American Railway Signaling Principles and Practices

CHAPTER XXIII

Railroad-Highway Grade Crossing Protection

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CHAPTER XXIII

RAILROAD-HIGHWAY GRADE CROSSING PROTECTION

Introduction

Protection at railroad-highway grade crossings occupies a prominent position among the operating functions of a railroad. It is a function which does not contribute to or augment the service rendered by railroads, i.e., transportation—yet large and continuing expenditures of time and money are required each year for construction, maintenance, operation and renewal of crossing protection.

For one to better understand the rationalization of grade crossing protection as we know it today, certain contributing factors must be acknowledged, including a brief history of development.

Protection at grade crossings was first afforded by placing conspicuous signs at the crossing, one sign generally sufficing for either a single or multiple-track crossing. The legends on the sign conformed with the ideas of various railroad officials, state laws or state authorities. It was required that the engine whistle be sounded at varying distances from the crossing, one-fourth mile being most favored. The engine bell also sounded until the train reached the crossing.

At some crossings where vehicular and train traffic was relatively heavy, crossing watchmen were used along with the signs. The watchmen usually flagged the traffic with a red flag during the day and a red light during periods of darkness. The warning given by the watchmen was frequently ignored by the drivers, a practice which not only increased the hazard of crossing the track, but also jeopardized the watchmen as well. To alleviate this problem, manually operated gates which extended over the roadway were developed and used at some crossings. These acted as a barrier to approaching vehicles. The gates were first actuated by wire or pipe connections; later they were operated pneumatically, then by electric motors. Appropriate signs were continued in use to denote the existence of the crossing.

The first device to be controlled automatically was the bell. Although several mechanical schemes were used for such control, the invention and subsequent refinement of the track circuit made it possible to provide automatic control with greater facility. With the reliability of the track circuit established for detecting presence of the train, automatic grade crossing protective devices became more desirable. Many different designs of signals were developed for this purpose; however, the first signal to come into general use was the wig-wag. This signal was essentially a motor-driven banner equipped with a red light for night indication. The movement of the banner simulated the warning given by a watchman.

As motor vehicle registration began its inevitable rise toward the present-day registration of 74,084,000*, the need for uniformity in grade crossing protection became necessary. In 1916, the American Railway Association, predecessor of the Association of American Railroads, formulated and adopted certain uniform standards of protection. These standards included the painting of crossing gates with black and white stripes, provided for installation of standard ap-

*ICC—year 1960.

proach signs at a given distance from the crossing, the display of red lights on crossing gates, and type of warning given by a watchman. At the 1923 Annual Meeting of the Signal Section of the American Railway Association, the first standardization of automatic highway grade crossing signals was accepted by adoption of the following resolution:

> *Resolved:* That an electrically or mechanically operated signal, used for the protection of highway traffic at railroad crossings, shall present toward the highway, when indicating the approach of a train, the appearance of a horizontally swinging red light and/or disc.

As the number of vehicles on the highway and their area of operation continued to increase, their influence on the grade crossing protection problem became more pronounced. It became desirable to promote acceptance of uniformity in crossing protection in the various states to eliminate or reduce factors and elements which tended to confuse the drivers of autos, busses and trucks.

In April 1930, a Joint Committee on Grade Crossing Protection was organized within the American Railway Association. This committee's functions were (1) to investigate various types of railroad-highway grade crossing protective devices, with reference to the application of the best methods to the several classes of crossings and to recommend to the Association, standards and practices for the purpose; (2) to review the proposals, concerning railroad-highway grade crossing protection, of other Divisions and Sections of the Association, in order that they might be harmonized and properly represent the opinion of the Association; (3) to maintain contact with federal, state and other public authorities and to keep them informed with respect to these recommended standards and practices, with a view to the establishment of uniformity in aspect and operation of grade crossing protective apparatus. This Joint Committee (now known as the Grade Crossing Protection Subcommittee of the Train Operation, Control and Signals Committee, A.A R.), has been functioning since that time and railroads have generally adopted its recommendations. The Bureau of Public Roads, Department of Commerce, and practically all the state regulatory commissions as well as other national organizations have either adopted or approved them.

