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[45] **March 20, 1973**

[54] RAILROAD LIFT BRIDGE REMOTE CONTROL SYSTEM

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[52] **U.S. Cl.** **246/118**, 14/1, 343/225

[51] **Int. Cl.** **B61l 23/04**

[58] **Field of Search**.....246/118; 343/225; 340/31 R, 340/148, 22; 318/16; 14/34, 44, 1, 31; 104/38

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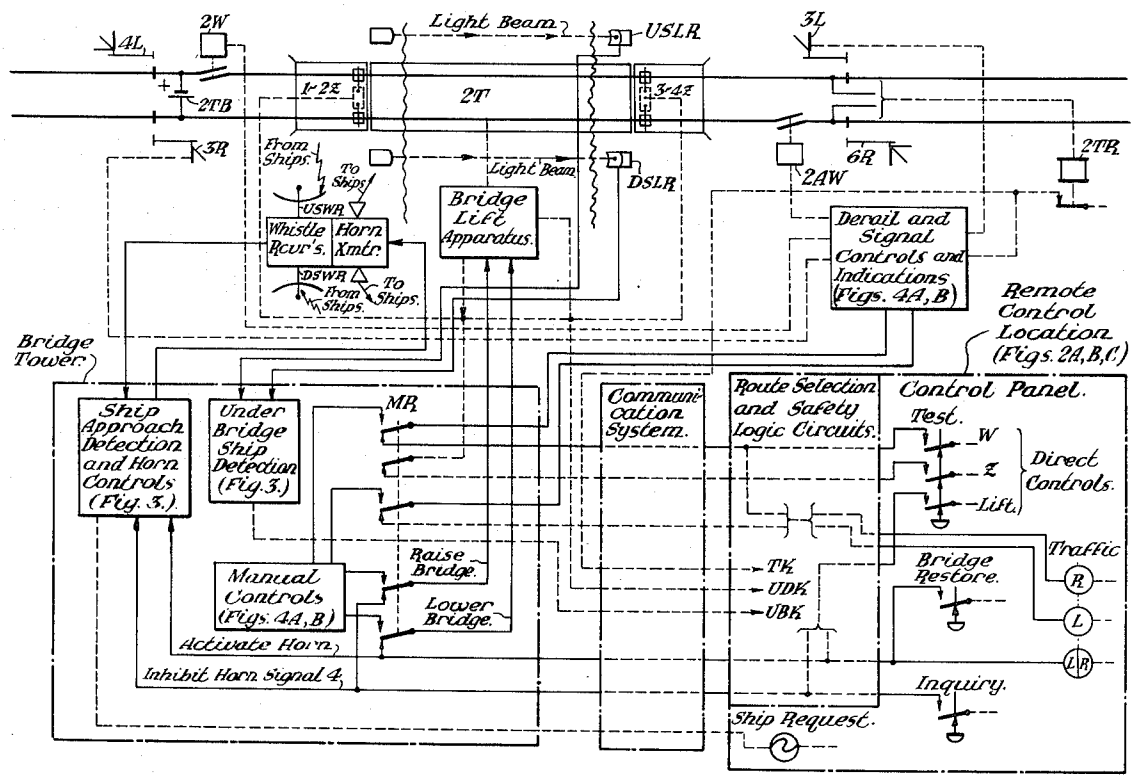
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Assistant Examiner—George H. Libman
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[57] **ABSTRACT**

Apparatus at the lift bridge receives whistle signals from approaching ships and records requests for raising the bridge span to allow ship passage. A horn transmitter on the bridge automatically responds to ship requests to indicate whether or not span will raise, as determined by the response of the control system operator. In response to a received ship request indication, the remote control operator, if conditions allow, initiates a command function to raise the bridge span. Safety logic sequencing circuitry checks the condition of the railroad traffic control system and transmits the bridge raise command only if no rail traffic route across the bridge is established or occupied by a train and if safety devices, e.g., derails, are in their blocking positions. The bridge lift apparatus properly sequences the actions necessary to raise and lower the bridge, including rail unlock and locking and starting and stopping the span, when the corresponding command function is received. Remote operator selection of a rail traffic route across the bridge initiates the safety logic circuitry sequence to lower the bridge, if up, and to then establish derail and signal conditions for train movement. Under-bridge ship detectors prevent lowering the span upon a ship occupying that space. When span-seated and rails-locked indications are received and checked, the safety logic circuitry closes the derails and subsequently clears the proper signal for the desired train movement.

8 Claims, 7 Drawing Figures



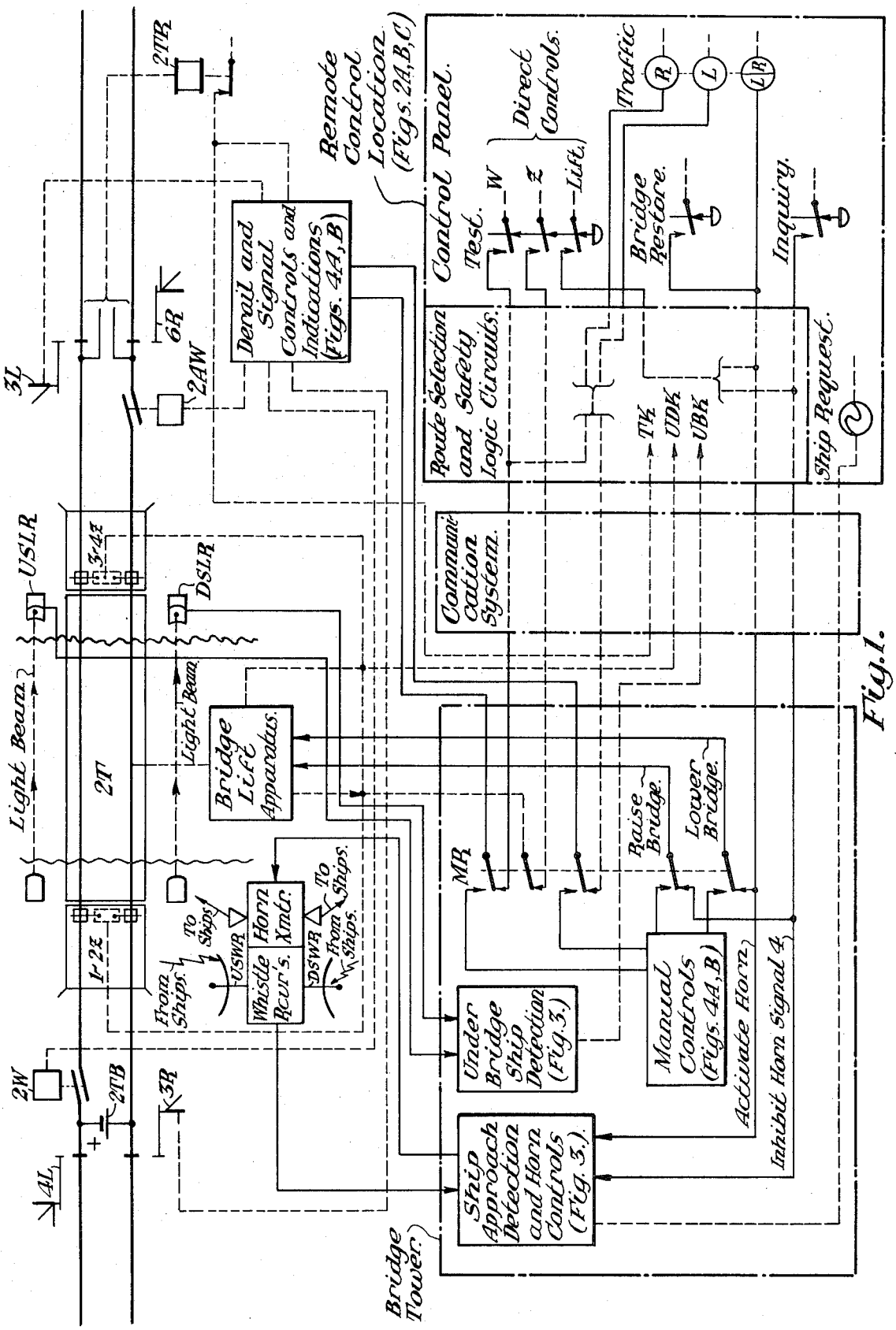

Remote Control Location (Figs. 2A,B,C)
Control Panel.
Test.
W
Z
Direct Controls.
Lift
Traffic
R
L
L/R
Bridge Restore.
Inquiry.
Ship Request.
Route Selection and Safety Logic Circuits.
TK
UDK
UBK
Derail and Signal Controls and Indications (Figs. 4A,B)
Communication System.
Bridge Tower
Ship Approach Detection and Horn Controls (Fig. 5.)
Under Bridge Ship Detection (Fig. 3.)
Manual Controls (Figs. 4A,B)
Activate Horn
Inhibit Horn Signal 4
MR
Raise Bridge
Lower Bridge
Bridge Life Apparatus
Light Beam
2T
1-2E
3-4E
USLR
DSLR
USWR
DSWR
Whistle Recvr's.
Horn Xmtr.
From Ships.
To Ships.
2W
2TB
4L
3R
2AW
6R
3L
2TB

Fig. 1.

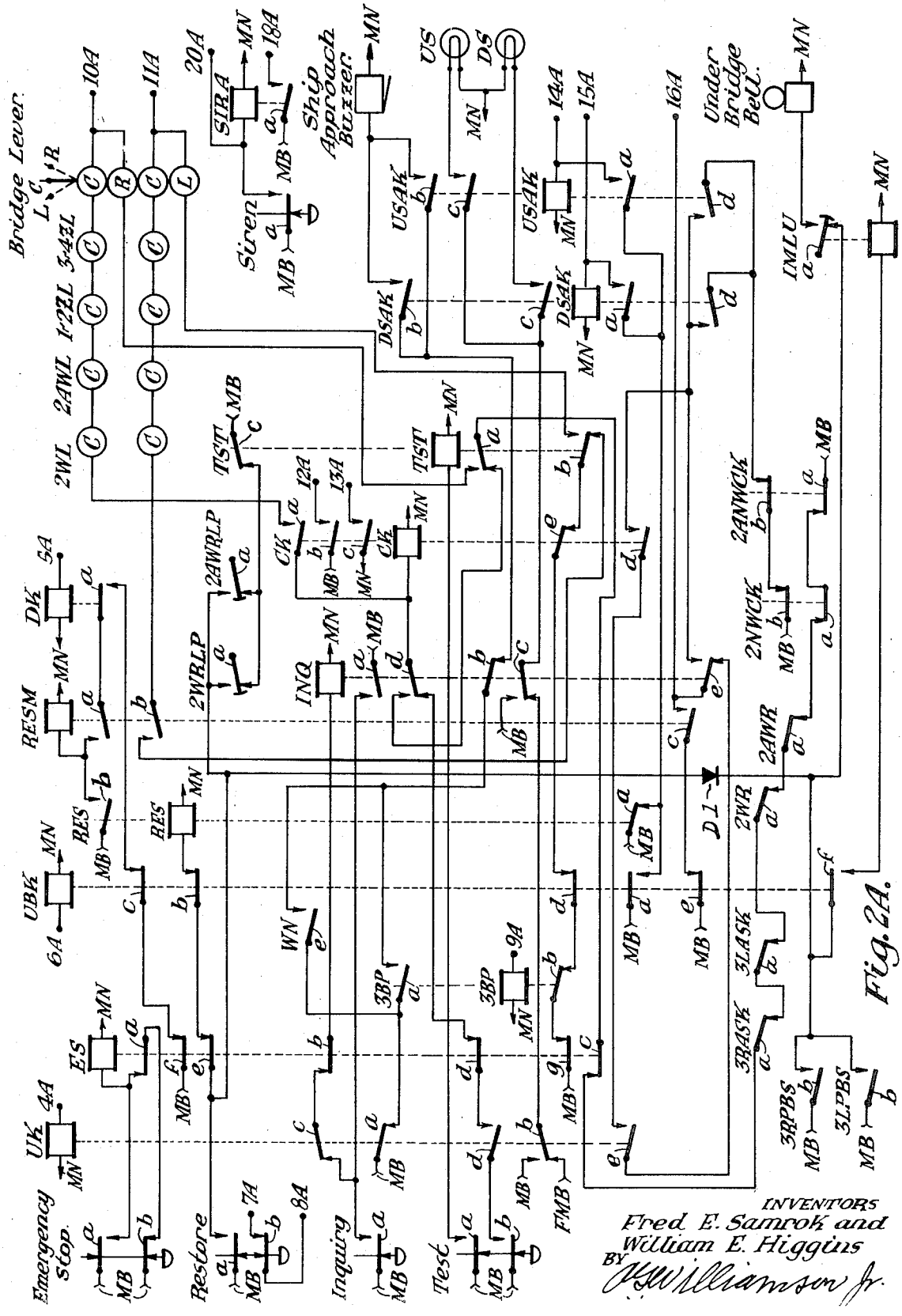

Bridge Lever
Emergency Stop
Restore
Inquiry
Test
Siren
Ship Approach Buzzer
Under Bridge Bell
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BY
J. W. Williamson Jr.

Fig. 2A.

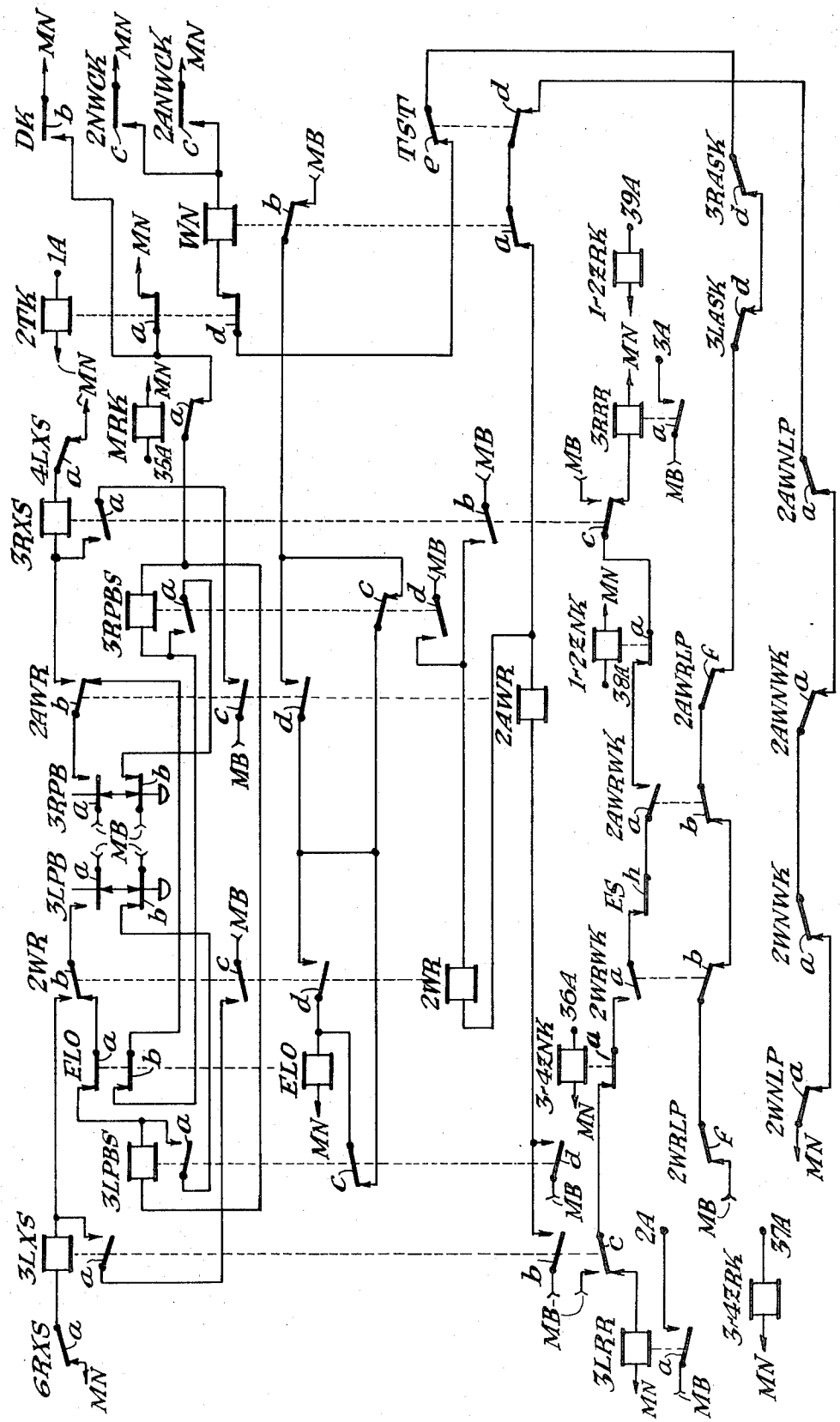

DK
2NWCK
2ANWCK
MN
WN
MB
TST
2TK
1A
4LXS
MRK
35A
3RXS
3RPBS
2AWR
3RPB
3LPB
2WR
ELO
3LPBS
3LXS
6RXS
2ZWR
3-4ENK
36A
2WRWK
ES
2AWRWK
1-2ENK
38A
1-2ERK
39A
3RRR
3A
3LASK
3RASK
2AWRLP
2AWNWK
2WNWK
2WNLP
2AWNLP
2WRLP
3LRR
2A
3-4ERK
37A

Fig. 2B.

