state; manual switch means at each said local station for selectively controlling the associated lamp means when said lamp means are in their illumination mode by producing signals for turning said lamp means on and off; and signal transmission means interconnecting said control station and said local stations, and said local stations and said lamp means for transmitting at least said signals for turning said lamp means on and off; comprising means for selectively applying a test signal to said signal transmission means at said central station; means for detecting said test signal at each of said local stations and producing an output upon said detection; and means at each of said local stations connected to the associated lamp means through said signal transmission means for disposing said lamp means in said predetermined test state without regard to the state of said manual switch means in response to said detecting means output.

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