The problem of designating particular crossings for automatic protection is, of course, a complex one. Through the years, various expressions were formulated in an attempt to develop relative ratings of the crossings. These formulas have not become universally acceptable mainly for the reason that values assigned to various factors, while acceptable in some areas resulted in a distorted rating in other areas. Use of the formulas could result in protection being installed at crossings where the need is not as pronounced as one with a lower index. The more acceptable approach to this problem is through a study of each situation by competent engineers.

In rural areas, where crossings are for the most part generally isolated, each crossing is evaluated in the light of existing conditions applying to that crossing. However, in urban areas the study for the need of crossing protection is no longer confined to individual crossings; rather, it is broadened to the extent that in a given area the pattern of traffic flow and relative use of the individual crossings are taken into account for need requirements. Thus, from the results obtained, little used crossings are in the most cases closed and automatic protection provided for those that remain. This method of evaluation in urban areas is timely for a number of reasons. Of paramount importance, the safety factor is considerably increased. Further, present-day installation costs range from $7000 to over $60,000 per crossing, and in addition, maintenance costs per year per installation range from $500 to over $1000. The closing of unimportant or little used crossings makes more money available for those crossings which warrant automatic protection. The accelerated construction of limited access highways, of course, has its influence on diverting local traffic to those streets which involve railroad crossings.

While grade crossing protective devices are designed, installed, operated and maintained by the railroads, regulations exist in most states covering the installation. Those regulations generally follow the specifications and recommended practices of the Association of American Railroads, thus providing for uniformity in aspect and discouraging departure from time-proven fundamentals involved in grade crossing protection.

In order for grade crossing protective devices to reach their maximum effectiveness the meaning of their aspects must be prescribed, the drivers educated and necessary law enforcement provided. The presence of crossing signals does not in itself insure safe passage over the track. The driver and others must be aware of their obligation to use due caution at such intersections, which includes obedience to the signals.

To promote understanding and to encourage drivers to be diligent at railroad crossings, many states now include rules and regulations in their "Rules of the Road" pamphlets or similar publications which pertain to obedience to crossing signals and in some cases indicating penalties for noncompliance.

The National Committee on Uniform Traffic Laws and Ordinances, an arm of the White House Conference on Highway Safety, publishes as a guide to the states, a manual known as the "Uniform Vehicle Code" and a supplement thereto entitled, "The Model Traffic Ordinance for Municipalities." Several states have adopted entire sections verbatim. Article VII—Special Stops Required, under Chapter 11—Rules of the Road, in the Code, is particularly significant in promoting safety at railroad crossings. It reads as follows:

Sec. 11-701—Obedience to signal indicating approach of train

(a) Whenever any person driving a vehicle approaches a railroad grade crossing under any of the circumstances stated in this section, the driver of such vehicle shall stop within 50 feet but not less than 15 feet from the nearest rail of such railroad, and shall not proceed until he can do so safely. The foregoing requirements shall apply when:

1. A clearly visible electric or mechanical signal device gives warning of the immediate approach of a railroad train;

2. A crossing gate is lowered or when a human flagman gives or continues to give a signal of the approach or passage of a railroad train;

3. A railroad train approaching within approximately 1500 feet of the highway crossing emits a signal audible from such distance and such railroad train, by reason of its speed or nearness to such crossing is an immediate hazard;

4. An approaching railroad train is plainly visible and is in hazardous proximity to such crossing.

(b) No person shall drive any vehicle through, around or under any crossing gate or barrier at a railroad crossing while such gate or barrier is closed or is being opened or closed.

Sec. 11-702—All vehicles must stop at certain railroad grade crossings

The (State highway commission) and local authorities with the approval of the (State highway commission) are hereby authorized to designate particularly dangerous highway grade crossings of railroads and to erect stop signs thereat. When such stop signs are erected the driver of any vehicle shall stop within 50 feet but not less than 15 feet from the nearest rail of such railroad and shall proceed only upon exercising due care.