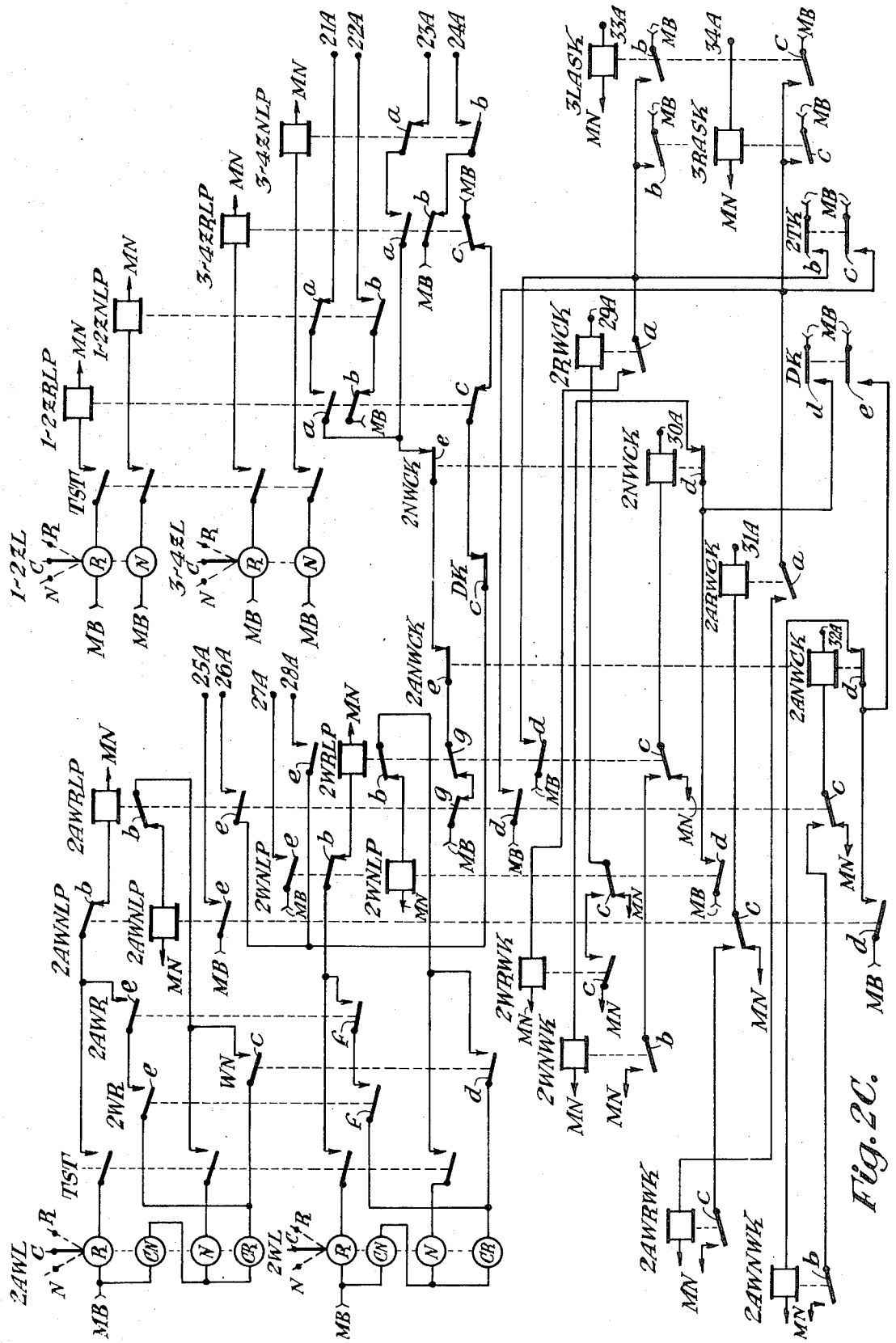


Fig. 2C.

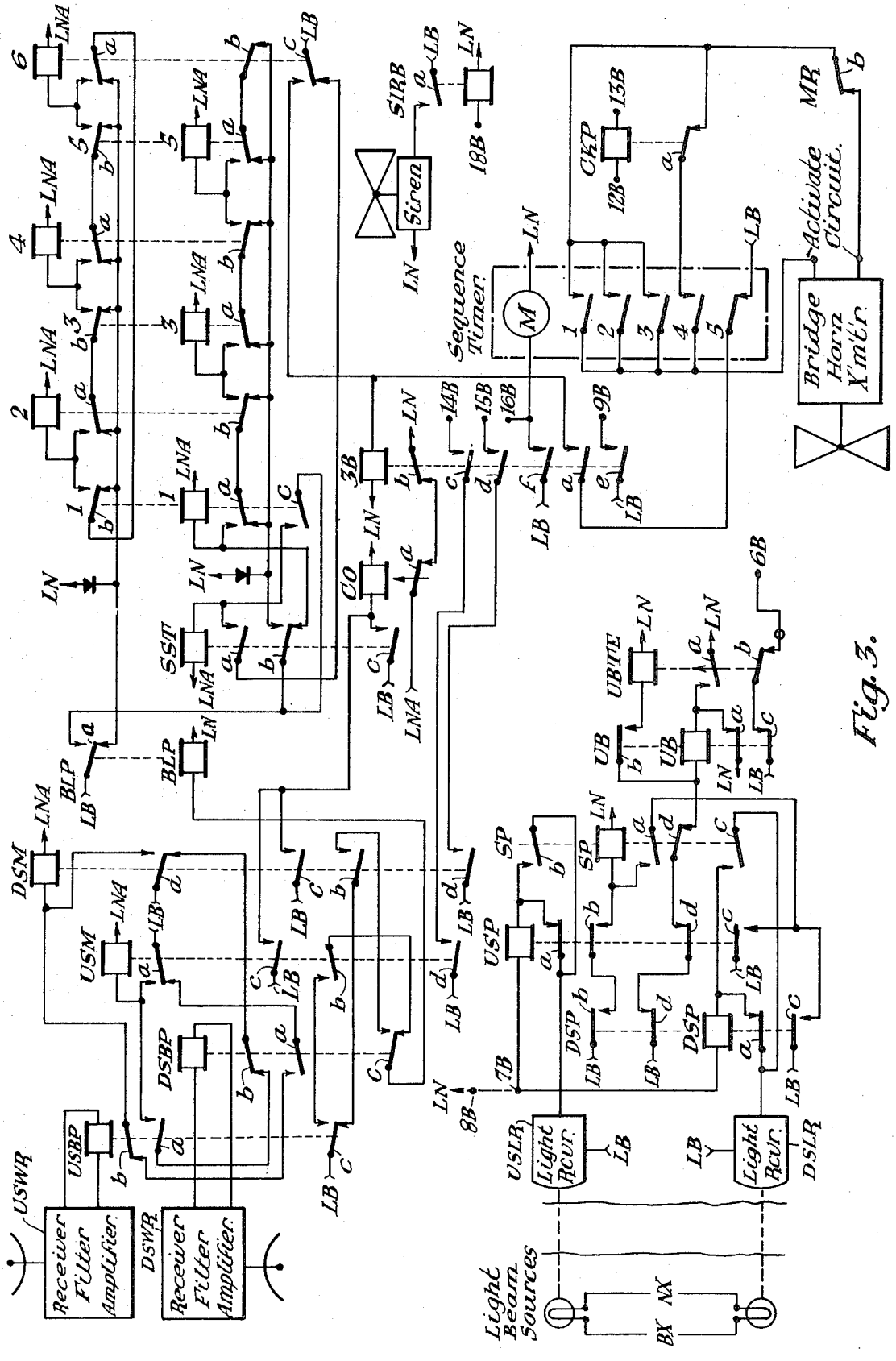
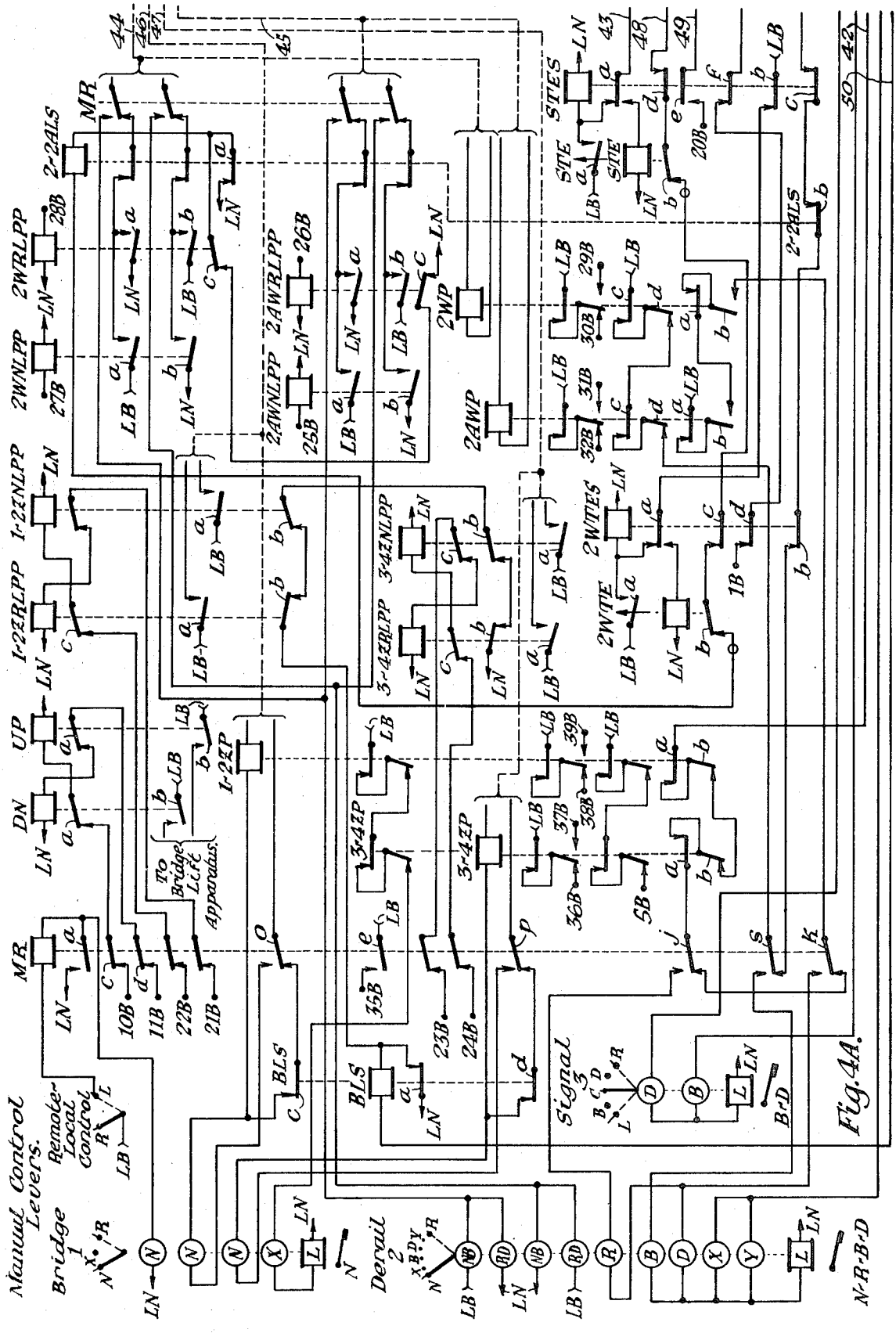
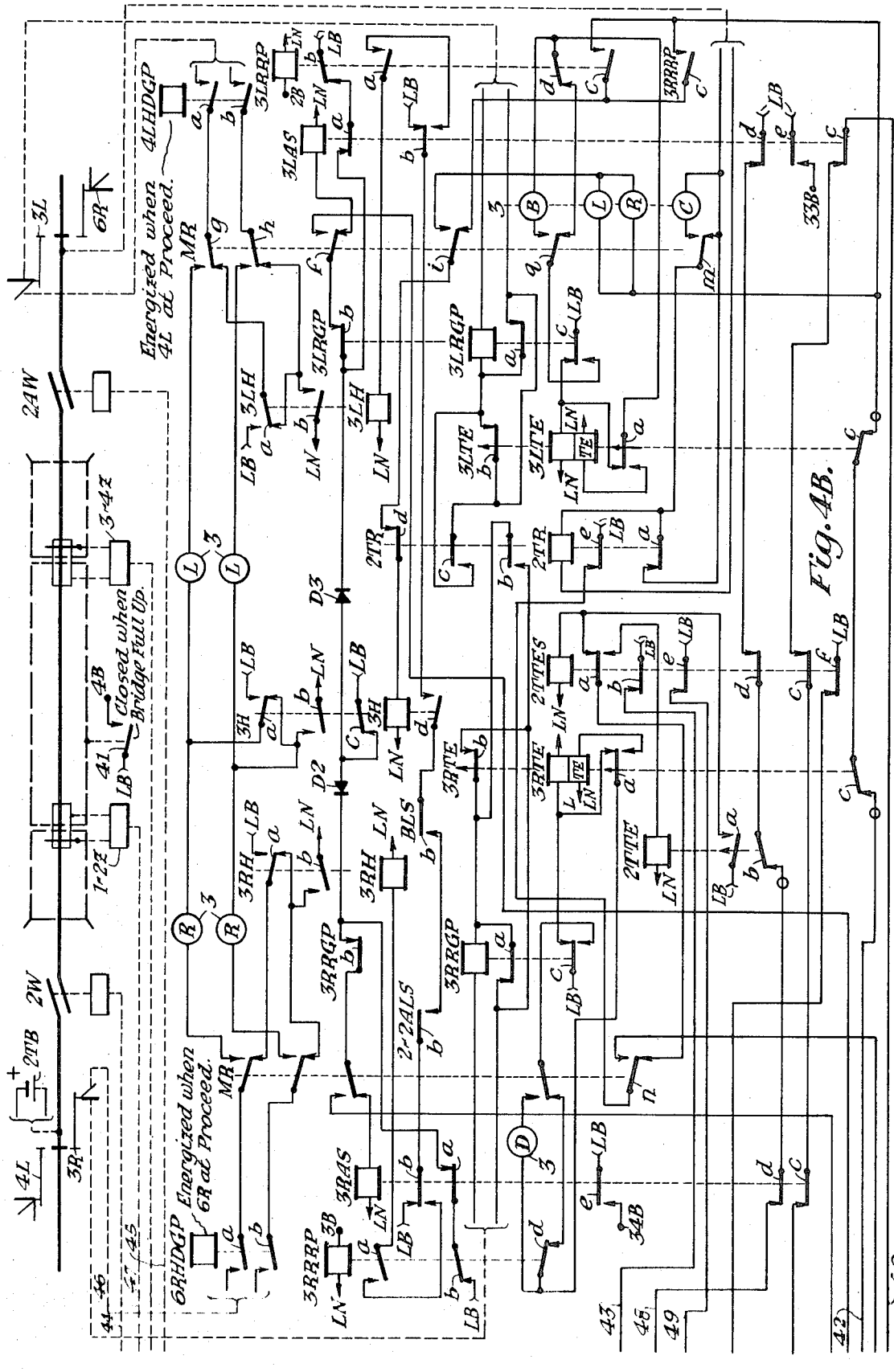

Receiver Filter Amplifier
Receiver Filter Amplifier
Light Beam Sources
Light Rcvr.
Light Rcvr.
Sequence Timer
Siren
Bridge Horn X'mtr.
Activate Circuit.
LNA
LN
LB
BLP
DSM
USM
DSBP
USBP
SST
CO
SP
USP
DSP
UBTIE
UB
SIRB
CKP
MR

Fig. 3.


Manual Control Levers:
Bridge 1
Remote
Local Control
Derail 2
Signal 3
To Bridge Lift Apparatus
MR
UP
DN
1-2ERLPP
1-2ENLPP
2WRLPP
2WNLPP
2-2ALS
2AWRLPP
2AWNLPP
2WP
2AWP
3-4ERLPP
3-4ENLPP
3-4EP
1-2EP
2WITE
2WITES
STE
STES
BLS
LN
LB
N-R-B-D
Fig. 4A.


Energized when 4L at Proceed.
Closed when Bridge Full Up.
Energized when 6R at Proceed.
Fig. 4B.

RAILROAD LIFT BRIDGE REMOTE CONTROL SYSTEM

BACKGROUND

This invention pertains to a remote control system for a movable span railroad bridge. More specifically, our invention relates to a control arrangement by which a railroad lift bridge or other types of movable bridge spans may be remotely controlled from an off-bridge location, with automatic sequencing of the bridge span movements in accordance with selected conditions relating to train and ship movement.

