June 7, 1955 M. R. WINKLER **2,710,341**

APPROACH WARNING SYSTEM

Filed Sept. 6, 1949 4 Sheets-Sheet 1

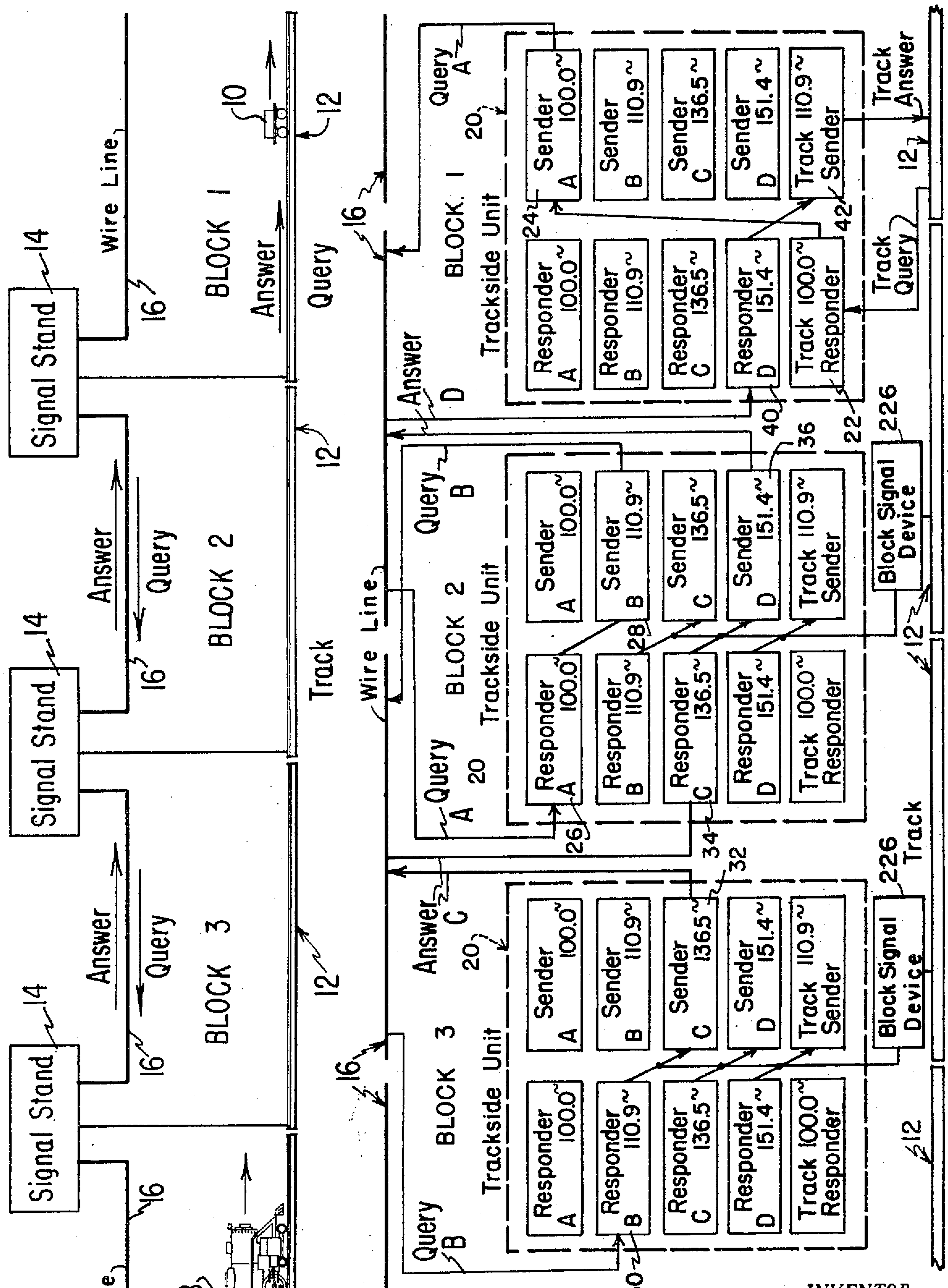


FIG. 1

FIG. 2

INVENTOR.
Marion R. Winkler

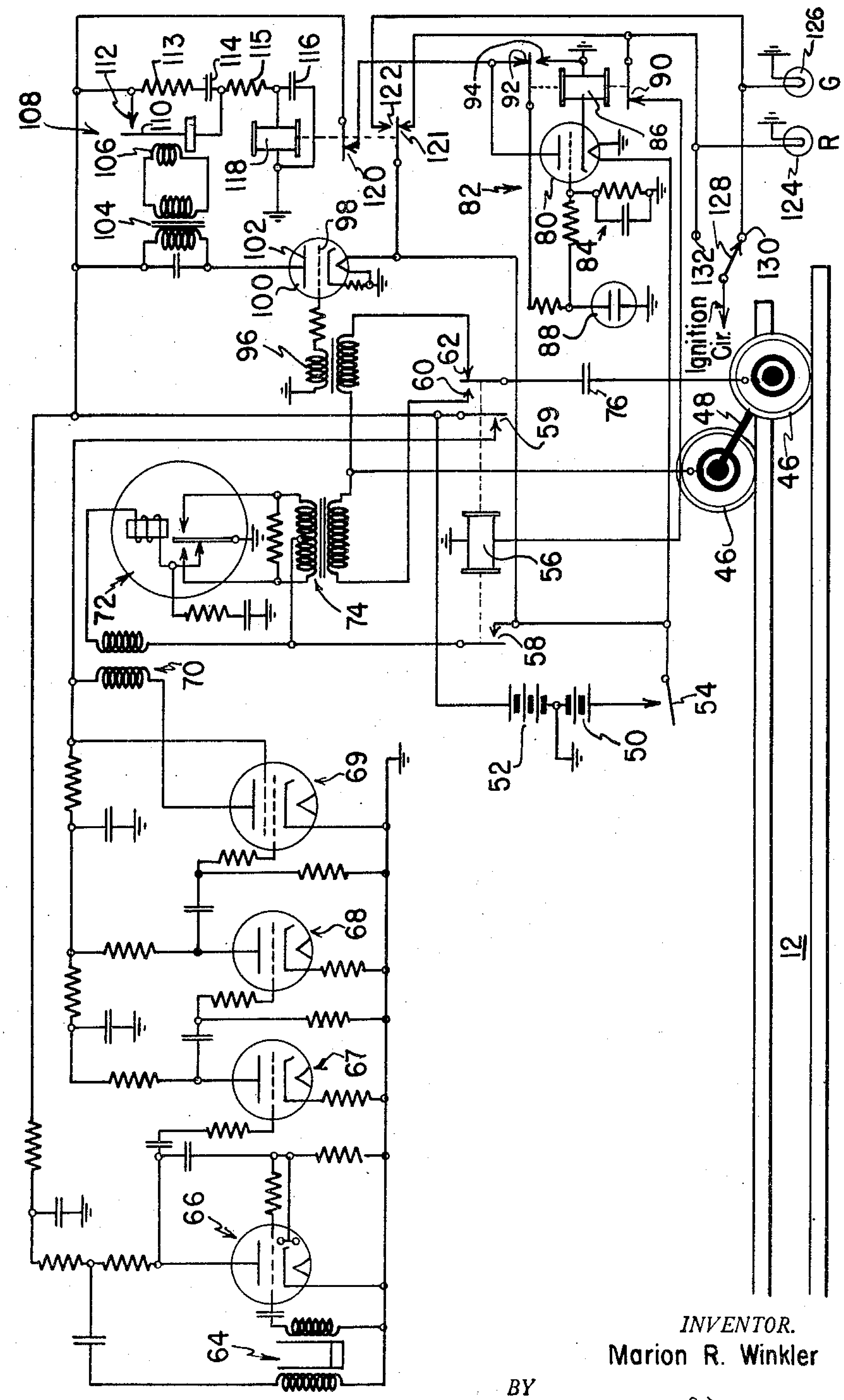
BY Foorman L. Mueller

Atty

APPROACH WARNING SYSTEM

