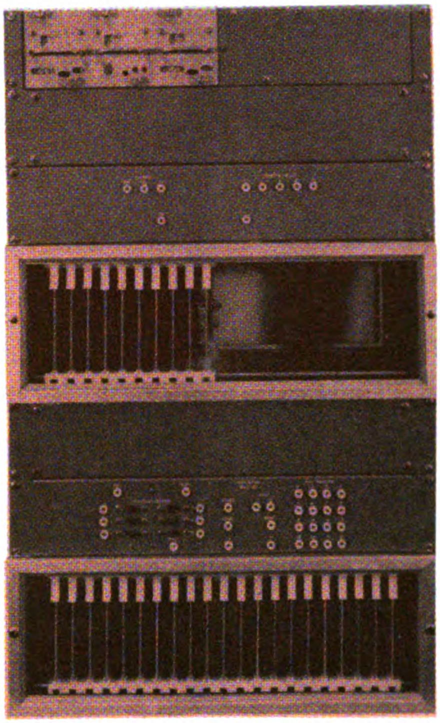
Railway
Signaling &
Communications

INTERLOCKING:

New Solid State Coding System Is Fast



Solid-state code unit at control office.

When consolidating the controls of two interlockings into an NX control machine at a third location, George B. Blatt, Reading's chief signal, communication and electrical engineer, selected the General Railway Signal Co. type L solid-state code system to handle the controls and indications. The consolidation or remote control project resulted from a warehouse fire that severely damaged RDG's Diamond street interlocking tower. Diamond street interlocking, on the 4-track commuter mainline 3½ miles from Reading Terminal, Philadelphia, Pa., consists of 6 crossovers and 3 switches (all switch machines are electro-pneumatic), and 15 color-light signals.

Instead of rebuilding the Diamond street tower, Mr. Blatt decided that it would be more economical to remotely control the plant from a new machine. A logical location was the Race street tower (controlling an existing electro-pneumatic interlocking) at the throat of Reading Terminal. As part of the project, a crossover and 4 signals at Brown street, ¾ mile from Diamond street, were also controlled from the new table-top, pushbutton control machine at Race street.

Commuter traffic is heavy, there being 169 departing and 168 arriving trains every 24 hr at Reading Terminal. The majority are operated during the morning and evening rush hours. To handle these trains through the interlockings without delay, Mr. Blatt decided to install an eNtrance-eXit type machine to control Diamond and Brown street plants. To set up a route on the NX control machine, the operator presses the entrance knob at the location where a train will enter the plant and pushes the exit button at the location where the train will leave the interlocking.

The condition of having many trains spaced only minutes apart at rush hours dictated the use of a high-speed code system to handle controls and indications. The type L code system for this installation has a control cycle time of approximately 70 milliseconds per station and an indication cycle time of approximately 1.5 seconds (continuous scan of all 16 field stations including 2 spares). In addition to high speed, Mr. Blatt mentions these advantages of the solid-state code system which prompted him to select it for this application: Compact size and modular construction with printed circuit boards and test points on the front of the equipment make for ease of maintenance. Operation over an existing wire pair in a telephone cable (non-shielded pair) is a definite plus, according to Mr. Blatt. For emergency use, another telephone cable pair has been set aside for this type L code system operation

The type L code system is duplex in operation with control and indication transmissions operating independently of each other over the same two wires. Frequency-shift carrier equipment (type FSK) is used on the line circuit for transmission of both controls and indications. Controls are sent at 8.2 kc. Stations are called using 10.0 kc in the continuous scanning for indications, and when a station replies, the indications are sent in to the con-