It is always desirable to reduce the work force required to control the operation of a railroad, from a standpoint of both economy and efficiency. In the past, full time local operators or bridge tenders normally have been required to control movable railroad bridges over active waterways, i.e., such as rivers, canals, and harbor channels, where the bridge in its railroad traffic condition does not provide sufficient clearance for ships moving along the waterway. Such control arrangements, when using a separate operator for the bridge itself, further require interface and cooperation with the other railroad traffic control systems. Thus communications channels are required, for example, for voice, for interlocking, and for safety checks, between the bridge control system and the signal system controlling the movement of trains along the stretch of track crossing the bridge. Where two or more people are involved in the overall control of the bridge and the trains, each with distinct responsibilities, extra communications are also required for checks and cooperation between the two or more individuals. Thus the elimination of a separate bridge tender or operator at or within the bridge tower location will save expenses, avoid the necessity for cooperation between two different controllers and controlled systems, and reduce the average delays to trains and to the ships, each moving along their own right-of-way.

Accordingly, an object of our invention is a remote control system for railroad movable span bridges.

Another object of the invention is an arrangement for remotely controlling the movements of a railroad lift bridge in response to a request from an approaching ship or from the operator of the railroad traffic control system.

Still another object of the invention is a circuit arrangement for interfacing the joint control from one location of a railroad traffic control or signaling system and the movement of a railroad lift bridge to provide for fail-safe operations in authorizing the movement of trains across the bridge and ships along the waterway under the bridge.

A further object is a control system by which the movement of a railroad lift bridge is automatically controlled from a remote location at which the signal system controlling movement of trains across the bridge is also controlled.

It is also an object of the invention to provide a joint remote control system for a railroad lift bridge and the associated railroad traffic control installation which includes automatic sequencing means for moving the bridge span between its clear and blocking position for waterway traffic; signals, safety derails, and rail locks for authorizing and protecting the safe movement of trains across the bridge; detectors for ships, trains, and

apparatus positions; and fail-safe interfacing logic circuits for controlling the operation of other apparatus from the remote control location only when safety conditions permit.

Other objects, features, and advantages of this invention will become apparent from the following specification when taken in connection with the accompanying drawings and appended claims.

SUMMARY OF THE INVENTION

In the practice of our invention, we provide, at the bridge, apparatus for receiving request signals from and transmitting answering signals to, ships approaching along the waterway. Specifically, receiver-amplifier units detect whistle signals from the ships and associated apparatus determines the direction of approach and counts the number of whistle blasts. This arrangement determines if a valid approach detection and request for clearing the bridge exists. A transmitter device is used to provide preselected answering signals to the ship that the bridge will or will not be raised. Specifically, a four-blast answering signal indicates that the bridge will not raise at that moment, whereas this signal sequence is cut short to three blasts if the bridge will raise and is in the process of being lifted. The answering horn blasts in response to a ship's whistles are actuated automatically upon detection of a ship approach and only the number of horn blasts vary in accordance with the response of the remote operator. We also provide a presence detector to determine when ships are passing underneath the bridge span. Specifically, this is shown as being two light beams, one on the upstream and the other on the downstream side of the bridge, each transmitted across the waterway channel from a light source to a light detector unit. Various safety checks are included to determine the proper operation of such detectors. The lifting and lowering of the bridge is controlled without local supervision from a remote control location by the transmission of raise and lower command signals to receiving apparatus at the bridge. Various conventional sequencing equipment is included in the bridge lift apparatus to assure that the proper sequence of events, e.g., unlocking the bridge and track rails prior to raising, occurs during the lifting operation as well as during the lowering operation, e.g., relocking the rails after the span is seated in the proper manner. It may be noted that, although the circuitry shown is for a lift type bridge span with up and down positions only, other types of movable bridge spans for clearing the waterway may also be controlled by an equivalent system.

At the remote control location, we provide other automatic sequencing equipment and circuitry, also defined as safety logic circuits. These circuits receive checks of the presence of ships under the bridge and the position of the train control safety apparatus and control the sequencing of the operations in preparing to raise or lower the bridge and also in clearing routes for train movements in either direction across the bridge. This automatic sequencing equipment assures that each element of the operation occurs in the proper fashion and that all safety conditions are satisfied before the next item in the operating sequence can occur.

The signal and traffic control system for controlling train movements across the bridge includes derails in

the approach track stretches, rail locks for holding the rails together at the lift span, and detectors of the proper seating of the bridge span and the rails in the down position. The railroad signal system also includes wayside signals which authorize or restrict train movements across the bridge and a track circuit including the bridge rails to detect train occupancy. This traffic control system is controlled by a remotely located operator who is provided with a control machine of a conventional type which may also be used, and normally is, to control train movements along the stretches of track on each side of the bridge for some distance. The control panel in the operator's control machine also has indicators for ship requests for lifting the bridge and acknowledging controls which are actuated in response to cause the bridge to raise or lower in the proper manner. Normally the bridge, once raised, will be lowered by the initiation of a request to establish a traffic route across the bridge for a train movement but may also be restored by direct controls which accomplish only the lowering of the bridge. The route selection and safety logic circuit arrangement thus provides an interface between the railroad signal or traffic control system and the automatic sequencing circuitry for raising and lowering the bridge. This circuit arrangement and apparatus must operate on a fail-safe principle. In other words, no one action can take place unless all other possible actions or conditions permit it with full safety. The safety logic circuitry receives check functions regarding bridge position, waterway occupancy, bridge track circuit occupancy by trains, and the traffic control system condition in order to provide a complete interfacing between the two control systems. A final set of controls on the remote control panel allow the bridge and associated apparatus to be operated under test conditions without affecting the route control for railroad traffic. Also specifically shown are manual controls at the bridge location, by which a bridge tender may be substituted to control the bridge and immediately associated track signal system. These manual controls serve as standby if the remote control system is temporarily out of service.

SUMMARY DESCRIPTION OF THE DRAWINGS

We shall now describe the system of our invention in greater detail, referring from time to time to the drawings in which:

FIG. 1 is a schematic illustration of a bridge remote control system embodying the features of our invention, using a conventional block diagram for the system elements and control and indication function flow lines.

FIGS. 2A, 2B, and 2C, when taken together but in no particular pattern, provide a diagrammatic showing of the apparatus and circuits at the remote control location, including the route safety circuits, of a system conventionally shown in FIG. 1 embodying the features of our invention.

FIG. 3 is a diagrammatic illustration of specific apparatus and circuits usable in the basic system of FIG. 1 to detect the approach of a ship toward the bridge and the passage of a ship under the bridge span, and to signal the ship as to bridge movements.

FIGS. 4A and 4B, when placed adjacent with FIG. 4A to the left, provide a diagrammatic showing of the specific apparatus and local circuits at the bridge location for the remote control of bridge operation and the railroad traffic control system, and the manual control apparatus for alternate local control of these arrangements.

In each of the drawings, similar reference characters designate the same or similar parts of the apparatus or circuit arrangement. In the circuit diagrams, the relays are shown by conventional symbols and the contacts operated by each relay are normally shown in line above or below the symbol for the relay winding. For neutral relay contacts, the movable portion, which is shown in a generally horizontal plane, moves up to close against front contacts when the relay winding is energized and releases and moves to a lower position to close against back contacts when the relay winding is deenergized. Where the relays are of a polar type having not only neutral contacts but also polar contacts, the movable portion of each polar contact is shown in a generally vertical plane and moves to the left to close normal contacts when the relay is energized with normal polarity and moves to the right to close reverse contacts when the relay winding is energized with a reverse or opposite polarity. However, for convenience, the contacts of some relays are shown on other figures of the drawings, different from that in which the relay winding is shown. Where such contacts are remotely shown, they are referenced by the reference character designating the relay winding, as well as the individual reference for the contact itself. These latter references consist of lower case letters which are unique within the set of contacts operated by any one relay. Said in other words, where a relay contact is shown other than in a vertical line above or below the operating winding for that contact, it is referenced by the same character designating the relay winding plus a lower case letter distinctive to designate that contact alone among its associated relay contacts.

DETAILED DESCRIPTION

We shall refer first to FIG. 1 of the drawings for an overall description of the system embodying our invention. A stretch of railroad track is shown across the top of the drawing figure, using a conventional two-line symbol. Traffic, that is, trains, may move in either direction along this stretch of track. The track also crosses a bridge which spans a waterway channel designated by the two generally parallel irregular lines near the center of the top of the drawing. This bridge is shown by a conventional symbol and is divided into three portions, the center portion being a lift span which may be raised to clear the waterway for ship movement. As previously noted, other types of movable bridges may be also controlled by our system and such are included in the scope of the disclosed arrangement. The bridge lift apparatus is designated by a conventional block so titled and connected by a conventional dotted line to the span to indicate its control. This is conventional apparatus comprising motors, lift cables, various circuit controller devices, limit switches, over current detectors, and bridge position detectors, at least to detect the bridge in its up position. Such apparatus is designed for a particular lift bridge and is not in its details a specific part of our invention. Rather the circuit arrangement of our invention is used

to apply raise and lower command signals at the proper times to this bridge lift apparatus, the channels for such signals being designated by conventional flow lines having inputs to the bottom of the conventional block.

The railroad traffic control apparatus includes the signals 3R and 3L which control train moves to the right and left, respectively, across the bridge. These two signals display only a relatively low speed proceed indication in accordance with the speed limits for movement across the bridge. Other signals 6R and 4L control the train movements away from the bridge although no controls are shown for these two signals as they are not a specific part of our invention. These signals are shown for reference because the indications displayed thereby enter into the control of the proceed indications on signals 3R and 3L, as will be seen later. Each opposite pair of signals is located at a set of insulated rail joints, shown conventionally, which insulate the bridge rail section 2T from the remainder of the track stretch. Section 2T is provided with a track circuit shown as a d.c. neutral type having a track battery 2TB at the left, connected across the rails, and a track relay 2TR connected across the rails at the right, which connections are shown partly in a conventional dotted manner and will be explained later. This track circuit shown conventionally in FIG. 1 basically detects the occupancy of section 2T by the release of relay 2TR when a train occupies this section. Also included in the traffic control system are two derails 2W and 2AW, located to the left and to the right of the bridge, respectively. Each of these derails is shown as an open rail type which is driven to a closed position by a switch machine in the manner of the control of switch points. The switch machines are indicated by conventional blocks since any type known in the art may be used. The normal position of these derails is with the rail open, that is, in the derailing condition. When the derail machines are controlled to a reverse position, the open rail points are closed to allow the passage of a train. The wayside control circuits for the signals and derails are shown by a conventional block at the upper right.

Although the final safety checks with regard to the derail positions and the track section occupancy are performed by the field apparatus in a conventional manner, the control of the signals and derails is initiated, if other safety checks permit, when commands are received from a remote control location. In other words, signal controls are received from the remote location, at which are located the route controls and automatic sequencing and safety logic circuitry. The function flow lines to the bottom of the convention block designating the derail and signal controls designate not only the channels for the reception of control functions but also the corresponding channels for returning indications of the derail and signal positions to the remote control location.

Another safety check in the signal system is the bridge rail locks designated by the conventional blocks 1-2Z and 3-4Z, one set at each end of the lift span. These rail locks lock the rails in their fully seated position when the bridge span is down. In this particular description, the symbols for convenience also designate circuit controllers which check the bridge span fully down and seated and the rails properly seated in the fittings. Thus a normal or N indication returned by the devices 1-2Z and 3-4Z designatess that the bridge span is fully down and seated, that the bridge span rails are properly seated in the rail fittings, and finally that the rail locks are in or locked to hold the rails for train movement. Such apparatus is conventional in the control and safe operation of movable bridges and whatever further explanation is needed for an understanding will be provided when the details of the apparatus are described in connection with FIGS. 4A and 4B. In FIG. 1, the conventional dotted line which symbolizes the control and indication function flow to and from these bridge rail locks and from the bridge lift apparatus results in a combined indication to the remote location designated as the indication UDK, that is, the up-down indication. In the actual detailed circuits, separate indications are provided for the raised and the lowered positions of the bridge and rails.

The apparatus described this far is associated directly with the bridge or the track. Our invention also adds ship detection apparatus shown within the bridge tower block at the lower left of FIG. 1. This tower or housing is located on the bridge, usually on one of the fixed portions thereof. Part of the detection apparatus, for obvious reasons, is mounted on the outside of the housing on the bridge or on the piers along the waterway bank. Ships approaching from either direction are required to sound a three-blast whistle request for passage under the lifted bridge, in other words, to signal a raised bridge request. The bridge apparatus, that is, the horn transmitter, answers with a three-blast signal if the bridge will lift and a four-blast signal if the bridge will not at that moment be raised. The whistles blasts from the ship are detected by up and down stream receivers USWR and DSWR, one for each direction of approach. These receiver units drive detection apparatus which counts the blasts and detects the direction of ship approach. As will be more fully described, all the blasts in a particular sequence must be received from the same direction or the apparatus will lock out the count. It is also designed to lock out extraneous noise and single sounds which may be received and trigger the receivers. The detection apparatus includes and activates a timer which drives the horn transmitter to answer. The answer normally comprises a safety signal of four horn blasts, indicating that the bridge will not lift, unless action is taken to initiate the raising of the bridge span in response to the ship request. If such action is taken and recorded at the bridge tower, the fourth horn blast is inhibited, as indicated in FIG. 1 by one of the command flow channels, so that a three-blast signal is given indicating to the ship that the bridge will raise and the passage will be clear. The horn is also activated when the bridge is automatically lowered to line up a traffic route for a train or merely to restore the bridge to its normal down position.

Our invention also adds detection means for determining when ships are under the bridge span in the waterway. Such detection is needed to prevent the inadvertent lowering of the bridge span upon a ship passing underneath. These detection means are shown conventionally as being light beams, each with a separate source, the upstream beam having a light receiving unit USLR and the downstream beam a

receiver DSLR. Any type of such visual detectors may be used and as specifically shown may provide an ordinary light beam or an infrared beam across the waterway with or without modulation for additional safety. Interruption of either beam registers the ship passage or, in other words, the occupancy of the underbridge space. The details of such detection and the reset means will be described later. An underbridge indication UBK is conventionally shown by dotted lines as being provided to the automatic sequencing apparatus at the remote location for a safety check.

The bridge tower location also has a set of manual controls for use in an emergency or as standby controls in the event that the remote control system is out of service. These manual controls are effective when a master relay MR, not shown in this figure, is energized to close its front contacts. Typical contacts of this relay to control the various bridge circuits are shown within the bridge tower block. These contacts, when relay MR is energized by a bridge tender placed on duty there, interrupt the circuits for controlling the bridge from a remote control location and connect these circuits to the various manual controls within the tower. Such manual controls and their emergency connections are shown in greater detail in FIGS. 4A,B.

The remaining apparatus and circuits shown in FIG. 1 are at the remote control location which may be in a nearby interlocking control tower or at a remote dispatcher's office. The remote control location is connected to the local control apparatus at the bridge by a communication system over which the remote control functions, both controls and indications, are transmitted. This communication system is designated by a conventional block so labeled as the details thereof are not part of the invention but are merely needed to complete the transmission between the two locations. As will become apparent, this communication system may be a direct-wire remote control arrangement or may be some form of a coded remote control system such as are well known in the railway signaling art. As such, it is used to transmit control or indication functions between the control location and the field or bridge station location. There may also be other remote station locations, part of the railroad traffic control system, which are connected by the same communication system to the single remote control office location.

The remote control location or control office, as they are frequently called, has at least a control panel with control devices related to bridge operation and traffic control of train movements across the bridge. There are also provided associated route and safety logic circuits which include the automatic sequencing arrangement for the bridge operation. As previously noted, some automatic sequencing control is exercised by the bridge lift apparatus at the bridge itself as it withdraws or relocks the rail locks as the bridge is raised or lowered, respectively, and directs the start, run, and stop actions of the lift motors in both directions of span movement, in order to assure that the actual raising and lowering of the bridge is conducted in a prefixed sequence.

As part of the control panel, there is mounted thereon a Ship Request indication and an associated Inquiry pushbutton. In this block or schematic showing, the indication means is shown conventionally as being an indication light but audio indications may also be used, as will appear later. The Inquiry pushbutton and others used in the arrangement are of the non-stick type, that is, contacts are closed or opened only while the actuating pressure is applied to the pushbutton. In this schematic FIG. 1 showing, all of the pushbuttons are of the push type but push and/or pull buttons may be used as actually shown in the various parts of FIG. 2. On the control panel also is a traffic control lever shown as being movable to establish traffic to the left or right across the span. This lever arrangement is shown by contacts only for convenience in this schematic illustration as the actual specific circuitry shown in FIG. 2 uses an entrance and exit type arrangement with pushbuttons for each location. Here the lever has a normal center position and, when positioned to establish a traffic direction, the corresponding contact shown within the circles is closed. The lowest illustrated contact is closed when the traffic lever is moved in either direction from its center position. The final elements in the control panel, as here shown, are a Bridge Restore and a Test pushbutton, to be described later.