Filed Sept. 6, 1949 4 Sheets-Sheet 2

FIG. 3



INVENTOR.
Marion R. Winkler
BY
Forman L. Mueller
Atty

June 7, 1955 M. R. WINKLER 2,710,341

APPROACH WARNING SYSTEM

Filed Sept. 6, 1949 4 Sheets-Sheet 3

FIG. 4

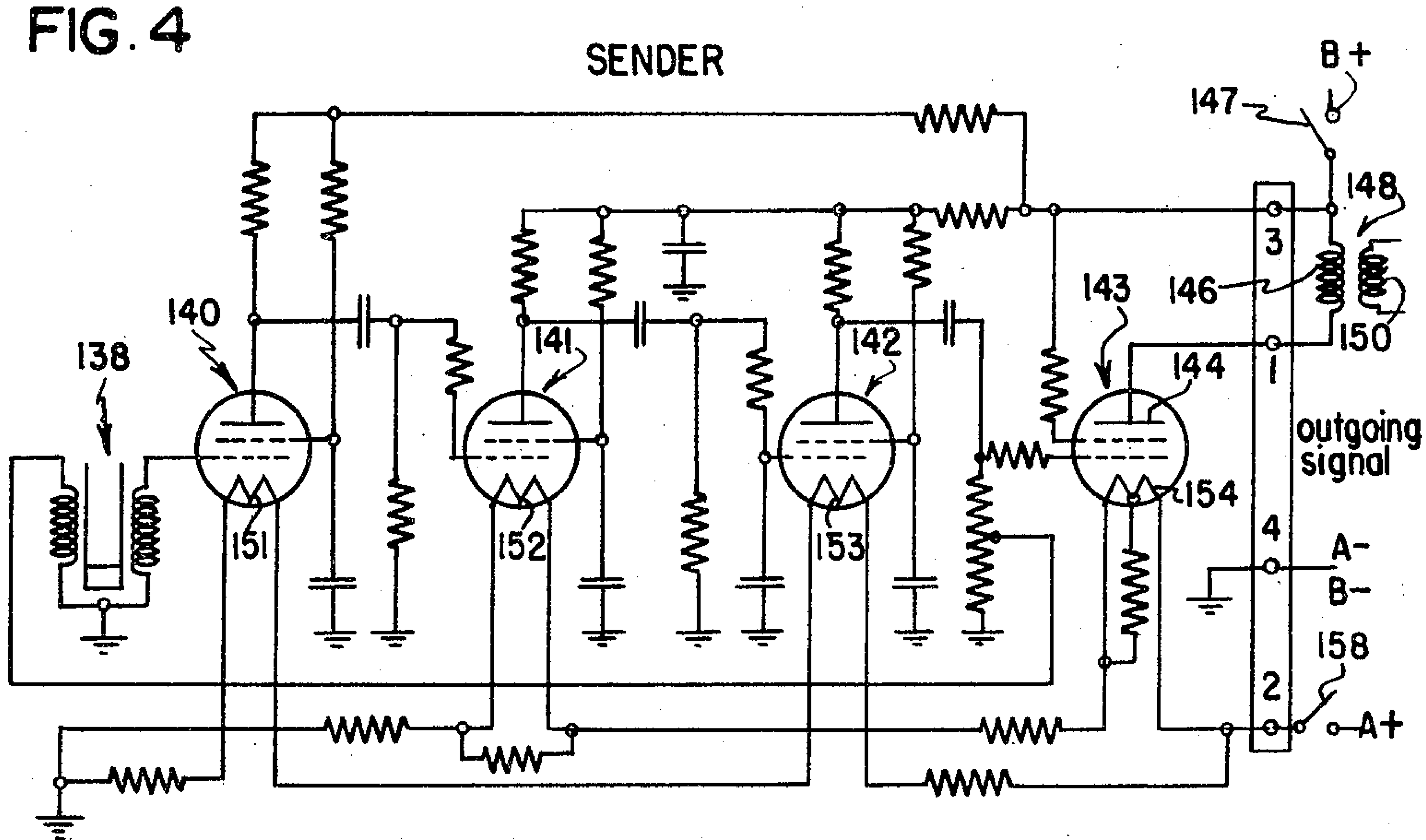
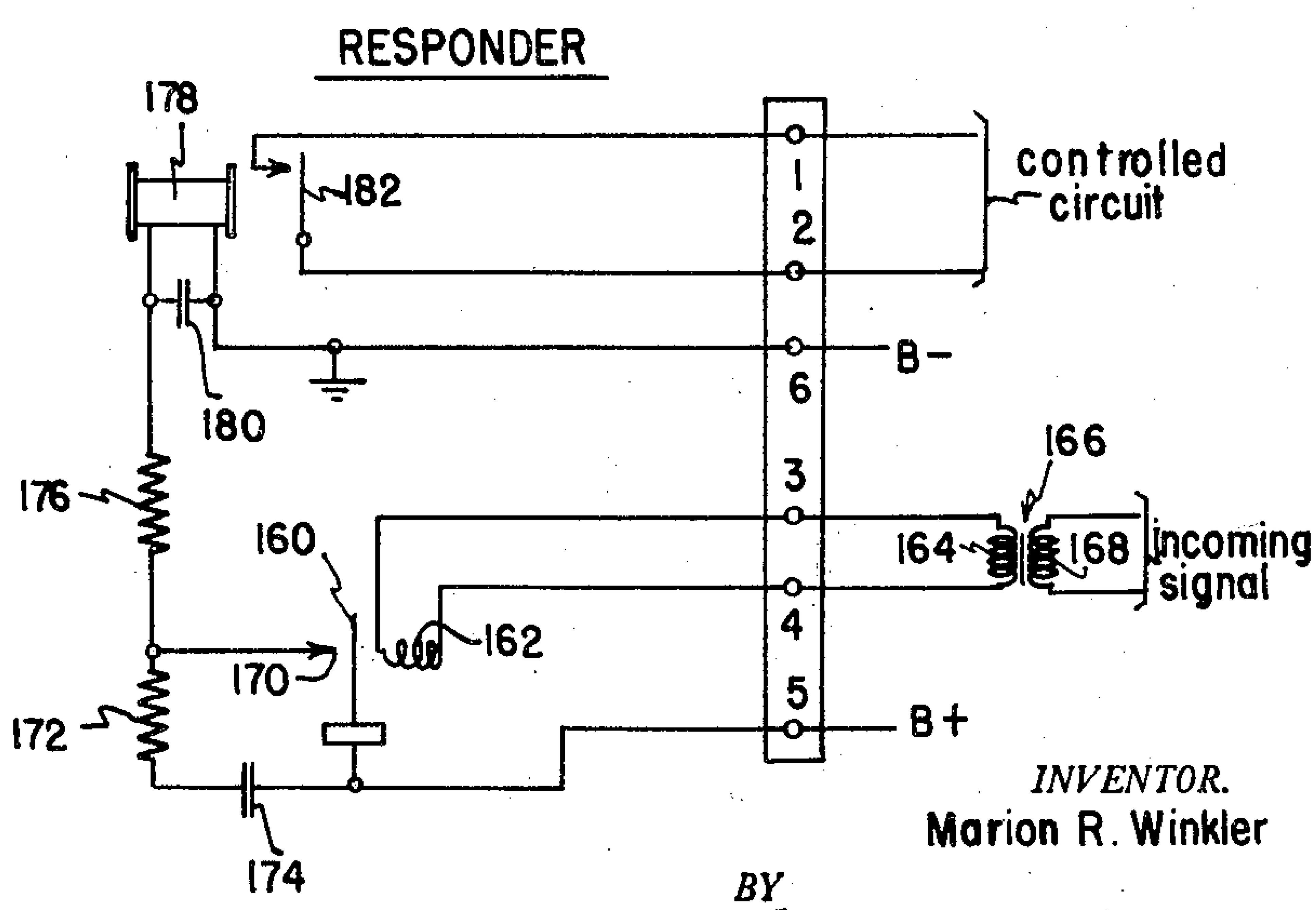