Sec. 11-703—Certain vehicles must stop at all railroad grade crossings

(a) The driver of any motor vehicle carrying passengers for hire, or of any school bus carrying any school child, or of any vehicle carrying explosive substances or flammable liquids as a cargo or part of a cargo, before crossing at grade any track or tracks of a railroad, shall stop such vehicle within 50 feet but not less than 15 feet from the nearest rail of such railroad and while so stopped shall listen and look in both directions along such track for any approaching train, and for signals indicating the approach of a train, except as hereinafter provided, and shall not proceed until he can do so safely. After stopping as required herein and upon proceeding when it is safe to do so the driver of any said vehicle shall cross only in such gear of the vehicle that there will be no necessity for changing gears while traversing such crossing and the driver shall not shift gears while crossing the track or tracks.

(b) No stop need be made at any such crossing where a police officer or a traffic-control signal directs traffic to proceed.

Sec. 11-704—Moving heavy equipment at railroad grade crossings

(a) No person shall operate or move any crawler-type tractor, steam shovel, derrick, roller, or any equipment or structure having a normal operating speed of 10 or less miles per hour or a vertical body or load clearance of less than one-half inch per foot of the distance between any two adjacent axles or in any event of less than 9 inches, measured above the level surface of a roadway, upon or across any tracks at a railroad grade crossing without first complying with this section.

(b) Notice of any such intended crossing shall be given to a station agent of such railroad and a reasonable time be given to such railroad to provide proper protection at such crossing.

(c) Before making any such crossing the person operating or moving any such vehicle or equipment shall first stop the same not less than 15 feet nor more than 50 feet from the nearest rail of such railroad and while so stopped shall listen and look in both directions along such track for any approaching train and for signals indicating the approach of a train, and shall not proceed until the crossing can be made safely.

(d) No such crossing shall be made when warning is given by automatic signal or crossing gates or a flagman or otherwise of the immediate approach of a railroad train or car. If a flagman is provided by the railroad, movement over the crossing shall be under his direction.

Further, under Chapter 11 of the Code, Article X—Stopping, Standing and Parking, reads:

Sec. 11-1003—Stopping, standing or parking prohibited in specified places

(a) No person shall stop, stand or park a vehicle, except when necessary to avoid conflict with other traffic or in compliance with law or the directions of a police officer or traffic-control device, in any of the following places:

****

9. Within 50 feet of the nearest rail of a railroad crossing.

Signals

It is recognized by those closely allied with the requirements of automatic highway grade crossing protection that such a thing as a *standard* installation cannot be achieved. Due to specific characteristics, each crossing must be studied individually and suitable protection designed to fit its requirements.

The descriptions of the signals, mechanisms, their location and control contained herein are for the most part generalized and may not in all cases completely cover existing installations. They are, however, basic and will convey to the reader the fundamental principles involved.

Visible Warning Signals

Two types of visible warning signals are in general use. They are the flashing light signal and the wig-wag signal. The latter is illustrated in Fig. 1.

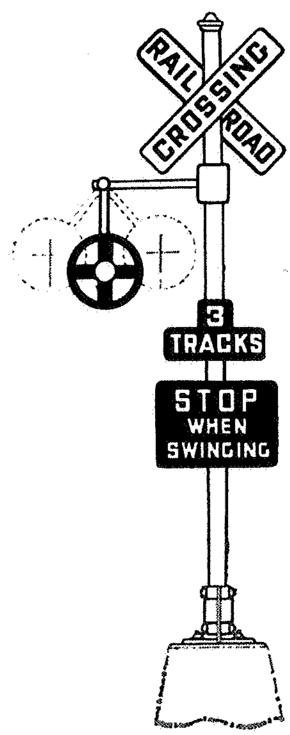


Fig. 1

As previously stated, this signal was the first to come into general use and it continues to provide protection at many grade crossings.

The wig-wag signal consists of a banner which swings to simulate the warning given by a watchman, a red light for night indication, a RAILROAD CROSSING sign which identifies the crossing, a "number of tracks" sign to indicate the number of tracks to be crossed where there is more than one track, and sometimes a STOP WHEN SWINGING sign.