We shall now briefly describe the general operation of our system based on the schematic showing of FIG. 1 but with control exercised only from the remote control location. In other words, it is assumed that relay MR remains released so that its back contacts are closed to establish control and indication function channels from the control office only. When a ship approaches the bridge, it requests the lifting of the bridge by sounding three blasts of its ship's whistle. These signals are detected and validated by the detection means at the bridge tower and a ship request indication transmitted to the control office to cause the lighting of the Ship Request lamp. The detection apparatus also actuates the transmission of answering blasts from the horn transmitter on the bridge. If there is no response by the system control operator, this horn control arrangement provides for the sounding of four horn signals to indicate that the bridge will not immediately lift for the ship's passage, thus warning the ship to halt its approach.

However, if there are no immediate plans for a train movement across the bridge and none is already in progress, the remote control operator will actuate his Inquiry pushbutton in response to the reception of the ship request. Closing of the contact of this pushbutton actuates various safety checks within the route selection and safety logic circuitry to assure that there are no trains on the bridge, that is, track relay 2TR is picked up, that no railroad signals are cleared, and that the derails are in the normal, open position. If all of the safety checks prove satisfactory, a control function to raise the bridge is transmitted to the remote or bridge tower location and is applied to the bridge lift apparatus to initiate such operation. This command function also is used as an inhibit signal to stop the horn transmitter after it has sounded three blasts. Thus, in this case, the answering signal to the ship indicates that the bridge is to be raised to clear the waterway passage. The bridge lift apparatus, in sequence, actuates the unlock of the rail locks Z and then initiates the raising of the lift span in a preset fashion. Thus the actuating of the Inquiry pushbutton by the remote operator, in response to the reception of a ship request indication,

initiates the automatic sequencing operation within the safety logic circuitry and subsequently in the bridge lift apparatus circuitry. This automatic sequencing operation checks the existence of safe conditions for lifting the bridge span and then transmits the command and sequences the lift operation of the bridge. It also initiates the transmission of a signal to the ship that the bridge will raise or allows the no raise signal to continue if safety conditions prohibit the clearing of the waterway passage.

As a ship passes under a raised span, the underbridge detectors, that is, the light beams, detect its passage and provide the transmission of such an indication to the remote location. As will be more fully explained later, both detector beams must be interrupted before a reset will occur as the ship clears the space under the bridge span. After the passage of the ship, the bridge span is lowered automatically if a traffic route for a train is requested by the operator. The operation of the traffic lever to a right or left position, to close the lowermost contact shown, actuates the automatic sequencing action in the safety logic circuitry. The clearance of the underbridge space is checked, that is, the indication UBK must show clearance of the ship. The safety logic circuits also check that no ship is approaching, that is, no request approach signal has been recorded. If all the safety checks prove satisfactory, a bridge lower command is transmitted from the remote office location to the bridge lift apparatus and this latter apparatus initiates the controls for the lowering of the span. When the span is properly lowered and seated on its blocks, the sequencing apparatus drives home the rail locks Z to assure that a train passage can be safely conducted. Following this bridge lowering sequence and the relocking of the rail locks, the route selection circuits at the remote location then actuate the closing of the derails and the clearing of the desired wayside signal. The wayside signal can be cleared only when the track section 2T is reported clear and the derails have been reversed, that is, have been placed in their closed position. The safety logic circuits in this action will also check that the rail locks and the bridge span position are proper for train movement. Other route checks involving opposite moves and the clearing of the departing signals in a conventional manner are also accomplished.

If the system operator desires to lower the bridge span after the passage of a ship but does not wish to establish a traffic route for a train, he operates the Bridge Restore pushbutton only. The safety logic circuitry checks the various conditions, especially the underbridge indication UBK and the lack of any recorded ship request signal. The automatic sequencing then transmits a command function to the bridge apparatus to lower the bridge span if all safety conditions are satisfactory. The horn apparatus is activated any time the bridge span is lowered under this condition, or under the condition of lining a traffic route, to cause the horn transmitter to sound four blasts to warn any approaching ship or others in the area who should be alerted regarding the lowering of the span. The system operator also is provided with individual controls for the derails, the rail locks, and the bridge span itself for test purposes. However, in order to actuate and transmit such individual commands, he must hold the Test pushbutton actuated to complete the circuits for the particular individual control function which he desires to transmit. The safety logic circuitry still checks that safety conditions exist before any of the individual actions can be transmitted. A bridge tower operator, if on duty, has local control of all elements of the bridge system, that is, the derails, the bridge span itself, and the signals and traffic routes, but must have first energized relay MR to shift the control circuits to his local manual control devices and to interrupt controls from the remote location.

We shall now describe in greater detail the various apparatus and circuit elements as shown in the remainder of the drawings and the operation thereof as they embody the details of our invention. For convenience, it is assumed that the communication system shown by the conventional block in FIG. 1 comprises a direct-wire control system although the direct connections between the various parts of the drawings are not shown. The field and control office ends of each of the control wires are shown only by terminals designated A at the office and B in the field with the same numerical prefix. For example, terminal 6A, shown in the upper left of FIG. 2A associated with the underbridge indication relay UBK, is connected by a direct wire with the similar terminal 6B shown in the lower center of FIG. 3.

Each location is provided with a source of direct current energy for operating the relays and similar apparatus. Since any one of several well-known types of such sources may be used, a specific source is not shown. However, the connections to the positive and negative terminals of the source at the field locations are designated by the references LB and LN, respectively. A specific connection to terminal LN from an intervening terminal LNA in FIG. 3 will be discussed in connection with that drawing. The equivalent connections to the source terminals at the control office location are designated by the references MB and MN, respectively. At one point, the office also has a terminal FMB which is a periodically interrupted connection to the positive terminal MB of the source for a flashing light indication. Because of the assumption that a direct-wire remote control system is used as a communication system in the detailed arrangement, the negative terminals MN and LN at the office and field, respectively, must be connected to provide an energy return connection for all of the described circuits. This specific connection is not shown but is herein designated. Although, for convenience, only a single supply source at each location is discussed and shown, it will be understood that different voltage levels may be required for different types of apparatus and furnished in any conventional manner. It will be further understood that, in some arrangements, an alternating current supply for lamps, timing motors, and equivalent apparatus may be necessary and will be furnished as required. The use of such different voltage levels and different types of sources, if required, is included in the scope of our disclosure.

We shall describe first the ship detection apparatus, both for detecting the approach of ships and the passage of ships under the bridge, as shown in FIG. 3. In the upper left of this drawing figure are shown the two ship whistle receivers which are the same as that shown in FIG. 1 except two individual units, one for

each direction of approach, are indicated. Receiver USWR receives whistle blasts from ships approaching from upstream while its opposite unit, receiver DSWR, receives the whistle signals from ships approaching from downstream. These are highly directional receivers and, as indicated, also include filter apparatus and amplifier circuit elements. Each receiver controls a blast repeater relay designated by the references USBP for the upstream receiver and DSBP for the downstream receiver. Each repeater relay is energized and picks up its contacts when each whistle blast is received by the corresponding receiver, the relays releasing between the separate whistle blasts of a particular series of request signals. Each direction of ship traffic also has a lock relay M, specifically the upstream lock relay USM and the downstream lock relay DSM. Each lock relay picks up and holds up, by a stick circuit, upon reception of the first whistle blast from the corresponding direction. There is also a joint blast lock repeater relay BLP which picks up on the reception of each blast if the consecutive whistle blasts are received from the same direction of traffic. The received whistle blast signals are further counted by a counting chain apparatus including the sequence start relay SST, the counting relays 1, 2, 3, 4, 5 and 6, and a three-blast relay 3B.

It will be noted that one terminal of the relay winding of lock relays M, relay SST, and the counting relays is connected to a source terminal LNA rather than directly to the negative terminal LN of the direct current source. Terminal LNA is connected to negative terminal LN over back contact *a* of a cutout relay CO and back contact *b* of relay 3B. Relay CO is a timing relay, for example, of the thermal type having a fixed operating period, and is energized over a multiple path arrangement including front contacts *c*, in multiple, of relays USM, DSM, and SST. When any one of these front contacts is closed, the winding of relay CO is connected between terminals LB and LN of the local direct current source. This relay has a fixed timing period which must expire subsequent to the energization of the relay winding before it operates to open its single back contact *a*. Thus the connection between terminal LNA and negative terminal LN is interrupted at the end of the timing period of relay CO when it opens its back contact *a*, or when relay 3B is energized at the end of a counting cycle and opens its back contact *b*. Each of the relays which has one side of its winding connected to terminal LNA is therefore deenergized either when relay 3B picks up or when relay CO picks up at the end of its timing period, if this latter action occurs first due to an incomplete count.

The operation of this whistle reception apparatus will now be described with the assumption that a ship is approaching from upstream so that receiver USWR receives and responds to the whistle signal request from that ship. Each time a whistle blast is received from the ship, relay USBP picks up. Assuming that the usual bridge request signal is received consisting of three blasts, this relay thus will pick up and release three times during the sequence. The initial pickup of relay USBP to close its front contact *a* completes the energizing circuit for relay USM, this circuit extending from terminal LB over back contact *a* of relay DSM, back contact *b* of relay DSBP, the aforementioned front contact *a* of relay USBP, and the winding of relay USM to terminal LNA, which at this point is directly connected by the previously described series circuit to negative terminal LN of the source. Relay USM, thus energized, picks up to close its front contact *a* and complete a stick circuit, including this front contact *a* and the relay winding, from terminal LB to terminal LNA. When front contact *b* of relay USM closes, it completes a circuit further including front contact *c* of relay USBP and back contact *c* of relay DSBP to energize relay BLP. The closing of front contact *c* of relay USM completes one path in the circuit arrangement for energizing the winding of relay CO which thus starts its timing period at this point. The opening of back contact *a* of relay USM further interrupts the energizing circuit for relay DSM, which circuit further includes front contact *a* of relay DSBP and back contact *b* of relay USBP. Since relay USM holds energized at least during the timing period of relay CO, it thus effectively locks out any response by relay DSM due to the subsequent reception of a whistle sound or other noise by receiver DSWR during this operation. Relay BLP, with front contact *b* of relay DSM remaining open, thus responds only to the operation of contact *c* of relay USBP. In other words, relay BLP picks up each time that a whistle signal is received by receiver USWR and relay USBP picks up. Conversely, when the whistle signal ends and relay USBP releases, relay BLP likewise releases.

When relay BLP picks up, the closing of its front contact *a* completes the circuit, further including back contact *b* of relay SST, for energizing counting relay 1. This latter relay picks up and the closing of its front contact *c* completes the circuit, also including front contact *a* of relay BLP, through the winding of relay SST which, thus energized, picks up. Relay SST closes its front contact *a* to complete a stick circuit further including back contact *c* of counting relay 6. The shifting of contact *b* of relay SST from its back to its front position shifts the energization of counting relay 1 to a stick circuit including front contact *a* of relay 1, back contact *b* of relay 2, and the aforementioned front contact *b* of relay SST, this circuit originating at terminal LB at front contact *a* of relay BLP. When relay BLP releases at the end of the whistle blast from the ship, the closing of its back contact *a* completes a circuit for energizing counting relay 2, this circuit further including back contact *a* of relay 6 and front contact *b* of relay 1. This latter front contact remains closed for a sufficient period to energize relay 2 since a diode is connected to the common bus connection, over which energy is provided for the stick circuit of the odd-numbered counting relays, to slow the release of relay 1 sufficiently to allow the energization of the subsequent counting relay. This is necessary since the opening of front contact *a* of relay BLP interrupts the stick circuit for relay 1 and at the end of this short slow release period relay 1 releases. However, the closing of front contact *a* of relay 2 has completed a stick circuit which includes back contact *b* of relay 3 and back contact *a* of relay BLP. Another diode is connected to the common connection for the stick circuits for the even-numbered counting relays so as to slightly retard the release of each of these relays when its stick circuit is interrupted.

When relay BLP picks up at the beginning of the second whistle signal from the ship, a circuit is completed from terminal LB over front contact *a* of relay BLP, front contact *b* of relay SST, back contact *a* of relay 1, and front contact *b* of relay 2 to the winding of relay 3, and thence to terminal LNA so that relay 3 is energized and picks up. This counting action continues as this second and the subsequent third whistle signal from the ship are received. It will be noted that each odd-numbered counting relay picks up at the beginning of the reception of the corresponding whistle signal and the next even-numbered counting relay picks up at the end of that corresponding whistle signal. At the end of the third whistle blast from the ship, relay 6 picks up, the circuit including back contact *a* of relay BLP, back contact *a* of relay 4, and front contact *b* of relay 5. The closing of front contact *c* of relay 6 completes a direct and simple circuit for energizing relay 3B which thus picks up. Relay 3B closes its front contact *a* and completes a stick circuit for itself which further includes the normally closed contact 5 of a sequence timer which will be discussed shortly. The opening of back contact *b* of relay 3B interrupts the series circuit between terminal LNA and negative terminal LN so that stick energized relays connected to terminal LNA, in this specific case relays USM, SST, and 6, are thus deenergized and release at this time.

It should be noted that unless three consecutive whistle blasts are received from the same ship so that the counting chain completes its action and relay 6 picks up, relay 3B will not be energized and pick up to indicate the reception of a request from a ship for raising the bridge span. In the event that a faulty signal, e.g., from both directions, or an incomplete signal due to extraneous noises is received, relay CO will eventually complete its timing period and pick up so that the opening of its back contact *a* interrupts the connection between terminals LNA and LN. The energized lock relay M, relay SST, and any energized counting chain relays will then release to restore the counting apparatus to its normal at-rest condition. The timing period for relay CO thus must be at least longer than the time normally required to complete the counting chain action in response to the reception of three standard whistle signals from an approaching ship.

In the specific case here discussed, with relay USM picked up, the picking up of relay 3B completes a circuit for transmitting a ship request indication to the control office, the circuit extending from terminal LB over front contact *d* of relay USM and front contact *c* of relay 3B to communication channel field terminal 14B. If relay DSM had been picked up due to the ship approaching from the downstream side, an indication circuit is completed, including front contacts *d* of relays DSM and 3B, to terminal 15B of the communication system. Briefly referring to FIG. 2A, at the right, it will be noted that approach lock indication relays USAK and DSAK are connected, respectively, to terminals 14A and 15A, which are the office terminals corresponding to those cited in FIG. 3. Thus one or the other of these relays is picked up to indicate the approach of a ship requesting the raising of the bridge. It will be subsequently described that each of these relays at the office is provided with a stick circuit to hold the indication since the indication circuits at the field location are shortly interrupted by the release of either relay USM or relay DSM at the completion of the counting action. A similar indication is transmitted over front contact *e* of relay 3B and field terminal 9B to terminal 9A at the office, shown at left in FIG. 2A, where a repeater relay 3BP is energized. The transmission of this indication continues beyond that of the lock relay indication since relay 3B is held energized for a period following the counting action by its stick circuit. The use of these indications at the office will be discussed later in the description.

When relay 3B picks up, the closing of its front contact *f* completes a circuit for energizing the motor M of a sequence timer shown by a conventional dot-dash rectangle. This sequence timer is shown only conventionally since any device which will provide the subsequently described operation may be used and it need not necessarily be a motor driven device as assumed here. When motor M of this sequence timer is energized, it starts a cycle of operation in which the normally open contacts 1, 2, 3, and 4, shown within the block are closed in sequence, each for a preselected period of time. Following the closing sequence of these four contacts, each of which opens before the next contact is closed, the normally closed contact 5 will then be opened to complete the cycle of operation. It will be noted that the opening of contact 5 interrupts the stick circuit for relay 3B which immediately releases, opening its front contact *f* to deenergize the motor of the sequence timer.

Immediately below the sequence timer is a conventional block designated as the bridge horn transmitter which has attached thereto a double symbol representing apparatus faced in each direction to transmit horn signals from the bridge location to an approaching ship. The bridge horn transmitter is so designed that when a circuit path is completed between the two input terminals designated as the activate circuit, the transmitter responds to transmit a horn signal toward the approaching ship. Although not specifically shown, it will be understood that energy for this operation will be applied to the horn transmitter unit from a suitable source of energy, either the local d.c. source or other type as may be required. It will be noted that, under normal conditions, the closing of each of the contacts 1, 2, 3, and 4 of the sequence timer completes a circuit path across the activate circuit terminals of the bridge horn transmitter so that a series of four horn signals are normally transmitted during the operation of the sequence timer. However, if a check repeater relay CKP is activated over the communication system in response to the operation of the inquiry pushbutton at the office, the opening of back contact *a* of relay CKP interrupts the circuit otherwise completed by contact 4 of the sequence timer so that the transmission of the fourth horn blast is inhibited under these conditions. As previously explained, the fourth blast signal returned to the approaching ship indicates that the bridge span will not lift. However, if the remote control operator has taken action to initiate the raising of the bridge span, the opening of back contact *a* of relay CKP in response to this action inhibits the fourth horn signal and the resulting three-blast signal to the ship indicates that the bridge span will raise and allow passage of the ship along the waterway. It will be noted that if a local

bridge tender has actuated local controls so that master relay MR is picked up to open its back contact *b*, all activation of the bridge horn transmitter is inhibited from the sequence timer circuit arrangement. Since under these conditions all movements of the bridge, both for waterway and railroad traffic, are under local control, the automatic operation of the horn transmitter is not desirable and is thus interrupted. Also shown in FIG. 3 above the sequence timer is a siren device which is energized and becomes active upon the closing of front contact *a* of a siren relay SIRB. This relay is controlled from the remote location, when various test operations are to be conducted, to warn personnel working in the area that the bridge apparatus or associated safety equipment may be operated and to exercise due caution.