FIG. 5



INVENTOR.
Marion R. Winkler

BY Forman L. Mueller

Atty

June 7, 1955 M. R. WINKLER 2,710,341

APPROACH WARNING SYSTEM

Filed Sept. 6, 1949 4 Sheets-Sheet 4

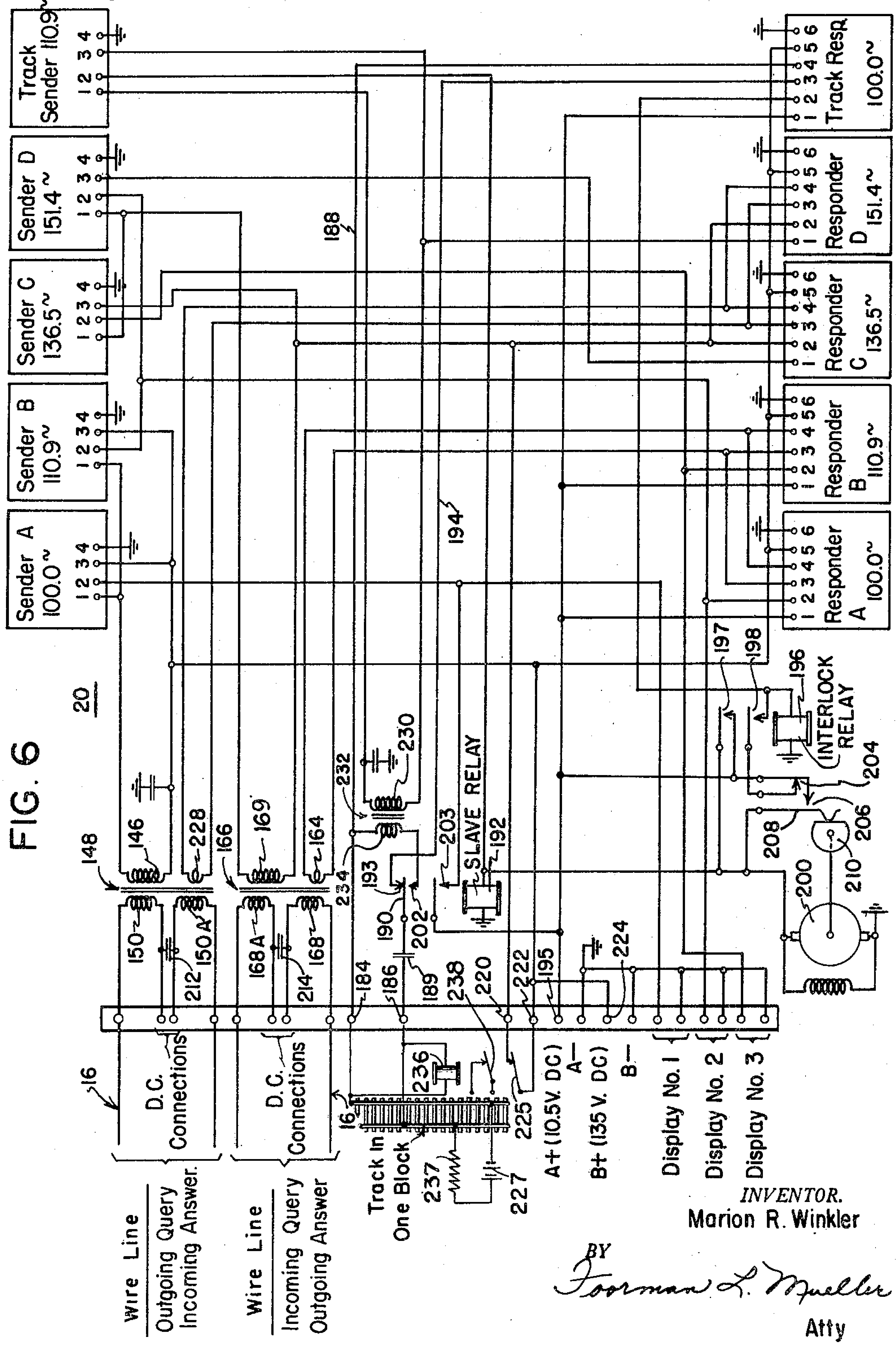


FIG. 6

INVENTOR.
Marion R. Winkler

BY Foorman L. Mueller

Atty

United States Patent Office

2,710,341

Patented June 7, 1955

2,710,341

APPROACH WARNING SYSTEM

Marion R. Winkler, La Grange Park, Ill., assignor to Motorola, Inc., Chicago, Ill., a corporation of Illinois

Application September 6, 1949, Serial No. 114,181

4 Claims. (Cl. 246—28)

This invention relates to query-and-answer signalling systems, and particularly to a system which automatically gives warning of an approaching object such as a train on a railroad track.

In present-day railroad operations involving high-speed trains and frequent schedules, there is a constant danger that service cars (i. e., handcars or motor cars) operated by railroad maintenance personnel will be run over by trains due to inadequate train approach warning facilities. This danger has become so acute in recent years that measures are being proposed in some quarters for compelling railroads to schedule their service car operations. This would, of course, greatly hamper railroad operations and render efficient operation impossible in many instances. On the other hand, if unscheduled service car operations are continued under present conditions, the resultant loss of life and property on a large scale will arouse public indignation, injure the reputations of railroad companies, and be a source of great expense to them.

Most railroad signalling systems are organized on the block principle. A certain length of track constitutes a block, and at the beginning of each block there is a signal stand which indicates to a train entering that block whether the track ahead is clear or not, so far as the presence or absence of another train is concerned. Service cars are so constructed that they do not operate the conventional block signals. When a train is approaching, the occupants of the service car are required to stop the car, get off and remove the car from the track. Customarily they must rely upon their natural senses to warn them of danger. Several theories have been proposed to explain why service cars sometimes are overtaken and run down by trains. Some believe that the persons riding on these cars do not hear the train approaching them until it is too late to escape. This might be true especially in the wintertime, when the men's ears are covered with headgear to protect them from the cold. Others believe that even though a man on a car sees or hears a train coming upon him, he may be paralyzed with fright and unable to jump.