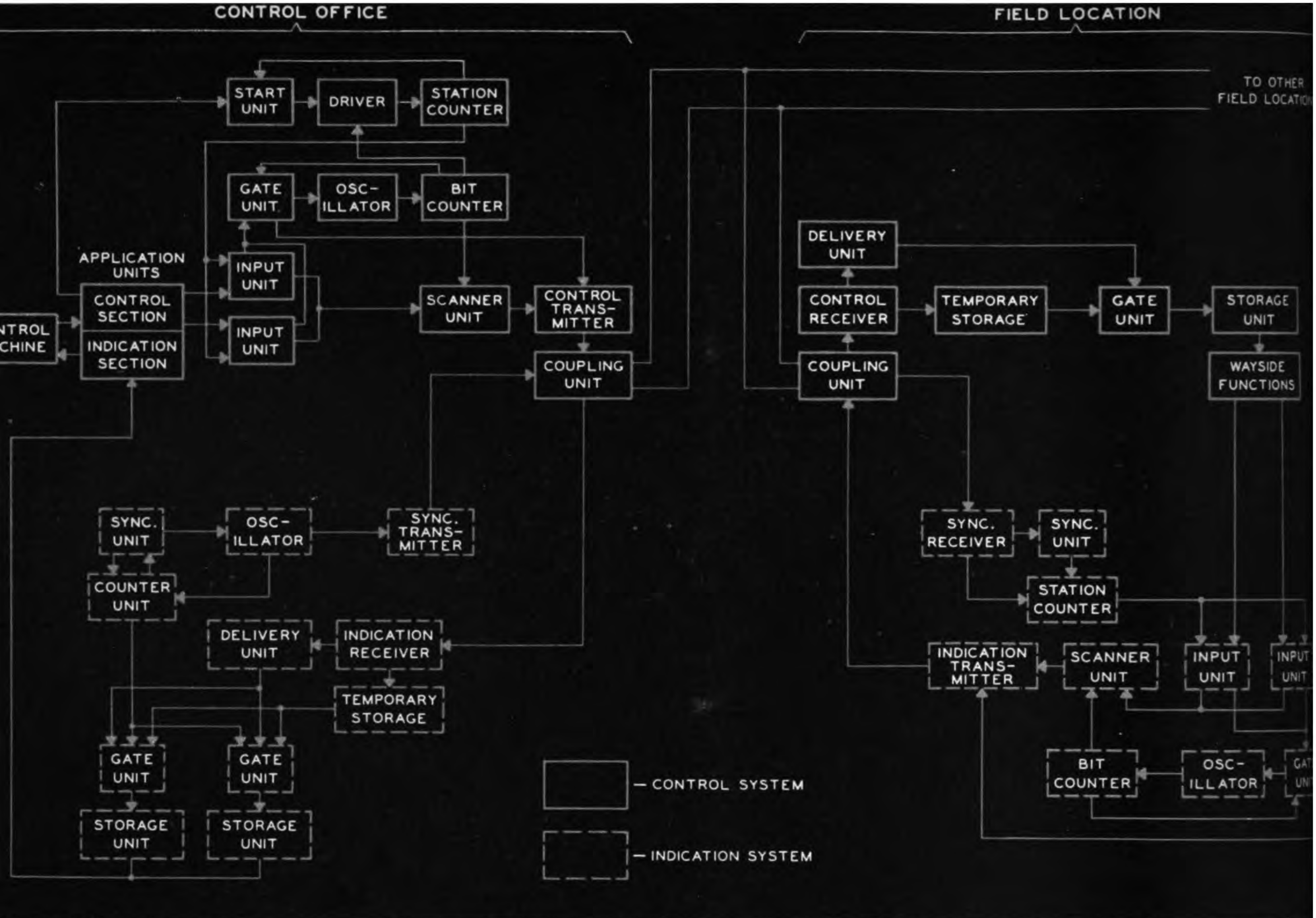


Fig. 1: Block diagram of the organization of type L solid-state control and indication system.

trol machine on 6.4 kc.