We shall now describe the apparatus used for detecting the passage of a ship under the bridge itself and its operation. At the lower left of the drawing there are shown in a conventional manner two separate light beam sources energized by a suitable source of energy. On the opposite bank of the waterway, illustrated by irregular lines, are located the light receivers USLR and DSLR which are the same as those shown in FIG. 1. The specific type of light beam detecting units is a matter of choice for each installation and, as previously mentioned, may be ordinary light, infrared light, or another selection. Further, if desired, a modulated beam may be used for additional fail-safe protection. It is assumed here that as long as the light beam, whether it be steady or modulated, is received from the associated source by a particular light receiver, the circuit is completed through the receiver unit from terminal LB of the source to the output lead. Thus the light receiver repeater relays USP and DSP are normally energized over their stick circuits, each of which extends from the corresponding receiver output over front contact *a* of the corresponding relay and, in common, over the remote control system circuit connected between field terminals 7B and 8B to terminal LN. This circuit path between terminals 7B and 8B, shown dotted, is normally complete and may be found in FIG. 2A to include, between corresponding office terminals 7A and 8A, a normally closed contact of the Restore pushbutton which is opened only when this particular pushbutton is pulled. This Restore pushbutton is the same as the Bridge Restore device shown in FIG. 1 as part of the remote control panel, but the normally closed contact is not there shown. This connection is used for reset of the underbridge detection apparatus if one of the light beams only is inadvertently interrupted, such as by a beam failure or even by a bird flying through the light beam. Pulling of the Restore pushbutton obviously opens this circuit connection and will cause the release of each of the relays USP and DSP, which actuates the reset operation in a manner which will be shortly understood.

Relay USP has a pickup circuit which may be traced from the output of the corresponding light receiver USLR over front contact *b* of a stream repeater relay SP, through the winding of relay USP, and thence to terminal LN by the circuit connections between terminals 7B and 8B of the communication system. A similar circuit for relay DSP includes the output connection from light receiver DSLR and front contact *c* of relay SP. Thus, once released, relays USP and DSP can only be reenergized when stream repeater relay SP has been energized and has picked up. The pickup circuit for relay SP includes, in series, back contacts *b* of relays DSP and USP. The stick circuit for relay SP includes its own front contact *a* and, in multiple, back contacts *c* of relays DSP and USP. Also included in the arrangement is an underbridge relay UB which is normally held energized as long as the waterway is clear by a stick circuit traced from terminal LB over front contacts *d*, in series, of relays DSP and USP, back contact *d* of relay SP, and the winding and front contact *a* of relay UB to terminal LN. The pickup circuit for relay UB is the same as that just traced except for including a timing front contact *a* of the underbridge time element relay UBTE in place of front contact *a* of relay UB. Relay UBTE is a timing relay which, subsequent to the energization of the relay winding, requires the passage of a predetermined time period before it operates to close its front contacts, such as the previously mentioned contact *a*. This time element relay and others which are used elsewhere in the apparatus of our invention also include checking back contacts, such as contact *b* of relay UBTE, which are designated specifically by the small circle superimposed on the connection to the back contact point itself. Such contacts are immediately opened when the relay winding is energized to indicate that the timing period is under way but that the front timing contacts have not yet been closed. Such back contacts do not reclose until the relay winding is deenergized and all contacts release. Relay UBTE has an energizing circuit which includes front contacts *d* of relays DSP and USP, back contact *d* of relay SP, back contact *b* of relay UB, and the winding of relay UBTE.

In describing the operation of this underbridge detection apparatus, it is assumed that the bridge has been raised for a ship moving downstream and that, as the ship moves under the bridge, it first interrupts the upstream light beam and subsequently the downstream light beam. Thus relay USP and then relay DSP release in that order. When these relays have released, relay SP is energized and picks up to close its front contact *a*. This completes its stick circuit which remains effective as long as either relay DSP or USP is released to close its back contact *c*. The closing of front contacts *b* and *c* of relay SP prepares the energizing circuits for the two light receiver repeater relays but since both light beams are presently interrupted neither relay becomes energized. Relay UB releases when the first receiver repeater relay, in this case relay USP, releases to open its front contact *d* and thus interrupt the stick circuit for relay UB. The opening of front contact *c* of relay UB interrupts the indication circuit by which energy is normally transmitted to the control office, the circuit further including checking back contact *b* of timing relay UBTE and normally applying energy from terminal LB to the communication system terminal 6B. Referring to FIG. 2A, at the top of the figure, the corresponding communication system terminal 6A is shown connected to the winding of the underbridge indication relay UBK. This relay thus is normally energized and, when a light beam is interrupted, becomes deenergized and releases.

Relays USP and DSP are energized and pick up in that order as the ship clears the corresponding light

beams. Relay SP remains energized until both beam repeater relays have picked up to open their back contacts *c*. Upon the release of relay SP to close its back contact *d*, timing relay UBTE becomes energized since back contact *b* of relay UB is also closed. At the end of the timing period, relay UBTE picks up to close its timing front contact *a* and thus complete the energizing circuit for relay UB which immediately picks up and completes its stick circuit at its own front contact *a*. The opening of back contact *b* of relay UB deenergizes relay UBTE which shortly releases. Upon the closing of checking back contact *b* of this latter relay, the indication circuit is again complete and energy is supplied to terminal 6B and thus causes relay UBK at the control office to again pick up to show a clear or unoccupied indication for the waterway space under the bridge. Relay UBTE thus enforces a time delay period subsequent to the passage of the ship before an underbridge clear indication is transmitted to the control office. This also prevents momentary reflections which might be received by the light receivers from causing a false indication of a clear waterway prior to the actual clearance of a ship. This safety measure is further enforced by including the check back contact *b* of relay UBTE in the indication circuit since this contact is immediately opened at any time that the time element relay winding is energized. It will be noted that if a single beam is inadvertently interrupted so that the corresponding receiver repeater relay releases, it will be necessary for the remote control operator to interrupt the circuit between terminals 7B and 8B by pulling the Restore pushbutton at the office in order to release the other receiver repeater relay. A reset to the normal condition will then occur as above described with relay UBTE enforcing a timing period prior to the restoration of a clear indication.

Reference is now made to the apparatus at the remote control or office location as shown in FIGS. 2A, 2B, and 2C. It is to be noted that no special arrangement of these three drawing figures is necessary, that is, there are no interconnecting lines between the various figures. However, some contacts of relays illustrated on one figure appear on another figure and are designated by references in the manner previously described. Beginning with FIG. 2A, the system operator at this remote control or office location has available on the operating or control panel various pushbutton devices, shown at the left of FIG. 2A, such as the Emergency Stop pushbutton, the Restore pushbutton, an Inquiry pushbutton, and the Test pushbutton. In addition, a Siren pushbutton is provided, as shown at the right of FIG. 2A. The equivalent representations of the Restore, Inquiry, and Test pushbuttons were shown, of course, in FIG. 1 in the very schematic illustration of the bridge control system. These pushbuttons, shown in FIG. 2A, are mounted on a control panel but are distinct from any track diagram representing the railroad traffic or signal control system, and are also separated from the associated traffic control pushbuttons for the control of train movements, as shown in FIG. 2B. As previously mentioned, each of these pushbuttons is of a non-stick type and, in some instances, are actually push-pull buttons but their actual contact arrangement will be described as each individual device is discussed.

Also available for the system operator are various direct control levers, such as the bridge lever shown in the upper right of FIG. 2A, and the derail and rail lock control levers shown in FIG. 2C. Contacts of these levers are shown by small circles, each including a letter designation indicating the lever position in which the particular contact is closed. For example, the bridge lever in the upper right of FIG. 2A normally occupies its center position and the contacts designated by the reference C, shown in line below the lever, will be closed in that position. The position to the left, designated by the reference L, actuates a lowering of the bridge span and a contact indicated by the letter L is closed when the lever is placed in that position. Conversely, the right-hand position, designated by the reference R, actuates the raising of the bridge span and the contact designated by a similar letter is closed when the lever occupies that position. Similar explanations pertain to the contacts of the derail (WL) and rail lock (ZL) levers shown in FIG. 2C. However, for the derail control levers, where two letters are shown within a contact symbol without a dividing line, that particular contact is closed with the lever in either of those positions and during the movement of the lever between such positions. For example, the second contact down for derail lever 2AWL is designated as a CN contact and will thus be closed when the lever occupies its usual center position C and when it is moved to the derail normal position N to the left.

Associated with the pushbuttons are certain similarly designated relays. For example, there is an emergency stop relay ES, a restore relay RES, an inquiry relay INQ, and a test relay TST, as well as a second siren relay SIRA. FIG. 2A also includes the restore lock relay RESM, a check relay CK, and various indication relays, such as the bridge-up indication relay UK, the underbridge detection indication relay UBK, the bridge-down indication relay DK, and the ship-approach indication relays USAK and DSAK. Associated with these latter two relays are an upstream approach light US, a downstream approach light DS, and a ship-approach buzzer indication device. Also shown in FIG. 2A is an improper lineup relay IMLU and an associated underbridge warning bell.

Considering the emergency stop relay ES, it is noted that it is normally held energized by a stick circuit including its own front contact *a* and winding and a normally closed contact *b* of the Emergency Stop pushbutton. This pushbutton is actually a push-pull device and the normally closed contact *b* is opened when the pushbutton is pushed to interrupt the stick circuit. Relay ES, once deenergized, can be reenergized by the simple circuit including the normally open contact *a* of the Emergency Stop pushbutton which is closed when the pushbutton is pulled. Front contacts of relay ES are used to interrupt various control circuits if an emergency stop condition is necessary. Relay TST is energized when the Test pushbutton is actuated, that is, pushed to close a normally open contact *a* which applies energy direct to the winding of relay TST. This relay is held energized only as long as the pushbutton is actuated and this condition is utilized when the system operator desires to exercise control by any one or more of the direct action levers for the bridge and associated apparatus. The circuit including normally open contact *b* of the Test

pushbutton will be discussed later in connection with system operation.

It will be noted that relay SIRA has a first circuit which energizes the relay when a normally open contact *a* of the Siren pushbutton is closed, that is, the pushbutton is pushed. A second circuit, to be discussed later, receives signals from the field location over communication channel terminal **20A**. When relay SIRA is energized and picks up, the closing of its front contact *a* applies positive energy to the communication channel office terminal **18A**. Referring to FIG. **3**, the corresponding field terminal **18B** is connected to one terminal of the winding of relay SIRB. Since the other terminal of this relay is connected to the common negative terminal of the direct current sources, relay SIRB is also energized when the Siren pushbutton is actuated.

We will now describe the operation of the office apparatus when a ship request for raising the bridge is received at this remote control location. As previously described, this request signal, after reception at the field location, is transmitted and results in the pickup of relay USAK or DSAK. Relay **3BP** is also picked up and is held up as the signal continues from the field location. Assuming that relay USAK picks up in keeping with the previous description of a ship approaching from upstream side, the relay closes its front contact *a* to complete a stick circuit which originates at terminal MB at back contact *a* of relay RES. This upstream approach relay USAK thus remains energized until a bridge restore action is initiated to again lower the bridge span, unless the operation should be initiated improperly while an underbridge indication exists so that relay UBK is released to close its back contact *a* and thus retain the stick circuit for relay USAK. The closing of front contact *b* of relay USAK completes a circuit, further including back contact *b* of relay INQ, front contact *a* of relay **3BP**, and back contact *a* of relay UK, for energizing the ship approach buzzer to actuate an audio warning of the ship approach. The upstream approach lamp US is also energized by the closing of front contact *c* of relay USAK, this circuit initially including back contact *c* of relay INQ and back contact *b* of relay UK. Since back contact *b* of relay UK is connected to the source terminal FMB, the approach lamp initially provides a flashing indication together with the audio warning. If the operator responds to initiate the bridge raise request, the pickup of relay INQ, as will be shortly discussed, interrupts the audio warning by opening the circuit for the buzzer at its back contact *b* and shifts the lamp indication to a steady signal by connecting the circuit to terminal MB at front contact *c* of relay INQ. When relay UK picks up, it also provides a connection over its front contact *b* to terminal MB for a steady indication on the approach lamp after relay INQ eventually releases.

At this time, if the operator can accede to the ship's request and initiate the raising of the bridge span, he actuates the Inquiry pushbutton to close its normally open contact *a*. This energizes relay INQ, the circuit further including back contact *c* of relay UK and front contact *b* of relay ES. Relay INQ picks up, closing its front contact *a* to complete a stick circuit for itself which bypasses the normally open contact of the Inquiry pushbutton which again opens as soon as the operator removes the pressure. It may be noted in passing that this is one of the uses of a front contact of relay ES, since if any emergency arises and the Emergency Stop pushbutton is actuated by pushing it, front contact *b* of relay ES would open to interrupt the energization of relay INQ and thus halt the raising of the bridge.

When relay INQ picks up and closes its front contact *d*, energy is supplied to the winding of check relay CK, this circuit further including back contact *a* of relay TST, front contact *c* of relay ES, back contacts *a* in series of relays **3RASH**, **3LASK**, **2WR**, and **2AWR**, which four relays will be discussed shortly, and front contacts *a* of the derail normal correspondence indication relays **2NWCK** and **2ANWCK**. When relay CK picks up and closes its front contact *a*, the circuit is extended over this front contact and through the C position contacts of levers **2WL**, **2AWL**, **1-2ZL**, **3-4ZL**, and the bridge lever to communication system terminal **10A**, to which energy is thus applied from terminal MB of the direct current source. It is to be noted that this circuit checks, by the various back contacts, that no test condition exists and that an emergency stop situation has not been established. Further the circuit checks, by the back contacts of the ASK relays, that no wayside signal has been cleared; in the back contacts of the WR relays, that no request for moving the derails to a reverse position has been initiated; and, with the front contacts of the NWCK relays, that the derails actually are in their normal position. The C position contacts of the various levers indicate that no manual direct control action has been initiated or taken by the remote control operator. The command transmitted from terminal **10A** to the corresponding terminal **10B**, shown in FIG. **4A**, provides energy over back contact *c* of relay MR and back contact *a* of the bridge-down command relay DN to the bridge-up command relay UP. This latter relay picks up and, by closing its front contact *b*, applies energy to the bridge-lift apparatus to initiate the performance by this apparatus, shown in FIG. **1**, of the raise-bridge sequence. This sequence, as previously described, includes the withdrawing of the rail locks and the controlled raising of the bridge span to a stop at its full-up position.

It may be noted that, when relay CK picks up, it also connects the direct current source, through the closing of its front contacts *b* and *c*, across the communication system terminals **12A** and **13A**. Transmission of this energy signal to the field location and its reception across the corresponding terminals **12B** and **13B** energizes the check repeater relay CKP, shown in FIG. **3**. This relay picks up and opens its back contact *a* to inhibit the transmission of the fourth horn signal to the approaching ship. The resulting three-blast horn signal will thus indicate to the ship that the bridge span is to be raised and that the process has been initiated. When the bridge span, at the end of the lift sequence, reaches its full-up position, it closes a contact **41**, as shown in the top of FIG. **4B**, which causes the transmission of an indication signal over terminals 4 of the communication system to energize the bridge-up indication relay UK at the office. When relay UK picks up, the opening of its back contact *c* interrupts the stick circuit for relay INQ, which releases. However, the opening of back contact *a* of relay UK has further interrupted the energizing circuit for the approach buzzer device but front

contact *b* of relay UK retains the upstream approach lamp US illuminated upon the closing of back contact *c* of relay INQ. Relay 3BP also releases to open its front contact *a* when relay 3B is released by the opening of contact 5 of the Sequence Timer at the bridge location.