Whatever the reason may be, such fatalities demonstrate very strongly the need for warning the occupants of service cars long in advance of the time when the train reaches them. In some cases it may be sufficient to warn the occupants of the service car that a train has entered the block in which they are located. In other cases, however, particularly on lines where high-speed trains run, this may not allow sufficient time for safety, and it may be desired to warn the service car occupants whenever an approaching train is within several blocks of them. Preferably, also, the service car personnel should be given sufficient advance warning so that they can travel to a convenient place for removing the car from the track. If the car is travelling over a trestle, for instance, time should be allowed to reach the other side before getting off the track. Many other considerations, too numerous to mention specifically, enter into the problem of providing an adequate train approach warning system, and to date the many complications involved in this problem have prevented the development of a commercially acceptable system of this character.

An object of the present invention is to provide an improved train approach warning system which gives the service car occupants ample warning of danger, even when the train is approaching at an extremely high speed and the service car has to travel a distance down the track before it can be removed.

Another object is to provide an improved train approach warning system which enables an oncoming train to warn any service car of its approach for several blocks ahead.

Still another object is to provide an improved system of this character in which all trackside units are of identical construction, and any trackside unit can relay a query or answer to another trackside unit, or directly answer a query from a service car, depending upon where the query originates in relation to such trackside unit.

A further object is to provide a practical train approach warning system which is adapted to "fail safe," that is, react as it would to a dangerous situation if any of its components should fail.

A feature of the invention is the provision of an improved trackside unit which may serve as the first, second or third relay station in a chain, depending upon the origin of the query signal. Another feature of this trackside unit is that it consumes no power except when responding to a query, and still another is the provision of means in conjunction with such units for signalling an approaching train when there is a service car on the track ahead.

Another feature is the uniform design of various components throughout the system. All trackside units are identical, and each unit contains the requisite senders and responders so that it may act in the capacity of the first, second or third link in the signal chain, as circumstances may dictate. Each service car unit has a sender and a responder which are similar in their design to the corresponding components employed in a trackside unit, enabling many identical parts to be used in the two types of units.

Still another feature is the provision of a trackside unit capable of utilizing both the track and an adjacent wire line for signalling purposes without in any way interfering with the standard signal facilities that utilize said track and said line.

A further feature is the provision of an improved service car signal unit which gives warning of an approaching train both by flashing a red light and by shutting off the motive power of the car, making it necessary for the operator to throw an emergency switch in order to resume travel. In this way the operator is made fully aware of his danger.

The foregoing and other objects, features and advantages of the invention will be apparent from a study of the following description thereof taken in connection with the accompanying drawings, wherein:

Fig. 1 is a general schematic representation of a train approach warning system in which the invention may be utilized;

Fig. 2 is a block diagram of certain trackside units employed in the system;

Fig. 3 is a circuit diagram of a service car signal unit;

Fig. 4 is a circuit diagram of a typical sender employed in a trackside unit;

Fig. 5 is a circuit diagram of a typical responder employed in a trackside unit; and

Fig. 6 is a schematic layout of a typical trackside unit.

In practicing the invention, each service car is equipped with a vibratory-reed sender for generating and transmitting a query signal of a given frequency down the track, and it is provided also with a vibratory-reed responder for receiving from the track an answer signal of a different frequency. The output of the sender is stepped up before it is fed to the track by suitable amplifying means, such as a vibrator synchronized with the frequency of the sender. The query signal travels down the track to the trackside unit which is located in the signal stand at the beginning of the block. Each trackside unit has a track responder tuned to the frequency of query signals generated by the service cars. This responder controls a sender in the trackside unit for transmitting a signal down a wire line to the next trackside unit in the preceding block. There, another responder-sender combination functions to relay the query down the wire line again to the third subsequent trackside unit. Each time a query is relayed, its frequency is changed. At the third trackside unit (assuming that the track is clear), a responder-sender combination is automatically operated to transmit an answer signal up the wire line to the second trackside unit. There, a responder-sender combination relays the answer signal to the first trackside unit, where a responder functions to operate a track sender for returning the answer signal to the service car on the track. If the track is not clear as far back as the third block, no answer signal will be sent to the service car. The service car unit alternately sends and listens, until it receives an answer. If no answer signals are received, the apparatus causes a red light to flash on, and it also breaks the normal ignition circuit. This warns the operator that a train is approaching him within the range of protection afforded by the system. He then knows that he must get off of the track, and if he wishes to continue the motion of the car to a more convenient point for removing the car from the track, he must throw an emergency switch to reestablish the ignition. On the other hand, if answer signals are received regularly, a green light remains on and the motive power of the car is not interrupted.

Referring now to Fig. 1, a service car **10** (generally a motor car but which may also be a hand-operated car) is represented on a railroad track **12**, travelling in the direction indicated by the arrow. The portion of the track **12** on which the car **10** is located is designated, for convenience, block **1**. At the beginning of block **1** is a signal stand **14**. This signal stand is equipped with the standard railroad block signals and, according to the invention, it also contains a trackside unit which is included in the present train approach warning system. The construction and operation of the trackside unit will be explained in detail hereinafter.

Each block of the railroad track **12** is provided with a conventional signal stand **14** at the beginning of the block, as shown in Fig. 1. The signal stands **14** communicate with one another through a wire line **16** which extends parallel to the track **12**. This wire line may be one that is already available as a part of the standard block signal system and would therefore not have to be specially installed. The wire line **16** is not continuous but includes sections interconnecting the various signal stands. The signal stands **14**, in accordance with conventional practice, operate in such fashion that whenever a train (represented by the locomotive **18** in Fig. 1) enters a block, a visual warning signal such as a red light automatically is displayed on the stand **14** for that particular block. As the train travels out of that block into the next one and thereafter continues its travel, the signals may turn amber and then green to indicate that the track is clear again.

Service cars as **10** have insulated wheels so that the presence of a service car in a block has no effect upon the standard railroad signals in the stand **14**. Thus, the engineer of the train normally is not given any warning that a service car is on the track ahead. It is the responsibility of the personnel on the service car to detect the approach of a train and remove the car from the track before the train arrives. The present invention insures that the service car personnel are given ample warning whenever a train is approaching them. The system is so designed that if the service car **10** is in block **1**, for example, it will receive a warning when a train **18** enters block **3** to the rear of the car. The system is adapted for use on a double-track line in which the movement on each track is always in the same direction. However, the principles of the invention can be applied likewise to a single-track line in which the train may move toward the service car from either direction.

The service car **10** intermittently sends a query signal down the track **12** to the first signal stand **14**. This query is relayed on through the wire line **16** to the next signal stand **14**, which in turn relays the query to the third signal stand **14**. The third signal stand then sends an answer through the wire line **16** to the second signal stand, which in turn relays the answer through the line **16** to the first signal stand **14**. The last-mentioned signal stand then sends the answer up the track **12** to the service car **10**, where it is received during the listening period of the service car warning unit.

Each signal stand **14**, Fig. 1, in accordance with the present invention, is provided with a trackside unit **20**, Fig. 2. Each of these trackside units **20** has five responders and five senders. One of the responders and one of the senders communicate directly with the track **12**. The other responders and senders communicate wtih the wire line **16**. Assuming that the service car is in block **1**, the query from the track **12** is received by the track responder **22** in the block **1** trackside unit. As indicated in Fig 2, all track responders are tuned to a frequency of 100 cycles per second. The responder **22** causes a sender **24** in this trackside unit to commence operating, which sender transmits a query signal through the wire line **16** at a frequency of 100 cycles per second. At the block **2** trackside unit, a responder **26** tuned to a frequency of 100 cycles per second receives this query and causes a sender **28** in this trackside unit to transmit a query signal through the wire line **16** at a frequency of 110.9 cycles per second. At the block **3** trackside unit this second query signal is received from the wire line by a responder **30** tuned to that frequency.