What follows is more information about the type L solid-state code system, as described by GRS engineers:

The initiation of a control start causes the system (Fig. 1) to transmit a complete cycle of all controls for the particular field location. When a start is initiated, the station counter unit selectively operates, in turn, the input units for the stations that are required to transmit all the controls to the field. If a start is initiated during the transmission of a control cycle, the start is stored and a second cycle is immediately transmitted. From the input unit, the selected d-c signal turns on the gate unit and also connects the 16 bits of the code to the scanner. The gate unit triggers the control transmitter and the oscillator. The oscillator is the "clock", that is, it establishes the time base for the system. The oscillator drives the bit counter unit at a predetermined code rate. The counter unit, which counts to 16 twice per control station, drives the scanner unit.

The scanner unit passes the controls in sequence to the control transmitter. The transmitter applies high- and low-shift frequency pulses (which constitute the code) to the line circuit. The control receiver at the field location detects this code and feeds it into temporary storage. If the field function relay is to be energized, the code pulse for this function will be at the low-shift frequency; if the function relay is to be deenergized, the code pulse will be at the high-shift frequency. After a brief interval indicating the end of bit transmissions for a station, the controls for that station are transmitted again. This permits checking that the information has been correctly received.

CONTROLS RECEIVED

When the controls have been received and temporarily stored, the delivery unit generates a delivery pulse which drives the gate unit. If the controls in the temporary storage unit are valid, the gate unit permits their transfer from temporary storage to the storage unit. An invalid code prevents any response from the temporary storage unit. A small delay is provided to operate the storage unit in the field while the scanner unit resets the gate unit in preparation for the next station code.

The continuously scanning indication system uses two channels of frequency-shift carrier—one wide-band channel and one narrow-band channel.

The narrow-band synchronizing carrier is transmitted from the control office to the field locations. It is shifted between the low and the center frequency in a regular pattern. Each pair of one low and one center represents the time assigned to one field station. These frequency shifts are detected in the field by the synchronizing receivers. After the number of lows corresponding to the number of stations in the system have been transmitted, a reset pulse is generated in the office to reset the office counter to zero. Simultaneously, a center frequency pulse is sent for a longer than normal time. This center frequency pulse is identified at the field location to cause it to reset its counter to zero. Thus synchronism is ensured between the office counter and the field counter.

Each station is assigned a number. When the field counter unit has progressed to its assigned station number, the selected output from the station counter is fed to the input unit corresponding to the selected station identity—each input unit represents a station. When the output from the counter is received, the input unit feeds the 16 inputs for that station to the scanner, while an additional output triggers the gate unit.

The gate unit turns on the indication wide-band carrier transmitter and permits the oscillator to drive the bit counter unit, which counts to 16 and resets the gate unit to turn the indication transmitter off. The bit counter unit also drives the scanner unit. The scanner unit feeds the 16 inputs in sequence to the indication transmitter. The transmitter applies high and low frequency-shift pulses, which constitute the code, to the line circuit.

At the control office, the code pulses received by the indication wide-band carrier receiver are fed into the temporary storage unit. This unit stores the 5-bit station identity and the 11 indication bits from the reporting field station, and supplies outputs on separate lines for each indication not used for station identity.

The delivery unit supplies a delivery pulse to the gate unit, after the 16 bits have been received from each station. Upon receipt of a pulse from the delivery unit, the gate unit checks the station identity in temporary storage with the station identity of the station called, as received from the counter unit. If the indentities are the same, the gate unit transfers the balance of the indications from temporary storage to the storage unit.

The storage unit retains the indications until a new set of checked indications is received for that station.

A functional block diagram of the control office solid-state equipment is shown in Fig. 4. This equipment scans the positions of contacts on the switch and signal call relays in the application unit and/or on the control console levers and/or pushbuttons.

During this scanning function, a sequence of voltage pulses are produced which have two distinguishable states, that is, they are binary in character. These binary bits (ground for 0, negative for 1) cause the carrier to shift above the center frequency (high), or below the center frequency (low). A center frequency occurs in the spaces between binary bits.

A series of frequency shifted bits is called a "word". A complete "message" consists of two words—a direct word (the first 16 bits) and a complementary word (the second 16 bits). The aggregate of the frequency shifted bits in the direct word is inverted in the complementary word to provide a validity, or parity, check.