The closing of front contact *d* of relay UK prepares a second circuit for relay CK which extends over the second normally open contact *b* of the Test pushbutton, front contact *d* of relay UK, front contact *d* of relay ES, and back contact *d* of relay INQ. If a ship approaches along the waterway with the bridge span already up and transmits a three-blast signal request for passage under the bridge, the remote control operator, upon reception of the indication of the ship request, pushes the Test pushbutton which picks up relay CK, and subsequently relay CKP, to answer the ship with three horn blasts providing the operator intends to allow the bridge to remain up. Under these conditions the Sequence Timer, which drives the bridge horn transmitter, is also actuated over the communication system terminals **16A** and **16B**, energy being supplied from terminal MB over front contacts *b* of relays 2NWCK and 2ANWCK, front contact *d* of relay DSAK or USAK, front contact *d* of relay CK, front contact *e* of relay UK, and back contact *e* of relay INQ. It is to be also noted that if the initial lifting of the bridge span was delayed because of the passage of a train or the already established route for a train, the subsequent operation, when conditions are clear, of the Inquiry pushbutton will still initiate the same lifting operation. Under these conditions the bridge horn operation is also reinitiated through terminals **16** with three blasts only being transmitted due to the energization of relay CKP. Under this condition, energy for the operation of the Sequence Timer at the field is applied to terminal **16A** over front contacts *b* of relays 2NWCK and 2ANWCK, front contact *d* of the energized stream approach relay, and front contact *e* of relay INQ.

A direct restoration operation for lowering the bridge after the ship has cleared will now be described. This description assumes that no train movement is required or desired across the bridge but that the remote control operator wishes to lower the bridge span into its down position. In order to initiate the operation, the remote operator pushes the Restore pushbutton to close its normally open contact *a*. It is to be noted that contact *b* of this pushbutton is not affected by this action since this normally closed contact is opened only when the device is pulled. Relay RES is energized, the circuit including contact *a* of the Restore pushbutton, front contact *e* of relay ES, and front contact *b* of relay UBK. Relay RES picks up and, although this relay has no stick circuit, the closing of its front contact *b* energizes the restore lock relay RESM over a simple circuit. This latter relay picks up to close its front contact *a* and complete a stick circuit further including front contact *f* of relay ES, front contact *c* of relay UBK, and back contact *a* of relay DK, this latter relay being in its released condition since the bridge span is up, that is, not down. It is to be noted that the circuits for both relays RES and RESM check that relay UBK is picked up, that is, that no ship is detected in the space under the bridge, and relay RESM, in its stick circuit, further checks that the bridge is actually up, that is, relay DK is released. It is obvious that, with relay RESM in the arrangement having a stick circuit, the operator need not hold the restore pushbutton actuated for a lengthy period, only sufficient to pick up relays RES and RESM in sequence.

When relay RESM closes its front contact *b*, it transmits a command to the field location to initiate the lowering of the bridge span. This circuit extends from terminal MB at front contact *g* of relay ES, over back contact *b* of relay 3BP, front contact *d* of relay UBK, back contact *e* of relay CK, back contact *b* of relay TST, front contact *b* of relay RESM, center position contacts of the derail control levers 2WL and 2AWL, center position contacts of the rail lock control levers 1-2ZL and 3-4ZL, and a center position contact of the bridge control lever to terminal 11A of the communication system. It is to be noted that this circuit checks the non-operated condition of all of the direct control levers available to the operator, that check relay CK is released, and again that an emergency stop condition does not exist and that no ship is detected under the bridge span. Also, it checks that no three-blast signal request from an approaching ship has been received at the field location. At the field, shown in FIG. 4A, this command is received at the corresponding terminal 11B and, over the circuit including back contact *d* of relay MR and back contact *a* of relay UP, energizes the down-bridge relay DN. This relay picks up and closes its front contact *b* to actuate the bridge lift apparatus to initiate the sequence by which the span is lowered, which sequence terminates with the driving home of the rail locks to their normal locked position.

With relay RESM picked up, a signal is also transmitted over terminals **16A** and **16B**, with energy supplied over front contact *e* of relay UBK and front contact *c* of relay RESM, to actuate the Sequence Timer shown in FIG. **3** to sound four horn blasts to warn any ships and other personnel in the bridge area that the bridge span is about to be lowered. If relay UBK is by any chance released, indicating either that a ship is under the bridge or that the timing period has not yet expired since ship clearance, operation of the Restore pushbutton will energize the improper lineup relay IMLU, the circuit including contact *a* of the Restore pushbutton, a diode D1, back contact *f* of relay UBK, and the winding of relay IMLU. When relay IMLU picks up, its single contact *a*, which is of the continuity-transfer type, or in other words, a make-before-break contact, causes a single pulse of energy to be applied to the underbridge warning bell which sounds a single stroke to indicate to the operator that he is attempting an improper action. Of course, with front contact *b* of relay UBK open, relay RES cannot pick up so that the bridge restore action is not initiated. Under these conditions, the energy for operating the underbridge bell is provided from terminal MB at the Restore pushbutton contact *a*. Other circuit paths for energizing relay IMLU are provided. One set of paths includes, in multiple, front contacts *b* of the traffic control pushbutton stick relays 3RPBS and 3LPBS. A final path for relay IMLU, and for providing energy to the bell, is traced from terminal MB at back contact *c* of relay TST, over the continuity-transfer contacts *a*, in multiple, of relays 2WRLP and 2AWRLP, and thence through diode D1 and back contact *f* of relay UBK to the winding of relay IMLU and terminal MN. If relay UBK is released, its

front contacts interrupt other circuits, particularly its front contacts *d* and *e*, which interrupt the circuits to terminals 11A and 16A, respectively. It is also to be noted that, if relay UBK is released so that its back contact *a* is closed, the stick circuit for whichever stream approach indication relay SAK is energized remains complete. When relay UBK is picked up, the pickup of relay RES to open its back contact *a* interrupts the stick circuit for relay USAK or DSAK and the energized relay immediately releases.

We shall now describe the restoration of the bridge to its down position when a traffic route is to be established across the bridge with the span initially in its up position. This description incidentally will also include the establishment of the traffic route from the office location. Referring to FIG. 2B, there is shown across the top route selection circuitry for the traffic control system. This is assumed to be of the entrance-exit selection type control which means that a circuit controller device such as a pushbutton is actuated to establish an entrance position for a train route, and a similar device is then subsequently actuated to establish the exit point from the route. Two such pushbuttons are provided for traffic control in the track section across the bridge, pushbutton 3LPB corresponding to the location of signal 3L and pushbutton 3RPB corresponding to the location of signal 3R. Each is a non-stick, push-pull type device with a normally open contact *a* closed when the pushbutton is pushed and a normally closed contact *b* which is opened when the pushbutton device is pulled. In the operation of this system, the first pushbutton operated, that is pushed, represents the entrance to the route, and the second pushbutton to be actuated (pushed) designates the exit from the desired traffic route.

It is now assumed that a train is to move to the left across the bridge, specifically for example in the track stretch shown in the top of FIG. 1. It is further assumed that the bridge span is up after the passage of the above-described ship which has now cleared the underbridge area. Obviously, signal 3L will be the controlling signal for this train movement. Having decided or been instructed as to the requirement for this train move, the system operator actuates the associated pushbutton 3LPB, pushing it to close its contact *a* to thus designate the entrance to the selected route. This operation energizes the pushbutton stick relay 3LPBS over a circuit traced from terminal MB over the now closed contact *a* of pushbutton 3LPB, back contact *b* of derail reverse relay 2WR, front contact *a* of the entrance lockout relay ELO, the winding of relay 3LPBS, back contact *a* of master relay indication relay MRK, and, under the present conditions, back contact *b* of relay DK to terminal MN. It will be noted that this energizing circuit checks, by including back contact *b* of relay 2WR and front contact *a* of relay ELO, that no previous route selection has occurred. Further, if a bridge tender operator on duty has selected local control, relay MRK will be picked up as an indication thereof and control by the remote operator of the traffic movements is interrupted. The circuit also checks that either the bridge is up, i.e., relay DK down, or that the track circuit is clear, relay 2TK up. This latter relay is controlled from the field location and generally will be energized and picked up when the track circuit is clear. However, the specific control of this relay from the field location will be discussed later in connection with the detailed discussion of the field circuits.

Energized as described, relay 3LPBS picks up and closes its own front contact *a* to complete a stick circuit which originates at the normally closed contact *b* of pushbutton 3LPB which remains closed unless the operator pulls this device to cancel a route selection. The remainder of the stick circuit includes the previously mentioned path over back contact *a* of relay MRK and either back contact *b* of relay DK or front contact *a* of relay 2TK. Thus when the operator releases the pushbutton so that its contact *a* reopens, the pushbutton stick relay has already completed a stick circuit and remains energized. The opening of back contact *c* of relay 3LPBS interrupts the existing energizing circuit for entrance lockout relay ELO which releases to open, at its front contact *b*, a circuit similar to that just traced provided for the opposite direction stick relay 3RPBS. The closing of front contact *d* of relay 3LPBS completes an energizing circuit for the switch, or in this case, derail reverse relay associated with the nearest derail 2AW. This circuit for relay 2AWR includes the aforementioned front contact *d* of relay 3LPBS, the relay winding, and a common circuit path including back contact *a* of derails normal relay WN, back contact *d* of test relay TST, and, in series, back contacts *a* of various derail lever repeater and position indication relays 2AWNLP, 2AWNWK, 2WNWK, and 2WNLP.

The operator then pushes pushbutton 3RPB to designate the exit location for the selected route, an obvious selection here since only the one exit is available. This action closes contact *a* of pushbutton 3RPB to complete the circuit for energizing exit stick relay 3RXS, which further includes front contact *b* of relay 2AWR, the winding of relay 3RXS, and back contact *a* of the exit relay 4LXS, which is associated with signal 4L and would be energized and picked up if the location of signal 4L had previously been designated and established as the exit of a traffic route. This latter check, of course, prevents establishing opposite direction train movements along the same section of track. It will be noticed that this circuit for relay 3RXS was prepared when relay 2AWR picked up after the selection of the entrance to the desired route. Relay 3RXS picks up to close its front contact *a* and complete a stick circuit further including front contact *c* of relay 2AWR and back contact *a* of relay 4LXS.

The closing of front contact *b* of relay 3RXS completes a circuit for the exit end derail reverse relay 2WR, the circuit in addition to the relay winding further including the common circuit path previously traced for relay 2AWR, beginning at back contact *a* of relay WN. Thus the circuits for the derail reverse control relays commonly check that a test condition does not exist and that no control exists for moving or holding the derails in their normal positions. When relay 2WR picks up to close its front contact *d*, relay ELO is reenergized over the circuit including back contact *b* of relay WN, at this time front contact *d* of relay 2AWR in multiple with back contact *c* of relay 3RPBS, and front contact *d* of relay 2WR. Relay ELO was released by the initial selection of an entrance location to prevent, as previously mentioned, the inadvertent double pickup

of two pushbutton stick relays. The route now having been established, i.e., exit also selected, this relay is reenergized and picks up.

Moving now to the upper left of FIG. 2C, there are shown the derail control levers 2AWL and 2WL and associated control circuitry. The levers, of course, are for use by the remote operator if he desires to test the derail movements. Each is a center position lever having a normal and a reverse position at the extremes of movement to the left and right, respectively. Each lever has associated therewith two lever repeater relays, one for the normal position and one for the reverse position. These are the relays 2AWNLP and 2AWRLP associated with lever 2AWL, and relays 2WNLP and 2WRLP associated with the other lever. These repeater relays, of course, also repeat the requests for normal and reverse positions of the derails from the automatic sequencing or safety logic circuitry which, of course, includes equipment associated with the establishment of rail traffic routes and the other apparatus associated with the raising and lowering of the bridge span in response to requests from ship traffic. In the presently assumed operation for establishing a traffic route to the left, when relays 2WR and 2AWR pick up during the process of selecting a traffic route, circuits are completed for energizing the WRLP relays. The circuit for relay 2AWRLP extends from terminal MB over a contact CN of lever 2AWL, the letters designating that this contact is closed with the lever in its center and normal positions, another contact CR of the lever, closed when the lever is in its center and reverse positions, and thence over front contacts *e*, in series, of relays 2WR and 2AWR, back contact *b* of relay 2AWNLP, and the winding of relay 2AWRLP to terminal MN. Back contact *b* of relay 2AWNLP, of course, checks that no request for a normal positioning of the derail exists. The corresponding circuit for relay 2WRLP includes two contacts (CN and CR) of lever 2WL in series, front contacts *f* of relays 2WR and 2AWR, and back contact *b* of relay 2WNLP.

In FIG. 2A, it is seen that the pickup of relays 2WRLP and 2AWRLP provides momentary energy to relay RES. This circuit extends from back contact *c* of relay TST over the continuity contacts *a* of the lever repeater relays, the contacts being in multiple, front contact *e* of relay ES, and front contact *b* of relay UBK to the winding of relay RES. This circuit provides sufficient energy to momentarily pick up relay RES and the closing of its front contact *b* energizes relay RESM, as previously described. This latter relay closes its front contact *a* to complete its stick circuit previously traced and thus remains picked up when relay RES releases. The closing of front contact *b* of relay RESM completes a circuit for initiating a lowering action of the bridge span, this circuit having been previously traced and extending further over back contact *b* of relay TST and including checks that no ship requests have been received and that the underbridge area is clear. Since the underbridge area is assumed to be clear, the circuit including front contact *e* of relay UBK and front contact *c* of relay RESM, when this latter contact closes, provides energy to terminal 16A of the communication system and thus to the Sequence Timer at the remote location to actuate the bridge horn transmitter. At this time a four-blast horn signal is sounded to indicate to all concerned that the bridge is about to be lowered. If, inadvertently, the operator had actuated the selection of a route when the underbridge area was still occupied, energy would be provided to the winding of relay IMLU both by the closing of front contact *b* of relay 3LBPS or momentarily when the continuity contacts *a* of the derail lever repeater relays change position. The sounding of a bell signal at this time would indicate to the operator that he had made an improper lineup action which could not be carried out.

When the bridge span is down, fully seated, and the rails locked again, relays 1-2ZNK and 3-4ZNK (FIG. 2B) at the control location pick up, the indication energy from the field being received over terminals 36A and 38A. These indications designate that all conditions at the field with regard to the bridge span are proper, as will be explained later. Relay DK is also energized, and picks up, by indication energy from the remote location over terminals 5 of the communication system. However, in the part of the timing sequence which is controlled by the field apparatus, an indication has been sent over terminals 1 which energizes relay 2TK, indicating a clear track section at the field so that front contact *a* of relay 2TK closes prior to the opening of back contact *b* of relay DK, thus maintaining the stick circuit for relay 3LBPS, as shown in FIG. 2B.

Circuits are now completed for the transmission of the derail reverse commands to the field location. In FIG. 2C, these circuits are traced from terminal MB at back contact *c* of relay 3-4ZRLP over back contact *c* of relay 1-2ZRLP, front contact *c* of relay DK, and thence over front contacts *e* of relays 2AWRLP and 2WRLP, to terminals 26A and 28A, respectively, of the communication system. These circuits obviously check that the rail lock lever repeater relays for the reverse positions of these levers are released, indicating that no command has been issued under test conditions for removing the rail locks to create an unsafe condition for train movements. The transmitted derail reverse commands are received at the field location and actuate the operation of the derails to their closed position. When this movement of the switch points is completed, indications are transmitted to the office over terminals 29 and 31 of the communication system to energize, respectively, relays 2RWCK and 2ARWCK, the derail reverse correspondence indication relays. Each of the indication circuit arrangements at the office checks, in this case, that the corresponding WNLP relay is released by including, in the connection to terminal MN, back contact *c* of the corresponding relay. This indication reception from the field, with the reverse lever repeater relays for the derails already picked up, completes circuits for energizing the reverse derail indication relays. For example, relay 2WRWK is energized at this time by a circuit traced from terminal MB at front contact *d* of relay 2WRLP, over front contact *a* of relay 2RWCK and the winding of relay 2WRWK to terminal MN. A similar circuit for relay 2AWRWK includes front contact *d* of relay 2AWRLP and front contact *a* of relay 2ARWCK.

Route relay 3LRR (FIG. 2B) is now energized by a circuit extending from terminal MB at front contact *c* of relay 3RXS, closed because signal 3R has been designated the exit for the route, over front contact *a* of relay 1-2ZNK, front contact *a* of relay 2AWRWK,

front contact *h* of relay ES, front contact *a* of relay 2WRWK, front contact *a* of relay 3-4ZNK, back contact *c* of relay 3LXS, and the winding of relay 3LRR to terminal MN. Front contact *a* of relay 3LRR closes to transmit an indication over terminals 2A and 2B to the remote locations to energize relay 3LRRP. This actuates the final clearing of signal 3L to establish the traffic direction for the train and a clear signal. The details of this operation are to be discussed next in this specification.