This process of relaying the query signal down the line can be repeated any desired number of times. In the illustrated system it is extended only to the third block. The responder **30** causes a sender **32** in the block **3** trackside unit to generate an answer signal at a frequency of 136.5 cycles per second, when a train is not in the respective insulated block of track to cause the block signal device or track relay **226** to prevent the generation of the answer signal. This answer signal is fed through the wire line **16** and is picked up by a responder **34** tuned to that frequency in the block **2** trackside unit. Responder **34** causes a sender **36** to operate and feed an answer signal through the wire line **16** at a frequency of 151.4 cycles per second, when a train is not in the respective insulated block of track to cause the block signal device or track relay **226** to prevent the generation of the answer signal. At the block **1** trackside unit a responder **40** receives this answer signal and causes the track seinder **42** to operate when a train is not in the respective insulated block of track to cause the block signal device or track relay **226** to prevent the generation of the answer signal. A block signal device **226** is shown in Fig. 2 for controlling each of the track side units for blocks **2** and **3** but has not been shown in connection with block **1** for the sake of clarity in the drawing. It should be understood that each of the trackside units for all insulated blocks for the track such as blocks **1**, **2** and **3** is provided with a track relay block signal device

226 to control the senders C and D and the track sender to prevent the transmission of an answer signal if a train is in the respective insulated block of track. The sender 42 supplies to the track 12 an answer signal at a frequency of 110.9 cycles per second, which signal travels through the track 12 and is picked up by the responder in the service car, as explained in greater detail hereinafter.

Fig. 2 represents the sequence of operations for a particular condition, that is, when the service car originating the query is in block 1. In this case the trackside units in blocks 1, 2 and 3 respectively constitute the first, second and third links in the communication chain. If the service car is in some other block, this relationship will change, but in any event, the trackside unit which is in the block where the service car is located will behave as does the trackside unit of block 1 in Fig. 2. The next block down the line will behave as does the trackside unit of block 2, Fig. 2, and so forth. The various responders A, B, C and D are highly selective as to the frequencies of the query and answer signals that are transmitted through the wire line 16. Likewise, the senders A, B, C and D have good frequency control so that there is no likelihood of signals becoming confused.

Fig. 3 shows the circuits involved in the service car signal unit. The wheels 46 of the service car are insulated from their axles as 48. Hence, the wheels 46 do not short-circuit the track 12. The wheels are adapted to pass alternating-current signals between the track 12 and the service car signal unit. Electric power for the operation of the signal unit is supplied by an "A" battery 50 and a "B" battery 52. Any other suitable source of power such as a motor-generator set may be employed, however. The switch 54 is closed to establish a circuit for energizing the heaters in the various electron tubes while the signal unit is in operation. A circuit for energizing relay 56 is also completed by switch 54, and extends from the battery 50 through the normally closed contacts 121 of relay 118, and through the normally closed contacts 90 of relay 86 to the winding of the relay 56. The relay 56 energizes and closes its contacts 58, 59 and 60, also opening its contact 62. The operation of the relay contacts in this manner places the unit in condition for transmitting a query signal.

For generating the query signal, an electromagnetic vibratory-reed device 64, Fig. 3, operates in conjunction with an oscillator tube 66 to produce an alternating-current signal at the required frequency Preferably, this signal generator is of the type disclosed in the copending application of Marion R. Winkler, Serial No. 343, filed January 2, 1948, now Patent No. 2,547,027, issued April 3, 1951, although the invention is not restricted to the use of that particular generator. Amplifiers 67, 68 and 69 are adapted to amplify the signals generated by the oscillator 66. Plate voltage for these amplifiers is supplied through the relay contact 59 when the relay 56 is energized.

The output of the final amplifier 69 is fed through a transformer 70 to a synchronous vibrator 72 which serves to amplify the power supplied to it. A wide variety of vibrators may be employed for this purpose, that shown in Fig. 3 being of the lock-in vibrator type. The stepped-up power output of the vibrator 72 is fed through a transformer 74 to the output circuit of the service car unit. When the relay contact 60 is closed, the secondary of the transformer 74 is coupled through a capacitor 76 to the wheels 46 of the service car. Thus, the generated query signal is fed to the track 12 through the connections from the transformer 74 to the wheels 46 of the service car, and through the wheels to the rails of the track on which the car is positioned. The two wheels are insulated from each other and the two tracks are similarly insulated and form separate conductors which are connected to the trackside signal unit as shown in Fig. 6.

At the same time that the sending portion of the service car unit commences to operate, a pulser tube 80 in a timing circuit 82 becomes operative. The timing circuit 82 includes a resistance-capacitance network 84 in the grid circuit of the tube 80, a relay 86 in the cathode circuit of this tube, and a neon tube 88 connected to the grid of the tube 80. The interaction of the resistance-capacitance network 84 and the pulser tube 80 causes the relay 86 to become energized after a predetermined time has elapsed. The pulsing cycle is about 4 seconds in length. The neon tube 88 serves to stabilize the pulsing action of the circuit 82.

The query signal is transmitted while the relay 86 is deenergized. When the relay 86 becomes energized (which occurs about once every 4 seconds as stated above), it opens its contact 90, thereby interrupting the circuit through the winding of relay 56. The relay 86 also opens a contact 92, thereby interrupting the circuit through which current is supplied to the resistance-capacitance network 84, and it also closes a contact 94, establishing a discharge path to ground for the network 84. The effect of this will be described presently.

When the relay 56 deenergizes, it opens its contacts 58, 59 and 60, thereby interrupting the transmission of the query signal, and it closes its contact 62 to initiate a listening operation of the apparatus. In this phase of the operation, the primary of an input transformer 96 is coupled to the track 12 through the capacitor 76 and the wheels 46. The secondary of the transformer 96 is coupled to the grid 98 of an amplifier tube 100. In circuit with the plate 102 of the tube 100 is the primary of a transformer 104, and the secondary of this transformer is in series with the coil 106 of a vibratory-reed responder 108. The reed 110 of the responder 108 is adapted to oscillate at a given frequency (110.9 cycles per second in the present instance). The reed 110, when oscillating, intermittently engages a fixed contact 112. Each time the reed 110 engages the contact 112, it shunts a portion of a series circuit including a resistor 113, a capacitor 114, a resistor 115, and the parallel combination of a capacitor 116 and the winding of a relay 118. When the reed 110 is disengaged from the contact 112, this shunt is removed.

The responder 108 is constructed in any suitable manner, preferably as disclosed in the copending application of Marion R. Winkler, Serial No. 342, filed January 2, 1948, now Patent No. 2,547,026, dated April 3, 1951. It will respond only to an answer signal received from the track at a frequency of 110.9 cycles per second (or whatever other arbitrary frequency may be chosen). The capacitor 114 alternately charges and discharges as the reed 110 vibrates. The capacitor 116, on the other hand, acquires a gradually increasing charge due to the action of the reed 110. As the charge is built up on the capacitor 116, the relay 118 becomes energized to open its contacts 120 and 121, while closing its contact 122.