The bit oscillator clock establishes the time base for the system, that is, it defines the time for each bit of the code. The clock output is shown (Fig. 2), as waveform A. The word gate generator triggers the clock gate, which in turn drives counters B1, B2, B3, B4, and B5.

The application unit has two types of simultaneous outputs: the first to each input unit (consisting of 16 bits each), and the second to the start unit.

Circuits through contacts on the lever repeater relays in the application unit are connected to the input unit. Each input unit has a capacity of up to 16 bits and is connected in parallel to the input of the bit diode matrix.

The output of the application unit is connected to the start unit and carries the automatic start pulses. The detector section of the start unit is triggered by a start and immediately transfers the start to the storage section, and hence to the station driver unit.

A station driver output pulse triggers the station counter cycling. The station counter feeds into the station diode matrix. The station counter counts to one which allows the 16 bits already seated in input unit 1 (station 1) to be connected to the bit diode matrix.

An output of the input unit triggers the word gate generator, which opens the clock gate in the bit oscillator section and starts the bit counter unit.

If a bit count 1, contact 1 into the bit diode matrix is closed, a 1 is produced. The second contact is probed next—if it is an open contact, a 0 is produced. The remaining contacts are sequentially scanned—a total of 16. The bit diode matrix output, waveform B (Fig. 2) is then fed to the encoder. The encoder transforms the implied word to the specific word, as shown in waveforms C and D.

After the count of 16, counter B5 sends a pulse to the clock gate. The clock gate, in turn, turns off the output from the clock, thus causing a period of rest to occur between the direct word and the complementary word. In addition, counter B5 also feeds the encoder. The encoder inverts code buses C and D during the next 16 bits of the code to produce the complementary word waveform. Bit counter B5, after the end of a message, turns off the word gate generator.

Each bit of the code at the input to the encoder is shortened to a half-bit period before leaving the encoder. This relationship can be seen when comparing waveform B with waveform C (bits are all ones), and waveform B with waveform D (bits are all zeros). Each state of a bit is shortened by a half-bit period.

Those bits, which are to be HIGHS when applied to the code line, are fed to the carrier transmitter through bus D—the negative-going pulses shown in waveform D. The bits of the code which are to be LOWS when applied to the code line, are fed to the carrier transmitter through bus C, the negative-going pulses shown in waveform C.

The carrier transmitter combines the two inputs as a single carrier channel on the wayside transmission line, waveform E. The station counter continues counting after station 1 has transmitted its message to the field. Station counting continues until all input units have been progressively scanned by the station diode matrix, and have been delivered to the bit diode matrix for scanning, encoding, and transmission to the field. After the last station