Turning now for the subsequent description to FIGS. 4A and 4B, placed adjacent with FIG. 4A on the left and the corresponding circuits or other connecting lines matching, these drawings show the apparatus and circuitry at the field or bridge location. Across the top of FIG. 4B, for convenient reference, is another conventional although single line representation of the track across the bridge, which is indicated by a conventional dash line symbol. This schematic illustration also represents or shows by conventional symbols the wayside signals, the derails, the rail locks, and the bridge seating detection units, with the operating devices for the derails and the rail locks indicated by conventional blocks. The track circuit for the track section across the bridge between the signal locations is symbolized by a conventional symbol for the track battery 2TB to the left of the bridge and a rail connection at the other end of the track section leading to circuitry to be later described for track relay 2TR. The dotted lines between the track or wayside apparatus and various elements of the circuit arrangement represent the control and indication connections between such wayside apparatus and the control and detection apparatus and circuitry shown elsewhere in these two drawings. The particular control or indication or both which a specific dotted line represents will be discussed when that portion of the apparatus is specifically described.

At the left of FIG. 4A are shown the levers for manual control of the bridge and traffic apparatus by a local operator or bridge tender when on duty. These generally are regular type interlocking levers having electromechanical locking in various control and indicating positions, such controls being indicated by a lock magnet associated with each lever and designated by the reference L. The positions of the lever in which the locking is effected are designated by the letter references, corresponding to the lever positions, associated with the locking arm of each lock magnet L. The master or bridge system lever No. 1 at the upper left of this figure is a two-position lever having a normal and a reverse position, the lever normally occupying the normal position N. An indicating position X is also designated and a corresponding lever contact is connected into the circuitry for energizing lock magnet L associated with this lever. This is a master lever and mechanical locking is arranged between the three levers shown so that this bridge lever locks the other levers in their normal position when it, itself, is in its normal position. Likewise, the mechanical locking requires that each other lever must be returned to its normal or at-rest position before the bridge lever can be returned to its normal position, this in addition to the electromechanical locking provided on the lever itself. Such interrelated mechanical locking between such levers is conventional and is provided to assure the coordination of the lever operation. The derail control lever 2 has a normal N and a reverse R position corresponding to the two conditions of the track derails. This lever is also illustrated with several indicating or intermediate positions which are important in the circuitry associated with the lock magnet for this particular lever. The signal lever 3 deals with the control of the wayside signals for establishing traffic direction and clearance across the bridge. This is a three-position lever normally occupying its center or C position and having a left L and a right R position corresponding to the control of signals 3L and 3R, respectively. Intermediate or indicating positions are shown and contacts closed in these positions are included in the energizing circuits for the lock magnet L associated with this particular lever. Other contacts of lever 3 are shown in circuits on FIG. 4B.

The additional lever, designated the Remote-Local Control lever, normally occupies a remote position R, in which it is shown, and is operable to a local position L. When this lever is moved to its local or L position, a circuit is completed from terminal LB over the lever arm in this L position through the winding of master relay MR and a contact N of bridge lever 1 to terminal LN. Relay MR picks up and closes its own front contact *a* to complete a stick circuit which bypasses the contact of bridge lever 1 in the energizing circuit. When relay MR is energized, the closing of its front contact *e* transmits an indication to the office over terminals 35B and 35A, previously described, to energize the master relay indication relay MRK, which is shown in FIG. 2B. As the discussion proceeds it will be noted that the bridge lever 1 actually does not control directly the movement of the bridge span to raise and lower the span. Such manual direct bridge lift controls are separate and, as they are conventional, are not shown here since they do not become involved in the arrangement provided by our invention. The manual control levers for operation by a bridge tender on duty are illustrated in order to show the coordination in connection between the automatic operation of the bridge and the more conventional manual controls.

Each signal 3, shown in the schematic diagram, has associated therewith two dotted lines. One is connected to the stop arm symbol of the signal to designate the indication control energy supplied, when the signal is displaying that indication, to the circuit arrangement for the associated red signal repeater relay RGP. The dotted line associated with the proceed arm, shown in the caution position, represents the control circuit from the corresponding home relay for that signal. As specific examples, signals 3R and 3L have associated therewith the red signal repeater relays 3RRGP and 3LRGP, respectively, while home signals 3RH and 3LH are associated respectively with two signals, there also being a master home relay 3H. When signal 3R is displaying a stop indication, energy is supplied from the signal unit over connections represented by the dotted line to a stick circuit shown within FIG. 4B, which extends through the winding and front contact *a* of relay 3RRGP for holding the relay energized. Following a period when signal may have displayed the proceed indication, a pickup circuit includes the winding of relay 3RRGP and back contact *b* of track relay 2TR.

Another parallel pickup circuit includes front contact *b* of the time element relay 3RTE, the operation and purpose of which will become apparent shortly. The circuit arrangement for relay 3LRGP is similar, energy being provided from the 3L signal unit at the wayside when displaying its stop indication. The relay has a stick circuit including its own front contact *a*, which is normally closed, and two pickup circuits, one including back contact *c* of relay 2TR and the other front contact *b* of time element relay 3LTE.

Since the specific description of the remote control or office apparatus was for clearing signal 3L in the establishment of a route to the left across the bridge, we shall describe the field circuit in connection with the controls for the same signal. Relay 3LH has an energizing circuit including front contact *a* of the route repeater relay 3LRRP, back contact *b* of signal approach stick relay 3LAS, front contact *d* of relay 3H, back contacts b of the bridge lock stick relay BLS and the derail lock stick relay 2-2ALS, and front contact *b* of the opposing signal approach stick relay 3RAS. The circuit for relay 3RH for the opposing signal is similar but, of course, includes front contact *b* of relay 3LAS, back contact *b* of relay 3RAS, and front contact *a* of the opposite direction route repeater relay 3RRRP. Each approach stick relay AS is normally held energized by a stick circuit which is interrupted if the associated signal occupies other than its stop indication position or if a route is established which will pass the signal in its proceed condition. Thus, relay 3LAS is normally held energized by a circuit including back contact *b* of relay 3LRRP, front contact *a* of relay 3LAS itself, front contact *b* of relay 3LRGP, closed as long as signal 3L displays stop, back contact *f* of relay MR, and the winding of relay 3LAS. The purpose of the contact of relay MR in this arrangement is to shift, when manual local control is substituted for remote control, the approach lock control from relay 3LAS to signal lever 3 in FIG. 4A. Signal lever 3 may then be moved to its left position, as permitted by the energization of the lock magnet, only when signal 3L already occupies its red or stop position. The energizing circuits for each relay AS and both circuits for magnet L of lever 3 have a common connection to terminal LB over back contact *c* of relay 3H.

A typical control circuit for the wayside signal unit is illustrated for signal 3L and may be traced from terminal LB over front contact *a* of relay 3LH, back contact *g* of relay MR, and front contact *a* of relay 4LHDGP, which is energized when signal 4L at the exit end of the bridge route for traffic moving to the left is at proceed, either caution or clear, thence through to the operating head of signal 3L, as shown by the conventional dotted line to the caution arm, returning over front contact *b* of relay 4LHDGP, back contact *h* of relay MR, and front contact *b* of relay 3LH to terminal LN. When relay 3LH is deenergized and released, which is its normal at-rest condition, a shunt is connected, over back contact *a* of relay 3LH, across this control circuit for signal 3L to assure that it remains in its stop position.

The master home relay 3H is controlled by a circuit which, tracing from the relay winding, includes front contact *d* of relay 2TR, back contact *i* of relay MR, front contact *c* of relay 3LRRP, or front contact *c* of relay 3RRRP, the two contacts being in multiple, thence over checking back contacts *c*, in series, of time element relays 3LTE and 3RTE, circuit connection 42 to FIG. 4A, front contact *a* and normal contact *b* in series of relay 1-2ZP, front contact *a* and normal contact *b* of relay 3-4ZP, back contacts *j* and *k* of relay MR, reverse contact *b* and front contact *a* of relay 2WP, and reverse contact *b* and front contact *a* of relay 2AWP. The various sets of front and normal or reverse contacts of the ZP and WP relays, as will become apparent, check the actual positioning of the rail locks and derails to assure the proper positioning of all of this apparatus prior to the clearing of the signal for a train movement.

Track relay 2TR is normally held energized by a stick circuit including its own winding and front contact *a*, the energy from track battery 2TB being received from the rails of the track section over connections represented by the conventional dotted line from the right end of section 2T. The normal pickup circuit for relay 2TR includes back contact *m* of relay MR. If local control is in effect so that front contact *m* of relay MR is closed, a center position contact of lever 3 is included in the pickup circuit to assure that the track is not indicated as clear unless the signal is held at stop. The transmission of a non-occupied track circuit indication involves the checking, not only of the position of relay 2TR, but of the expiration of various time periods subsequent to the reenergization of the track relay. A track time element relay 2TTE is energized, when relay 2TR initially picks up, by a circuit including front contact *e* of relay 2TR, back contact *n* of relay MR, back contact *a* of the track time element stick relay 2TTES, and the winding of relay 2TTE. It is to be noted that this time element relay, and others to be described in these two figures of the drawings, each include a previously described checking back contact which immediately opens when the relay winding is energized and does not reclose until the relay is deenergized and releases. When relay 2TTE has been energized for its preset time period, it closes its front contact *a* to energize relay 2TTES which then picks up and, by the shifting of its contact *a* to close in the front position, completes a stick circuit for itself and at the same time deenergizes the winding of relay 2TTE. Another set of timing relays are the siren time element relay STE and its associated stick relay STES. Relay STE is energized over a circuit including front contact *b* of relay 2TTES, circuit lead 43 to FIG. 4A, back contact *a* of relay STES, and the winding of relay STE. When relay STE completes its timing period and closes its front contact *a*, relay STES is energized and picks up, closing its front contact *a* to complete the normal stick circuit and at the same time opening the corresponding back contact to deenergize relay STE. A derail time element relay 2WTE and its associated stick relay 2WTES provide a final portion of the sequential timing cycle which runs each time that relay 2TR releases and subsequently picks up. Relay 2WTE is energized by a circuit including front contact *b* of relay STES and back contact *a* of relay 2WTES. Relay 2WTES is energized when front contact *a* of relay 2WTE closes at the expiration of the time period and then is held energized by a stick circuit including its own front contact *a* and the aforementioned front contact *b* of relay STES. When relay 2WTES picks up, it interrupts the circuit for relay

2WTE which then releases, at that time again closing, it may be noted, its checking back contact *b*.

Dotted lines **44** and **45** extending from the operating motor blocks of derails **2W** and **2AW**, respectively, represent the control of and the indication from the associated derail apparatus. Derail **2W** is controlled by the field derail lever repeater relays **2WNLPP**. Each of these relays is responsive to the control function transmitted over the communication system from the control office and one or the other, but not both, will be picked up when a control is received. The portions of the derail control circuits illustrated, including contacts *a* and *b* of each of these relays, apply direct current control energy to the derail operating motor at a first or second polarity to drive the derail points to their normal or reverse positions. Similar control circuits for derail **2AW** are provided using contacts *a* and *b* of each of the relays **2AWNLPP** and **2AWRLPP**. If local control is in effect so that relay MR is picked up, derails **2W** and **2AW** are controlled in multiple direct from the manual derail lever 2 in accordance with the positions of two paired sets of NB and RD contacts. The derail position is recorded by the derail repeater relays **2WP** and **2AWP**. These are polar neutral type direct current relays with polar contacts which repeat the normal or reverse position of the associated derail. The neutral contacts are closed when the associated derail is locked in either position, no movement is taking place, and there is no request for a movement of the derail. Indications of the position of the derails are reported by these last listed relays to the control office over the communication system terminals **29** through **32**, the selection of the terminals used being in accordance with the normal or reverse position of each relay.

The rail lock, bridge seated repeater relays **1-2ZP** and **3-4ZP** are similar polar neutral type relays and are used to detect the condition of the rail locks and the location of the bridge span in its down and properly seated condition. Energy is applied over the conventionally shown control-indication connection **46** from the rail lock circuit controller unit **1-2Z**, shown in FIG. **4B**, having a polarity in accordance with the actual conditions. This energy is applied to the winding of relay **1-2ZP** normally over a circuit including the relay winding, back contact o of relay MR, and front contact *c* of the bridge lock stick relay BLS. Thus when remote control is in effect and relay MR is released, that is, its back contact *o* is closed, relay BLS must be energized and picked up so that its front contact *c* is closed in order for relay **1-2ZP** to record the condition of the rail lock and bridge circuit controllers. If local control has been effected so that front contact *o* of relay MR is closed, the circuit for relay **1-2ZP** includes this front contact and a normal N contact of bridge lever 1. In order for lever 1 to be in its normal position, levers 2 and 3 for the derails and signals, respectively, must have previously been placed in their normal condition. The holding of lever 1 in its normal condition locks these other two levers so that a check of the local control conditions is accomplished. Similar circuits exist for relay **3-4ZP**, energy being provided from the **3-4Z** rail lock and bridge circuit controllers over conventional circuit connection **47**. The circuit is completed over front contact *d* of relay BLS and back contact *p* of relay MR, or in the local control condition, over front contact *p* of relay MR and another N contact of bridge lever 1. The normal and reverse indications for the rail locks and bridge seated condition are transmitted by relays **1-2ZP** and **3-4ZP** over the communication system terminals **36** to **39**, inclusive, as shown. If the rail locks are operated under test condition from the remote office, controls are received by the normal and reverse lever repeater relays ZNLPP and ZRLPP, one set for each rail lock apparatus. Normally both of these relays remain released and the rail locks are controlled by the bridge lift apparatus during the raise or lower operating sequence. When either relay ZNLPP or ZRLPP of a pair is energized, it actuates the rail lock unit to operate the rail lock normal or reverse, that is, driven in or withdrawn from the actual lock position, respectively. Simple front contact circuits are used to apply energy to the rail lock motors although polarized direct current energy, in the same manner as for the derails, may be used if desired, this simple showing being a matter of convenience to include the illustration that such controls are provided.

The bridge lock stick relay BLS (FIG. **4A**) is normally held energized by a stick circuit including its own front contact *a* and winding, and further extending over connecting lead **50** to FIG. **4B**, front contact *c* of relay **3LAS**, front contact *c* of relay **2TTES**, front contact *c* of relay **3RAS**, front contact *c* of relay STES, front contact *b* of the derail lock stick relay **2-2ALS**, front contact *b* of relay **2WTES**, back contact *s* of relay MR, and front contacts *c* and normal contacts *d*, all in series, of relays **2AWP** and **2WP**. This stick circuit will hold relay BLS energized if the rail locks are operated under test conditions from the remote office. However, once the relay is released, the pickup circuit, by including in series back contacts *b* of all rail lock lever repeater relays at the field location, checks that no operation of the locks is being exercised from the remote office before relay BLS is reenergized. It is also to be noted that the relay can not be held energized if either of the derails is in its reverse position. A check is also made that the various time element relays associated with the track circuit have completed their timing sequence. This is done by checking that their corresponding time element stick relays have picked up and are held energized by their stick circuits. The front contacts of relay **3RAS** and **3LAS** check that the home signals are at stop and no route across the bridge is established.

The derail lock stick relay **2-2ALS** is normally held energized by a stick circuit extending from terminal LB at front contact *d* of relay **3LAS** over front contact *d* of relay **2TTES**, checking back contact *b* of relay **2TTE**, front contact *d* of relay **3RAS**, circuit connection **48** to FIG. **4A**, front contact *d* of relay STES, checking back contact *b* of relay STE, front contact *c* of relay **2WTES**, checking back contact *b* of relay **2WTE**, the winding of relay **2-2ALS** and its front contact *a* to terminal LN. If only the derails are reversed under a test condition, this relay is held energized by this stick circuit. Its front contacts enter into the control circuits by which operating energy is applied to the operating motors for derails **2W** and **2AW**, and thus interrupt all automatic control circuits for these derails if this lock stick relay becomes released. Obviously it does release when a signal 3 is cleared or a route relay picks up and one or the other of the AS relays releases to open its front con-

results in the release of various other relays, in the manner previously described, ending with the release of relay 3LRRP at the field location. Relay 3H is deenergized when front contact *d* of relay 2TR opens, allowing relay 3H to release to close its back contact *c*. This provides energy through diode D3, front contact *b* of relay 3LRGP, back contact *f* of relay MR, and the winding of relay 3LAS to energize this latter relay which then picks up. The closing of front contact *a* of relay 3LAS completes a stick circuit which bypasses back contact *c* of relay 3H in the original energizing circuit, and relay 3LAS remains held up by its stick circuit as long as signal 3L remains at stop and a route is not established by relay 3LRRP.

At the office, following the release of relay 3LPBS, relays 2AWR, 3RXS, 2WR, and 3LRR release in that order. In FIG. 2C, both WRLP relays also release since the 2WR and 2AWR front contacts in their circuits open. However, with relay 2TK released, since the track section in the field is occupied, to close its back contacts *b* and *c*, relays 2WRWK and 2AWRWK are both held energized. It may be noted at this point that, if the signal in the field is placed back to stop by the remote operator and the reverse lever repeater relays 2WRLP and 2AWRLP release, relays 2WRWK and 2AWRWK are then held energized, not over back contacts of relay 2TK, but over front contacts *b* and *c*, respectively, of whichever ASK relay is energized because an approach stick relay is released in the field. Relay 3LASK, in the previously described operation, would have remained picked up since its corresponding relay 3LAS in the field remains released until the time period has expired after the selected route is cancelled. Relay 3LASK is energized over the communication system terminals 33 and back contact *e* of relay 3LAS when this latter relay is in its released condition.