As relay contact 120 opens, it prevents the establishment of a circuit for energizing the timing circuit 82. The timing circuit 82 remains inoperative so long as an answer signal is received continuously by the responder 108. If no answer signal is received, the relay 118 remains deenergized, and contact 120 remains closed. Under these circumstances the timing circuit 82 starts a new cycle as soon as the resistance-capacitance network 84 is discharged.

Assuming that an answer signal is received in due course by the responder 108, the contact 121 of the relay 118, in opening, prevents the relay 56 from again energizing when the contact 90 of the relay 86 closes. The opening of relay contact 121 also breaks the circuit through a red warning light 124. The relay contact 122, in closing, establishes a circuit through a green "all clear" light 126. It also closes the normal ignition circuit of the motor car. (A hand-operated car would not have this ignition circuit.) An ignition switch 128 normally is engaged with a contact 130, placing the ignition in parallel with the green light 126.

If no answer signal is received by the service car during the interval when the timing circuit 82 is maintaining the relay 86 energized, the contacts 120 and 121 of the relay 118 remain closed. Then, when the relay 86 again deenergizes, a circuit is completed from the battery 50 through the relay contacts 121 and 90 in series to the relay 56. This relay 56 thereupon energizes and switches the apparatus over to the transmitting condition again. This alternate switching back and forth between transmitting and receiving conditions continues until an answer signal is received. So long as no answer signal is received, or if the answer signal should fail, the contact 120 of relay 118 maintains a circuit to the red warning light 124, and the green "all clear" light 126 remains dark. While the red light 124 is on, the ignition circuit of the car cannot be established except by moving the switch 128 over until it engages the contact 132.

Thus, it can be seen that the operator of a motor-powered service car is given two types of warning when the track is not clear. First, the red light 124 flashes on, and second, the ignition is shut off so long as the switch 128 is in its customary position, that is, engaging the contact 130. To resume the travel of the service car, the operator therefore must turn the switch 128 over to its other position, engaging the contact 132. This may be necessary in order that the car can be brought to a convenient stopping-off place.

Fig. 4 illustrates schematically a typical sender unit employed in any of the trackside units 20. All of the trackside senders are of identical construction except for differences in the frequencies of the signals which they supply. The frequency of the sender is determined by the vibratory frequency of an electromagnetic reed device 138, which may be of the character disclosed in my aforesaid Patent No. 2,547,027. The reed device 138 operates in conjunction with an electronic oscillator 140, and the output of this oscillator is amplified by a series of electronic amplifiers 141, 142 and 143.

Positive plate voltage for the oscillator 140 and the amplifiers 141 and 142 is supplied from a suitable B+ voltage source to a terminal 3 of the sender. The plate 144 of the final amplifier 143 is connected to a terminal 1. Between the terminals 1 and 3 there is connected a primary winding 146 of a transformer 148. The secondary winding 150 of the transformer 148 has a connection with the wire line as will appear hereinafter. The alternating signal voltage developed by the sender is applied to the primary 146 and is fed to the wire line through the secondary 150. A switch 147 (such as a relay contact) may control the plate voltage circuit under some conditions, as will appear hereinafter.

It is desired that the senders in the trackside units have zero standby power, and they should also be capable of operating practically instantaneously when switched on. For this reason, the tubes in the oscillator 140 and the various amplifiers 141, 142 and 143 have filamentary cathodes which are connected in a series-parallel arrangement, as shown, between the A+ terminal 2 and the A— or ground terminal 4 of the sender. Filament voltage may be supplied to the terminal 2 through a switch device 158 which turns the sender on or off under certain conditions. This switch device may constitute any one of several relay contacts, as explained subsequently in connection with Fig. 6.

Fig. 5 illustrates schematically a typical responder as employed in any of the trackside units 20, Fig. 1. These responders are of identical construction except for the frequencies to which they are tuned. A vibratory reed 160 is mounted in a structure which includes a coil 162. A suitable structure of this type is disclosed in the aforesaid Patent No. 2,547,026. The coil 162 is connected across terminals 3 and 4 of the responder, which terminals are connected to the secondary as 164 of a transformer as 166. The primary 168 of the transformer 166 is connected to a wire line, as explained subsequently in connection with Fig. 6.

When an incoming signal having a frequency which corresponds with the frequency of the reed 160 is received, the reed 160 vibrates and intermittently engages a fixed contact 170. The reed 160 and contact 170 shunt the series combination of a resistor 172 and capacitor 174. This resistor and capacitor are included in a series circuit which extends from the B+ terminal 5 through capacitor 174, resistor 172, resistor 176 and winding of relay 178 to the B— terminal 6. A capacitor 180 shunts the winding of the relay 178. The capacitor 174 is alternately charged and discharged by the action of the vibrating reed 160, and the capacitor 180 builds up a steadily increasing charge. As the capacitor 180 becomes charged, the relay 178 operates and closes its contact 182, thereby connecting the terminals 1 and 2 electrically together. This closes a circuit which is controlled by the responder. This circuit may include a signal display for warning oncoming trains that a car is ahead on the track, or means to initiate some other operation, such as turning on an associated sender.

Fig. 6 represents the circuit layout of a typical trackside unit 20. The various senders and responders are illustrated in block form, with the terminals thereof numbered to correspond with the numbers of the terminals in Figs. 4 and 5, respectively. Each trackside unit is constructed in the same manner. The trackside unit is connected to the track in its particular block through the terminals 184 and 186. The track terminal 184 is connected directly to the terminal 4 of the track responder by a conductor 188. The track terminal 186 is coupled by means of a capacitor 189 to the contact spring 190 of a "slave" relay 192. Normally the spring 190 engages a stationary contact 193 when the relay 192 is deenergized. A conductor 194 connects the relay contact 193 to the terminal 3 of the track responder. Thus, if a signal is received from the track inquiring as to the presence or absence of an approaching train, the signal is referred directly to the track responder.

As the track responder operates, its relay 178 (Fig. 5) operates and closes the relay contact 182, establishing a short-circuit between the terminals 1 and 2. This closes a circuit from the positive A-battery terminal 195 through the terminals 1 and 2 of the track responder to the winding of an interlock relay 196. Relay 196 thereupon closes its contacts 197 and 198. As contact 197 closes, it establishes a circuit from the positive A-battery terminal 195 to the winding of the slave relay 192 and also to an electric motor 200. The relay 192 energizes, closing its contacts 202 and 203 and concurrently opening its contact 193. The closure of contact 203 establishes a circuit from the positive A-battery terminal 195 to the terminal 2 of sender A. As may be seen by reference to the specimen sender in Fig. 4, this closes the heater circuit of the sender A.

The closure of relay contact 202 conditions the apparatus for sending a reply to the service car when the track sender subsequently is rendered operative, as will be explained. The opening of relay contact 193 disconnects the track responder from the track. Meantime, the contact 198 of the interlock relay 196 has closed, and this establishes a circuit from the positive terminal 195 through a normally closed, cam-controlled contact 204 and through the relay contact 198 to the winding of relay 196. A holding circuit for the relay 196 therefore is established through the closed contacts 204 and 198, and the interlock relay 196 is held energized through this circuit. The slave relay 192 is energized through the relay contact 197 so long as the cam contact 204 is closed. Thereafter, the slave relay 192 continues to be held energized through another cam-controlled contact 206. The contacts 204 and 206 are associated with a cam follower spring **208** on a timing cam **210**, which is coupled to the shaft of the motor **200**. These contacts are so arranged that contact **206** makes before contact **204** breaks as the cam **210** rotates.