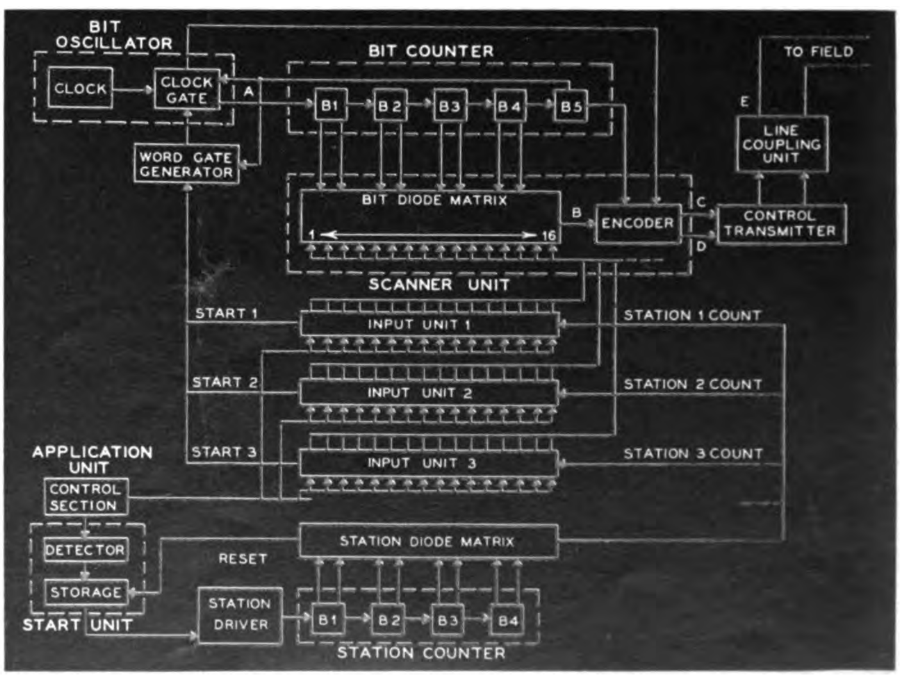


Fig. 4: Block diagram of the control office equipment of the control system.

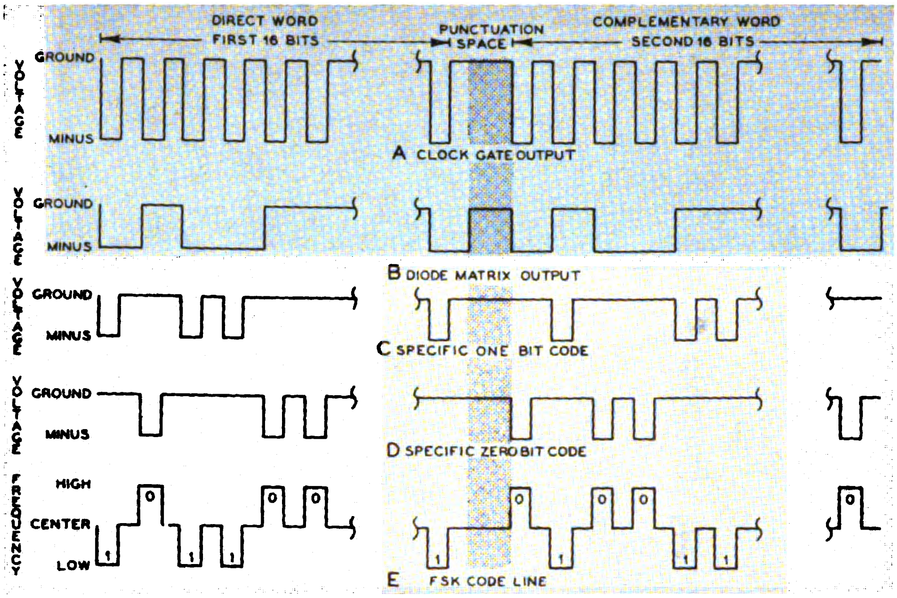
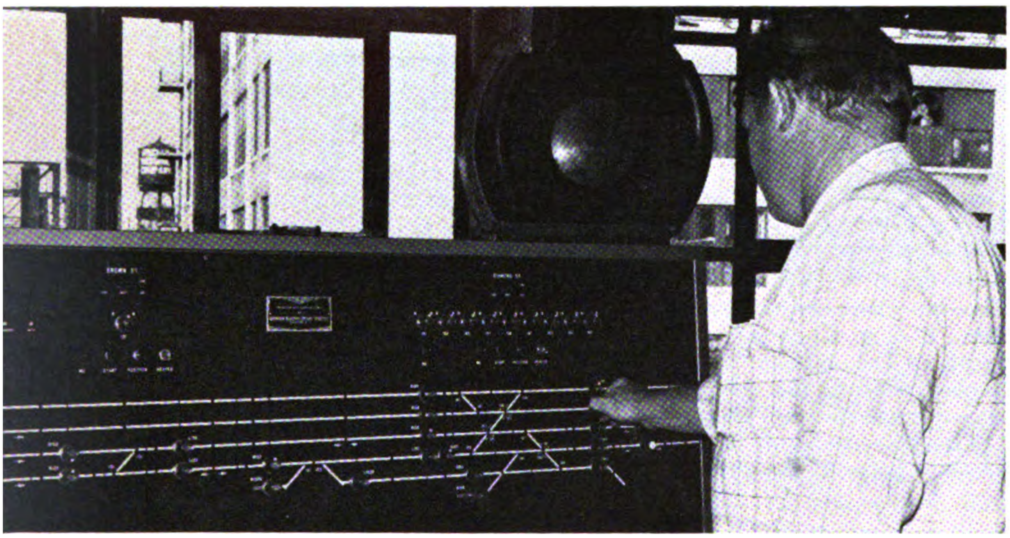