Returning to the normal clearing operation, when the train clears track section 2T so that relay 2TR in the field again is energized, relay 2TK at the office also is picked up at the end of the timing sequence. This opens the holding circuits for and causes the release of relays 2WRWK and 2AWRWK, which completes the circuit for energizing the derail normal relay WN, shown in FIG. 2B. The circuit for relay WN may be traced from terminal MB at back contact *f* of relay 2WRLP, now closed, over back contacts *b* of relays 2WRWK and 2AWRWK, back contact *f* of relay 2AWRLP, back contacts *d* of relays 3LASK and 3RASK, back contact *e* of relay TST, front contact *d* of relay 2TK, the winding of relay WN, and back contacts *c*, in multiple, of relays 2NWCK and 2ANWCK to terminal MN. These latter two contacts are closed since these relays are released with the derails in the field being in their reverse position so that no energy is being supplied over terminals 30 and 32 of the communication system. The closing of front contacts *c* and *d* of relay WN (FIG. 2C) completes energizing circuits for relays 2AWNLP and 2WNLP, respectively, each circuit further including back contact *b* of the corresponding WRLP relay as a check that such relays have released. The derail control levers are also checked as being in their center position. Relays 2AWNLP and 2WNLP transmit commands over terminals 25A and 27A, respectively, to energize at the field location relays 2AWNLPP and 2WNKPP. It may also be noted that with back contact *b* of relay WN open, relay ELO is deenergized and releases to block the selection and establishment of any route across the bridge by interrupting the energizing circuit for both pushbutton stick relays PBS.

Meanwhile at the field location, the pickup of relay 2TR energizes relay 2TTE since back contact *a* of relay 2TTES is closed. The previously described timing chain operation follows, initiated by the pickup and stickup of relay 2TTES when relay 2TTE completes its timing period. This is followed by the timing periods which result in the pickup of relay STES and 2WTES. It is to be noted that energy is applied to terminal 20B over front contact *e* of relay 2TTES, lead 49, and back contact *e* of relay STES to energize relay SIRA at the office during the timing period until relay STES picks up. This causes the siren to sound for a brief period established by the timing of relay STE to indicate that the track circuit is clear and that the derails will shortly be opening. When the timing chain sequence is complete and front contact *c* of relay 2WTES closes, relay 2-2ALS is energized over the previously traced circuit, picks up, and then sticks up over its own front contact *a*. It should be noted that the circuit for this latter relay has been prepared by the closing of back contacts *c* of relays 2WRLPP and 2AWRLPP and also by the closing of front contact *d* of relay 3LAS when this latter relay picked up.

When relay 2-2ALS picks up, the closing of its various front contacts, other than the stick contact, completes the control circuits for operating the derails to their normal or rail-open position. Energy of a proper polarity is applied over front contacts *a* and *b* of relays 2WNLPP and 2AWNLPP in each case. The operation of the derails under these conditions again opens the rail points to protect against train movements over the bridge which now is free to be raised if desired. When relays 2WP and 2AWP return to their normal positions upon completion of the derail movements, and with front contact *b* of relay 2-2ALS closed, the circuit is completed for energizing relay BLS which then picks up and completes a stick circuit over its own front contact *a*. Also indication signals are transmitted over terminals 30 and 32 of the communication system to energize relays 2NWCK and 2ANWCK at the office, the circuits further being completed over back contacts *c*, respectively, of relays 2WRLP and 2AWRLP. The NWCK relays thus pick up to assume their normal energized condition. However, the opening of back contacts *c* of both NWCK relays interrupts the circuit for relay WN which now releases. This deenergizes relays 2AWNLP and 2WNLP which subsequently release. The closing of back contact *b* of relay WN reenergizes relay ELO which picks up and closes its front contacts *a* and *b* to again allow a route selection to be made if desired. It may also be noted that relays 2WNWK and 2AWNWK may be briefly energized prior to the release of the WNLP relays when the NWCK relays pick up. Normally relays 2WNWK and 2AWNWK are energized only when the bridge span is lifted and back contacts *d* and *e*, respectively, of relay DK close to complete circuits over front contacts *d* of relays 2NWCK and 2ANWCK, respectively, for energizing the WNWK relays.

tact *d*. Relay 2-2ALS will pick up again only when no reverse derail control is under way, this check being made by including back contacts *c* of relays 2WRLPP and 2AWRLPP in the pick-up circuit. This pickup circuit, of course, is further completed only if the approach stick relays are picked up and the timing sequence cycle associated with track relay 2TR has completed.

We shall now return to the matter of describing the establishing of a traffic route from right to left across the bridge, that is, the clearing of signal 3L for a train movement, taking up the operation of the field apparatus following the apparatus operation at the remote control location. It has already been described how the bridge span is automatically lowered when the route selection is initiated. When the bridge is down and seated and the rails are locked, controls are transmitted from the control office to the field to operate the derails to their reverse position, that is, the rail points closed position. It will be obvious upon review that, if the bridge span had already been in its lowered position and the rails were locked, the route selection immediately initiates the operation of the derails to their closed condition, there being no need to wait for the lowering of the bridge span and the check of the final completion of the seating and rail locking. Relay 3LRRP is energized and picks up only after the derails are reversed, that is, the rails are closed since the route relay in the office traffic selection arrangement can not pick up until the corresponding reverse derail indication relays are energized from the field. Relay 3RXS must also be picked up, as may be seen by reference to FIG. 2B, before relay 3LRR picks up, thus designating that both the entrance and the exit of the route have been established. Relay 3LRR closes its front contact *a* and transmits a command over communication system terminals 2A and 2B to energize relay 3LRRP at the remote location. The closing of front contact *c* of relay 3LRRP completes the circuit previously traced for energizing relay 3H. Relay 3H picks up to open its back contact *c* and thus deenergize relay 3LAS, whose stick circuit has just been opened at back contact *b* of relay 3LRRP. Relay 3LAS releases, opening its front contacts *d* and *c* to deenergize relays 2-2ALS and BLS, respectively. The closing of back contact *b* of relay 3LAS and shortly back contacts *b* of relays 2-2ALS and BLS completes the previously traced circuit for relay 3LH. The pickup of relay 3LH to close its front contacts *a* and *b* applies operating energy to the head of signal 3L and it operates to its proceed position to display a slow speed proceed signal. This assumes that relay 4LHDGP is picked up with signal 4L already positioned to display a proceed indication, this action either occurring simultaneously or previous to the release of relay 3LAS as the remote operator clears a route across the bridge and through the adjacent territory.

With signal 3L operated to its proceed condition, relay 3LRGP is deenergized and releases. The opening of front contact *c* of this latter relay interrupts the holding circuit for signal time element relay 3LTE and this relay releases since its stick circuit is open at back contact *d* of relay 3LRRP. Relay 3LTE has a timing circuit for energizing its lower or time element winding which includes that winding and its own back contact *a*, back contact *d* of relay 3LRRP, back contact *q* of relay MR, and back contact *c* of relay 3LRGP. The purpose of relay 3LTE is to establish a timing period for reenergizing relay 3LRGP in the event that signal 3L is put to stop by the remote control operator rather than by the passage of a train operating under the proceed indication. If the operator decides to, or of necessity must, take away the clear signal, or, in other words, cancel the established route, he pulls pushbutton 3LPB (FIG. 2B) to cause its contact *b* to open, thus deenergizing relay 3LPBS by interrupting its stick circuit. Relay 3LPBS releases, opening its front contact *d* to deenergize relay 2AWR which releases to in turn deenergize relay 3RXS. When this latter relay releases, the opening of its front contact *c* deenergizes relay 3LRR at the office and, shortly after, the associated repeater relay at the field, relay 3LRRP, is also deenergized and releases. Signal 3L is immediately returned to its stop indication since relay 3LH releases due to the opening of front contact *a* of relay 3LRRP.

However, although energy is supplied from the head of signal 3L when it returns to its stop position, the energizing circuit for relay 3LRGP remains open since front contact *a* of relay 3LRGP is obviously open and back contact *c* of relay 3TR is not closed since a train is not occupying the track section. With relay 3LRGP remaining released so that its front contact *b* remains open, relay 3LAS can not be reenergized and the clearing of other signals is, for the present, inhibited. However, the closing of back contact *d* of relay 3LRRP completes the energizing circuit for the lower or time element winding of relay 3LTE and this relay begins its timing operation. When the preset timing period of relay 3LTE is completed, this relay picks up, closing its front contact *a* to complete a stick circuit through the upper winding which is the same as the energizing circuit except for this last change. Front contact *b*, one of the timing contacts of relay 3LTE, closes at this time and relay 3LRGP is now reenergized since energy is already being applied to the remainder of the circuit. The closing of front contact *a* of relay 3LRGP, of course, completes a stick circuit to retain the relay energized as long as signal 3L remains in its stop position. Relay 3LTE is held energized over front contact *c* of relay 3LRGP, this contact shifting the energy supplied from the pickup and stick circuit for relay 3LRGP to this holding circuit. It is to be noted that during the timing period of relay 3LTE, beginning as soon as the lower winding is energized, checking back contact *c* of this relay is open in the circuit for relay 3H. However, as soon as energy is removed from the lower winding, the checking contact *c* is released and again closes.

Normally, relay 3LRGP will be reenergized when a train passes signal 3L, displaying a proceed indication, and occupies track section 2T. Relay 2TR releases under this condition, closing its back contact *c* to prepare the energizing circuit for relay 3LRGP. The opening of front contact *e* of relay 2TR deenergizes relay 2TTES and this stick relay releases followed in turn by the release of stick relays STES and 2WTES. Energy at the field location is removed from terminal 1B of the communication system by the release of these various TES relays and at the office location relay 2TK releases to open its front contact *a*. This interrupts the stick circuit for relay 3LPBS which releases. This

The control of the bridge movements and the railroad traffic under local control conditions at the field, that is, with relay MR picked up, by the levers shown at the left of FIG. 4A, is obvious from an inspection of the circuits and the drawings and the general understanding of the operation of such interlockings. Since that control and interlocking between the control lever means and the various bridge and signal operating apparatus is conventional, no detailed description is herein provided for this portion of the illustrated arrangement.

The arrangement of our invention thus provides a fail-safe system for the remote control of a railroad lift bridge and of the traffic or train movements across the bridge span. The automatic sequencing embodied in the circuit arrangement requires a minimum amount of supervisory control by the system operator and at the same time keeps him fully informed as to the field conditions and operations. This minimum amount of supervision is true both in responding to ship requests for raising the bridge span and in selecting and establishing railroad traffic routes across the bridge. The full arrangement also insures that each element in the control process is accomplished at the proper time in the sequence. In other words, no process element can inadvertently occur out of step or out of its regular time in the cycle. This thus produces an efficient system which improves the economy of railroad operation by eliminating a requirement for a separate bridge tender assigned to no other task and allows a plurality of tasks to be performed by a single system operator.

Although we have herein shown and described but a single apparatus and circuit arrangement embodying the railroad lift bridge control system of our invention, it is to be understood that various changes and modifications may be made in the illustrated system within the scope of the appended claims without departing from the spirit and scope of the invention.

Having thus described our invention, what we claim is:

1. A remote control system for a movable railroad bridge, for selectively controlling from a remote location the movement of trains on the track stretch across the bridge and of waterway traffic under the bridge, comprising in combination,

a. bridge movement sequencing apparatus connected for controlling the movement of the movable bridge span in each direction between clear and blocking positions for waterway traffic when actuated by corresponding control functions received from said remote location,

b. a first detection means at the bridge responsive to signals from approaching waterway traffic for recording a request for a clear bridge span position,

c. a second detection means at the bridge, responsive to the passage of waterway traffic for detecting and recording the presence and absence of waterway traffic under said bridge,

d. railroad traffic control means along the track wayside operable between a proceed and a restricting condition for authorizing and prohibiting, respectively, movement of trains across said bridge,

1. said railroad traffic control means operable to its proceed condition only when the bridge span is in its blocking position and said bridge movement apparatus has established preselected safety conditions,

e. joint control means at said remote location operable for selecting and actuating the transmission of control functions to direct the operation of said bridge movement apparatus and said traffic control means to condition the system apparatus for a waterway movement or a train movement when the corresponding selection is made, and

f. safety logic circuit means at said remote location responsive to the operation of said joint control means and controlled at times by said first detection means and said traffic control means for transmitting a control function to said bridge movement apparatus to move the bridge span to its clear position when a request is received only if said traffic control means is in its restricting condition,

g. said circuit means controlled at other times, when a train movement is selected by said joint control means, by said second detection means and said bridge movement apparatus for transmitting control functions to said bridge movement apparatus and said traffic control means to establish a proceed condition on said railroad traffic control means for the selected train movement only when no underbridge waterway traffic is detected and all preselected safety conditions for the selected train movement are completed by said bridge movement apparatus.

2. A remote control system as defined in claim 1 in which,

a. said first detection means is a receiver-amplifier device responsive to ship signals for recording and transmitting to said remote location a clear bridge request only if a preselected sequence of signals is received from a single direction of ship approach along said waterway, and which further includes,

b. a signal transmitter at said bridge controlled by said first detection means and said joint control means for transmitting a distinct signal to an approaching ship in response to a clear bridge request in accordance with the operation of said joint control means to select a clear or blocking bridge position.

3. A remote control system as defined in claim 2 in which said second detection means comprises,

a. two or more light beam detection arrangements positioned with the beams transverse the waterway under said bridge to detect the passage of an object along the waterway through said beams,

b. recording means responsive to the interruption of each light beam to record occupancy of the underbridge waterway space,

c. said recording means further controlled by said light beam detection arrangement for recording a clearance of said underbridge space only when all light beams have been interrupted and subsequently restored.

4. A remote control system as defined in claim 1 in which said traffic control means comprises,

a. a wayside signal for each direction of train movement across said bridge, each signal normally dis-

playing a restricting indication and operable at times to display a proceed indication for authorizing a train movement,

b. a derail device in the track on each approach to the movable span obstructing in its normal position a train movement onto said span, each derail device operable to a reverse position to remove the train movement obstruction,

c. rail lock means connected for checking the physical seating of the track rails when the bridge span is in its blocking position and operable by said bridge movement apparatus for locking the rails on said span when seated to establish a safe passage condition for a train across said span,

d. a traffic control circuit network at the wayside connected to said signals and controlled by said safety logic circuit means, said derail devices, and said rail lock means for operating one signal only to display its proceed indication when said joint control means has selected the corresponding train movement control, said derail devices are in the reverse position, and said rail lock means has locked the span rails.

5. A remote control system as defined in claim 4 in which,

a. said first detection means is a receiver-amplifier device responsive to ship signals for recording and transmitting to said remote location a clear bridge request only if a preselected sequence of signals is received from a single direction of ship approach along said waterway, and which further includes,

b. a signal transmitter at said bridge controlled by said first detection means and said joint control means for transmitting a distinct signal to an approaching ship in response to a clear bridge request in accordance with the operation of said joint control means to select a clear or blocking bridge position.

6. A remote control system as defined in claim 5 in which said second detection means comprises,

a. two or more light beam detection arrangements positioned with the beams transverse the waterway under said bridge to detect the passage of an object along the waterway through said beams,

b. recording means responsive to the interruption of each light beam to record occupancy of the underbridge waterway space,

c. said recording means further controlled by said light beam detection arrangement for recording a clearance of said underbridge space only when all light beams have been interrupted and subsequently restored.

7. A remote control system as defined in claim 6 in which said safety logic circuit means comprises,

a. a route control circuit network responsive to the selection of a train movement control by said joint control means for transmitting a control function to said wayside traffic control circuit network, only when said derail devices are in reverse positions and said rail lock means has locked the seated rails, to operate corresponding wayside signals to display a proceed indication,

b. a derail position selection circuit network controlled by said route control circuit network for transmitting control functions to operate said derail devices to reverse positions when a train movement route is established and the bridge span is in its blocking position and to normal positions when the train movement is completed, and

c. a bridge position control circuit network controlled by said joint control means for transmitting a control function to move the bridge span to its clear position when said joint control means is operated in response to a ship request,

1. said bridge position network also transmitting a control function to said signal transmitter at said bridge to actuate a signal transmission that the span will operate to its clear position,

d. said bridge position circuit network further controlled by said route control circuit network and said derail position circuit network for transmitting another control function to operate the bridge span to its blocking position when a train movement route is being established and said second detection means records a clearance of the underbridge space.

8. A remote control system as defined in claim 7 in which,

said signal transmitter at said bridge is further controlled by said first detection means for always transmitting, when a clear bridge position request is recorded, a signal to an approaching ship that said bridge span will remain in its blocking position except when a control function is received from said bridge position control circuit network to actuate the transmission of a signal that said bridge span will operate to its clear position.

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