The motor **200** commences to rotate the cam **210** when the relay **196** closes its contact **197**, which occurs the instant that the track responder receives a query signal from the track. As the cam **210** rotates, it first closes the contact **206** thereby establishing an alternate energizing circuit for the slave relay **192**. The contact **204** then opens, interrupting the holding circuit for the relay **196**, which thereupon deenergizes. As the cam contact **206** closes, it also establishes a holding circuit for the motor **200**. Motor **200** therefore continues to rotate for one full revolution of the cam **210**, the slave relay **192** meanwhile being held energized through the cam contact **206**. At the end of its revolution, the cam **210** opens the contact **206**, thereby deenergizing the motor **200** and the slave relay **192**. During this interval while the cam **210** is rotating the various queries and answers are sent up and down the wire lines, and if all is clear, an answer signal is sent back to the service car originating the query.

As mentioned above, the sender A is rendered operative when the slave relay **192** closes its contact **203**, at the beginning of the two-minute cycle initiated by the timing cam **210**. Concurrently with this action, the relay contact **203** closes the circuit to display No. 1 at the signal stand for the first block. This flashes a warning to an oncoming train that a service car is in the block which the train is about to enter.

As sender A operates, it feeds a 100-cycle query signal to the primary **146** of the transformer **148**. The alternating voltage induced in the secondary **150** of the transformer **148** (and in its companion winding **150A**) passes through a capacitor **212** to the wire line **16** leading to the signal stand in block **2**. The split winding **150**, **150A** with the capacitor **212** connected across the break enables the various sections of the wire line to be used for direct-current signals without producing unwanted operation of the train approach warning system. This circuit arrangement also enables the train approach warning system to function independently of other control signals applied to the sections of the wire lines.

At the block **2** signal stand, the trackside unit **20** has the same arrangement of circuits as that shown in Fig. 6. The incoming query signal is fed to the companion windings **168** and **168*a*** of the transformer **166**, these windings serving as primaries in the present instance. A capacitor **214** couples the two windings insofar as alternating-current signals are concerned. Appropriate direct-current connections are made as indicated so that the sections of wire line **16** between the signal stands may be used to carry direct currents for other signalling purposes. Through the secondary winding **164** of the transformer **166**, the 100-cycle query signal is fed to terminals **3** and **4** of the responder A. This signal is also impressed upon terminals **3** and **4** of the responder B, but without effect inasmuch as responder B is not tuned to this frequency.

Responder A closes its relay **178** (Fig. 5), thereby electrically connecting the terminals **1** and **2** of this responder together. This has the effect of operating display No. 2 at the second signal stand, thereby indicating to an approaching train that a service car is in a second block ahead. The responder A also closes the filament heating circuits for the senders B and D. Sender B commences operating immediately, inasmuch as positive B-battery voltage is impressed upon terminal **3** of this sender at all times. Sender D does not commence operating until supplied with plate voltage in a subsequent phase of the operation, as will be explained.

Sender B transmits a 100.9-cycle query signal through the transformer **148** to the wire line **16**. At the third signal stand, the 110.9-cycle query signal passes through the transformer **166** to the secondary winding **164**, which feeds this signal to the responder B. (The passage of the signal down the line from one trackside unit to the next can be understood more clearly by occasional reference to Fig. 2 in conjunction with Fig. 6.)

Responder B closes a circuit from the positive A-battery terminal **195** through its terminals **1** and **2** to the filament heating circuit of sender C. Sender C is under the control of the block signalling device. If no train has entered block **3**, the auxiliary railroad control terminals **220** and **222** are connected together electrically by contact **225** of relay **236** in the signal stand that opens when the train enters the block. The relay **236** has a winding connected across the tracks and is normally energized by battery **227** which is connected in series with resistor **237** across the tracks so that the contact **225** of the relay **236** normally interconnects the terminals **220** and **222**. The relay and energizing circuit are basic components of standard block signalling devices. When a train enters the block the winding of the relay **236** is shorted and the relay drops out to disconnect the terminals **220** and **222**. The relay **236** may also include contacts **238** which are used in the railroad block signalling device. Alternatively, if an approach energizing relay is employed to turn on the power for the signal stand in advance of an approaching train, this relay may be used as the auxiliary railroad control. Any other circuit giving information as to the presence or absence of a train could, of course, be used. With the terminals **220** and **222** connected together, positive voltage is supplied from the B+ terminal **224** through the auxiliary control terminals **220** and **222** to the sender C. However, if a train is in any of the blocks within the protective range of the warning system, the plate voltage supply circuit is interrupted across the terminals **220** and **222**. Hence, sender C does not commence operating. Under these conditions, no answer is relayed back, and the service car personnel are warned of their danger automatically by the signalling means on the car. Responder B also closes a circuit to display No. 3 at the third signal stand, thereby warning any approaching train that a service car is in block **1**.

Assuming that the track is clear, sender C operates and transmits a 136.5-cycle answer signal through a primary winding **169** of the transformer **166** and through the windings **168** and **168A** of this transformer (which now serve as secondaries) to the wire line going back to the preceding signal stand. At the block **2** signal stand, this answer signal is fed through the windings **150** and **150A** of the transformer **148** (which now serve as primaries), thence through a secondary winding **228** to the terminals **3** and **4** of responder C. This causes responder C to operate and establish a connection between its terminals **1** and **2**. If the auxiliary railroad control associated with the second signal stand is in its "clear" position, plate voltage is supplied from the terminal **224** through the terminals **222** and **220** and thence through the terminals **2** and **1** of responder C to the terminal **3** of sender D, thus supplying sender D with plate voltage.

Sender D commences operating and transmits a 151.4-cycle answer signal through the transformer **166** to the wire line which leads to the first signal stand. At the first signal stand, the signal is passed to responder D. If the auxiliary railroad control at the first signal stand is in its "clear" position, plate voltage is supplied through the terminals **222** and **220** of this control and through the terminals **2** and **1** of responder D to the terminal **3** of the track sender. The filament heating circuit of this track sender was previously energized at the same time that the slave relay **192** was energized. The track sender commences operating and furnishes a 110.9-cycle signal to the primary **230** of an output transformer **232**. Inasmuch as the slave relay **192** is operated, the secondary **234** of the relay **232** is connected through the relay contact **202** to the track terminals **184** and 186. If the auxiliary railroad control at the first signal stand is not in its "clear" position, the track sender does not function.

Assuming that all of the three blocks are clear, the 110.9-cycle answer signal is transmitted through the track to the responder in the service car unit. The cam 210, Fig. 6, takes about two minutes to complete its cycle. Only a small fraction of this time is required for the queries and answers to be relayed down the wire line and back again, so that during substantially all of this time the track sender is functioning to send a reply signal to the service car. The two-minute interval ordinarily allows time for a service car to travel through a block. If the service car is travelling at an exceptionally slow speed, the indicating means may flash over to red at the end of the transmitting period of the track sender, when the cam 210 opens its contact 206. When this occurs, the holding circuit for the interlock relay 196, the slave relay 192 and the motor 200 are broken, shutting off any further transmission of the track sender. Each of the trackside units thereupon is restored to its inoperative condition. The signalling means on the service car flashes over to red, and the service car sender starts operating again to send out another query signal. If the track still is clear, a favorable answer comes back, and the service car signals promptly flash over to green again. If the car has passed completely out of the first block, the service car unit automatically starts a new query, which again is relayed down the line to the third block (in this case, block (2). The system then operates in a fashion similar to that described above when the service car was in block 1.