Fig. 2: Diagram of control system waveforms.



Operator pushes only two buttons to align a route.

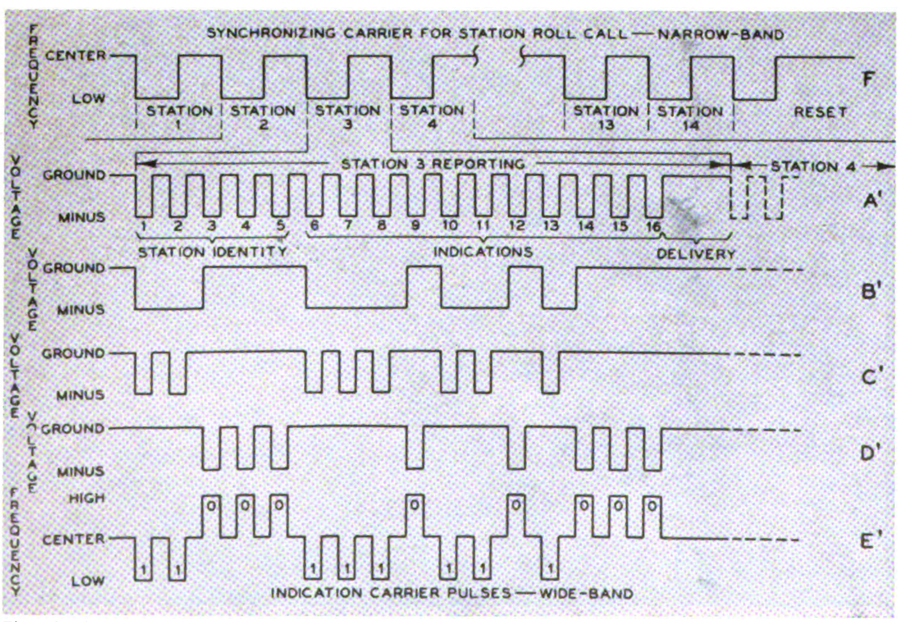


Fig. 3: Diagram of indication system waveforms.

in the system has been scanned, the station diode matrix establishes the end of transmission through a jumper arrangement, which resets the station counter to zero.

At the beginning of each system cycle, a reset pulse is fed to clear the storage section in the start unit. If a subsequent control start was initiated during the system cycle, the storage unit is then capable of remembering this information.

The message received from the code line at the field location is converted back to waveforms C and D by the control receiver, and applied to buses C and D, respectively (Fig. 5). These buses are fed into a word distributor.

FIELD LOCATION: CONTROL

The first 16 bits of the message (code)—the direct word—are sequentially fed into temporary storage—shift register SR 1 through SR 16. The punctuation space, immediately following the direct word, is sensed by the word distributor as a period of rest. This conditions the word distributor to transfer the next 16 bits—the complementary word—to shift register SR'1 through SR'16. When the direct word and its complement are stored, a sequence of functions occur simultaneously. Each step of the code, now lined up in both shift registers, must be in complementary order. This order is sensed by the comparators between each of the parallel shift registers. For example, as the first measure of a valid word, if SR 1 is one, then SR'1 must be zero. All bits of the message must be valid to produce an output at gate C. The resultant output from gate C is fed to "and" gate A.

Outputs from the direct-word register (SR1-SR16) are connected to a diode matrix and read gates. The first outputs correspond to station selection and are fed to the diode matrix. The remaining outputs correspond to field controls and are fed to the read gates.

The field control phase is now conditioned for the next step. During the period of rest following the complementary word, the word distributor initiates a delivery pulse which is fed to gate A. With an output from gate C present at gate A, the delivery pulse continues through gate A to the input of gate B.

Station selection was previously accomplished when the first bits of the code were applied to the input of the diode matrix. The diode matrix jumper arrangement leading to gate B represents the required connections for the particular field station.

With gate B conditioned by the output of the diode matrix, the delivery pulse passes through to become the execute pulse which is applied to each read gate. Outputs from the read gates are fed to the storage unit.

The same operating principles apply to the indication system at a field location as those which apply to the control system at the control office, with the following exceptions:

The relationship between the synchronizing and indication carriers is shown in Fig. 3. Field station 3 is shown expanded in time relation to its roll call allocation within the narrow-band synchronizing carrier waveform F.

The equipment scans the input units which are connected to contacts on the field function relays. Each input unit provides for the 16 bits which constitute station identity and indications. The input units supply parallel outputs, which are applied to the diode matrix scanner.

Only the direct word is generated in the indication system. Again, a clock, clock gate, and a word gate generator (Fig. 6) are used to operate the d-c pulsed time base for each bit and message, shown as waveform A′ (Fig. 3). Four counters are used—the fifth counter is omitted because its function is not required with the indication system, that is, no punctuation space or complementary word is used.

The encoder functions similarly in both systems in that it generates specific wave forms C′ and D′ from implied waveform B′. The negative going pulses (buses C and D) are fed to the indication transmitter which combines the two inputs as a single wideband carrier channel, waveform E′. In Fig. 6, these waveforms appear at A′, B′, C′, D′, and E′ respectively.

INDICATION AT OFFICE

The indication equipment in the control office is similar to the control equipment at a field location. A major difference is that the indication equipment includes a synchronizing channel, Figure 7, which maintains synchronism between the office and the field.

The counters in the field and office operate in synchronism and are controlled by the sync-time generator. As the sync-time generator advances the counters, the indications from each field station, in turn, are compared in the office for corresponding count (identity) between the two diode matrices which have a valid station identity. The resultant output is fed to an "and" gate and a common storage unit. The execute pulse, combined with the other two inputs to the gate unit, permits delivery to storage. The end of the cycle resets the counters to zero in preparation for a new cycle. **RSC**

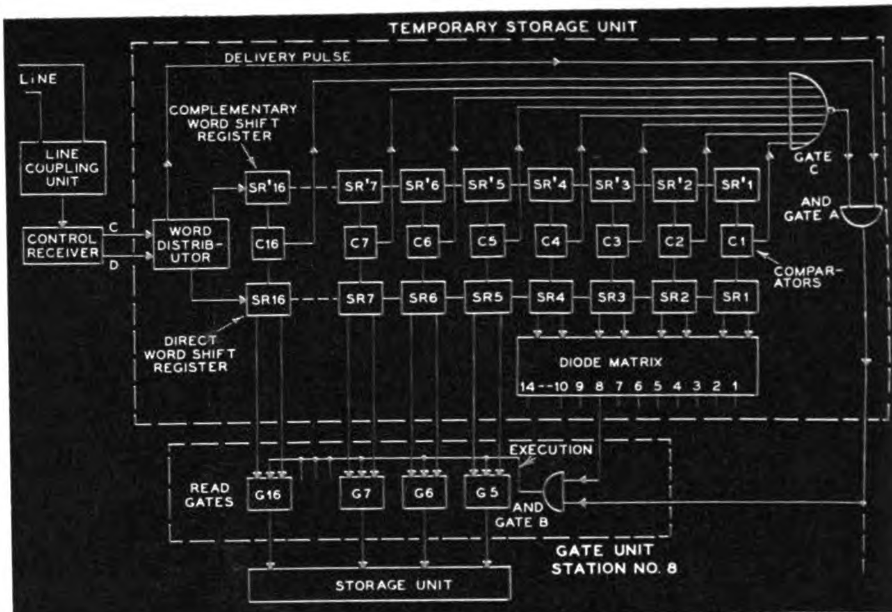


Fig. 5: Diagram of a field location in the control system.