Thus, it will be seen that the system extends the range of protection from one block to three blocks. Each trackside unit, when receiving a query from a service car, relays the query to another trackside unit, which in turn relays it to a third trackside unit. The answer then is relayed back from the third trackside unit to the second trackside unit, then to the first trackside unit, from which it is returned to the car. Any trackside unit may initiate a query or an answer to another trackside unit. If a train should enter any of the blocks in which the trackside units are operating, the service car instantly is warned of the train's presence. The train engineer likewise receives a warning indication from the signal stand, so that he is on the alert. If the system should fail in any of its components, it reacts safely by preventing the transmission of an answer signal to the service car. Hence, the operator of the service car is warned when there is a failure in the system as well as though there were an approaching train. Many other advantages of the disclosed system, not specifically mentioned hereinabove, may occur to those skilled in the art.

The disclosed signalling system may be viewed broadly as a query relaying system which "counts down" and "counts back" through the required number of relay stations for sensing and delivering information which was requested exactly to the place desired. Thus, the system in the present case counts down three stations and back three stations. Moreover, this can be accomplished even though other stations request a different though similar answer over a part of the same transmitting medium and through some of the same stations, without interference between the two sets of queries and answers.

While there has been described what is at present considered to be the preferred embodiment of the invention, it will be understood that various modifications thereof may be made within the true spirit and scope of the invention as defined in the appended claims.

I claim:

1. In a train approach warning system which utilizes a railroad track subdivided into blocks and having a pair of rails insulated from each other and an adjacent wire line for the exchange of signals among a plurality of trackside stands for respective blocks of track, with the rails of each block being insulated from the rails of the other blocks, and a service car having a pair of wheels insulated with respect to each other engaging the rails in a block of track, and in which each of the trackside stands includes a railroad signal device operative according to the presence or absence of a train having electrically interconnected wheels which interconnect the rails of the respective insulated block of track; the combination including, a sender on the service car adapted to transmit query signals of a certain frequency through the wheels thereof to the rails of a first insulated block of track on which the service car is positioned, a first trackside signal unit including first responder-sender means at the trackside stand associated with the first block of track for receiving said query signals of certain frequency from the track and in response thereto sending query signals of a first frequency through the wire line in one direction to a second trackside stand associated with a second block of track, a second trackside signal unit including second responder-sender means at the second trackside stand for receiving query signals of said first frequency from the wire line and in response thereto sending query signals of a second frequency through the wire line in said one direction to a third trackside stand associated with a third block of track, a third trackside unit including third responder-sender means at the third trackside stand controlled by the railroad signal device thereof for receiving query signals of said second frequency from the wire line, said third responder-sender means operating in response to said query signal of second frequency and in the absence of operation of the railroad signal device by a train in the third block of track to return answer signals of a third frequency through the wire line in the opposite direction back to said second trackside unit at the second trackside stand, fourth responder-sender means in said second trackside unit controlled by the railroad signal device of the second trackside stand for receiving from the wire line answer signals of third frequency, said fourth responder-sender means operating in response to said signals of third frequency and in the absence of operation of the railroad signal device by a train in the second block of track to send answer signals of a fourth frequency in said opposite direction through the wire line to said first trackside unit at said first trackside stand, said first, second, third, and fourth frequencies all being different from each other, fifth responder-sender means in said first trackside unit controlled by the railroad signal device of the first trackside stand for receiving from the wire line answer signals of said fourth frequency, said fifth responder-sender means operating in response to said signals of fourth frequency and in the absence of operation of the railroad signal device by a train in the first block of track to send answer signals of a frequency different from said certain frequency through the rails of the first block of track, and a responder on the service car for receiving answer signals of said different frequency from the rails of the first block of track.

2. In a train approach warning system which utilizes a railroad track subdivided into blocks and having a pair of rails insulated from each other and an adjacent wire line for the exchange of signals among a plurality of trackside stands for respective blocks of track, with the rails of each block being insulated from the rails of the other blocks, and a service car having a pair of wheels insulated with respect to each other engaging the rails in a block of track, and in which each of the trackside stands includes a railroad signal device operative according to the presence or absence of a train having electrically interconnected wheels which interconnect the rails of the respective insulated block of track; the combination including, a sender on the service car adapted to transmit through the wheels thereof to the rails of the insulated block of track on which it is positioned query signals of a

certain frequency, a trackside signal unit at each trackside stand including first responder-sender means for receiving query signals of said certain frequency from the block of track associated therewith and in response thereto sending query signals of a first frequency through the wire line in one direction to a subsequent trackside unit, second responder-sender means in each of said trackside units for receiving query signals of said first frequency from the wire line and in response thereto sending query signals of a second frequency in said one direction through the wire line to a subsequent trackside signal unit, third responder-sender means in each of said trackside units controlled by the railroad signal device of the associated stand for receiving query signals of said second frequency from the wire line and in response thereto returning answer signals of a third frequency through the wire line back in the opposite direction to a preceding trackside unit when the railroad signal device indicates that a train is not on the associated insulated block of track, fourth responder sender means in each of said trackside units controlled by the railroad signal device of the associated stand for receiving from the wire line answer signals of said third frequency and in response thereto sending answer signals of a fourth frequency through the wire line in said opposite direction to a preceding trackside unit when the railroad signal device indicates that a train is not on the associated insulated block of track, said first, second, third, and fourth frequencies all being different from each other, fifth responder sender means in each of said trackside units controlled by the railroad signal device of the associated stand for receiving from the wire line answer signals of said fourth frequency and in response thereto sending answer signals of a frequency different than said certain frequency through the rails of the first block of track when the railroad signal device indicates that a train is not on the associated insulated block of track, and a responder on the service car for receiving answer signals of said different frequency from the rails of the insulated block of track on which the service car is positioned.

3. The combination of claim 2 wherein said sender on the service car includes, a signal transmitter adapted to be energized by a source of electric power on the car which includes a vibratory reed constructed to oscillate at a given frequency, an electronic oscillator controlled by said reed, electronic amplifier-means for amplifying the output of said oscillator, a synchronous vibrator for amplifying the output of said amplifier means, and means coupling said vibrator to the track on which the service car is positioned.

4. The combination of claim 2 wherein each of said trackside signal units includes first coupling means for connecting the sender portions of said first and second responder sender means to the wire line extending in said one direction, second coupling means for connecting the responder portions of said second and third responder-sender means to the wire line extending in said opposite direction, third coupling means connecting the sender portions of said third and fourth responder-sender means to the wire line extending in said opposite direction, and fourth coupling means connecting the responder portions of said fourth and fifth responder-sender means to the wire line extending in said one direction, with said coupling means including means for isolating the wire line extending in said one direction from the wire line extending in said opposite direction with respect to signals generated by said senders of said first, second, third and fourth responder-sender means.

References Cited in the file of this patent

UNITED STATES PATENTS

1,550,538	Graybill	Aug. 18, 1925
1,583,110	Baugher et al.	May 4, 1926
1,971,482	Espenschied	Aug. 28, 1934
1,985,911	Arkenburgh	Jan. 1, 1935
2,000,166	Espenschied	May 7, 1935
2,487,102	Coley	Nov. 8, 1949
2,547,027	Winkler	Apr. 3, 1951
2,587,164	Jett et al.	Feb. 26, 1952
2,590,483	Volz	Mar. 25, 1952
2,611,075	Marlowe	Sept. 16, 1952