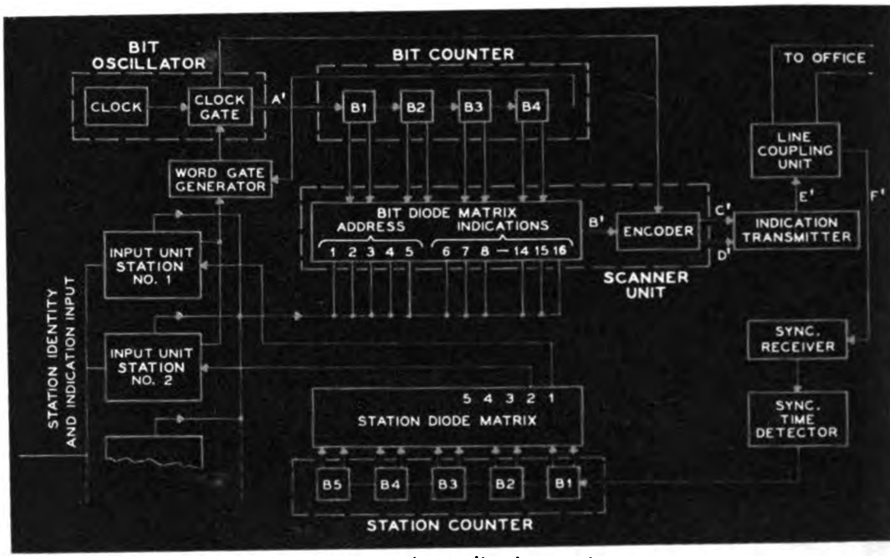


Fig. 6: Diagram of a field location in the indication system.

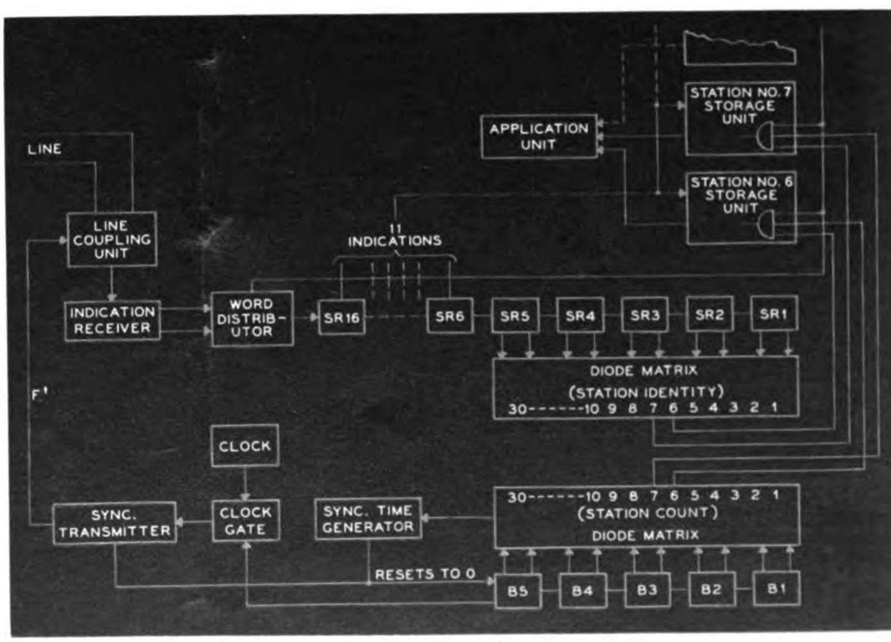


Fig. 7: Diagram of the control office in the indication system.