The RAILROAD CROSSING sign, commonly called the "crossbuck," is mounted near the top of the supporting mast. When there are two or more tracks at the crossing, a "2 TRACKS," "3 TRACKS," etc., sign is mounted under the crossbuck. The crossbuck, painted or reflectorized, has a white background with black letters. The track numeral sign when painted, likewise has a white background. However, when reflectorized, both the track numeral sign and STOP WHEN SWINGING sign have black backgrounds with white letters. While the foregoing are general provisions there are installations with other colors.

Reflectorization is accomplished by reflector buttons or reflective sheet material.

The signal and signs are attached to a pipe post which is mounted on a concrete foundation. When a bell is used, it is generally mounted on top of the pipe post in place of the pinnacle. The electric light unit in the banner indicates in both directions along the highway. The roundels are five inches in diameter and are designed to have a range of 1500 feet through an angle of 20 degrees when using a 10-watt lamp at rated voltage.

While wig-wags are used at many crossings, the trend is toward the use of flashing light signals for new installations because they can be applied to all crossing layouts thereby producing uniformity. Additional light units and other adjuncts can be added for the more complex crossing layouts. Figure 2 illustrates flashing light signals at a crossing.

Fig. 2

At those crossings where street intersections are in close proximity to the track, additional flasher lights are sometimes employed for traffic using the side street. Such configurations make the use of the flashing light signal particularly desirable, and there are combinations and variations available to suit the particular need.

In Fig. 3 it is noted that the signs used with the flashing light signal are the same as those with the wig-wag signal with the exception that the STOP WHEN SWINGING is replaced with a STOP ON RED SIGNAL sign. The two flashing red electric light units are mounted 30 inches apart on a horizontal crossarm and are generally attached to a mast 7 to 9 feet above the crown of the highway.

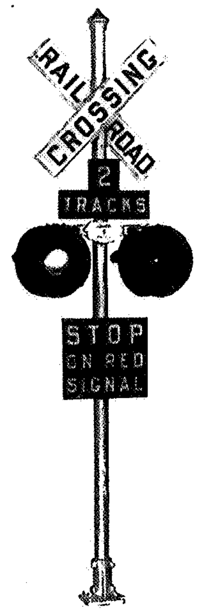
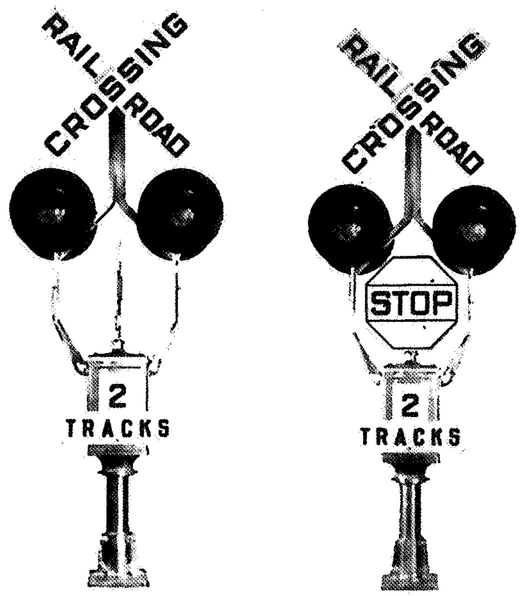


Fig. 3

Each light is alternately illuminated at a rate of 30 to 45 times per minute. Generally, the light units are installed "back to back" where the traffic over the track is in both directions. Such an arrangement provides an indication for the driver when passing another vehicle and when the near signal is obstructed by parked vehicles. Variations in light distribution as well as in the location of the signals themselves is often made where in the opinion of competent engineers such deviation is desirable or required to meet specific conditions. There are also different methods of assembly such as mounting of the lights, etc., depending on the particular manufacturer. However, the basic requirements are retained.

Through the use of other devices, the protection afforded by a flashing light signal is supplemented in many ways. These devices include the bell, rotating STOP sign, gates, NO RIGHT TURN or NO LEFT TURN sign, illuminated vertical or horizontal STOP signs and pre-emption of traffic light signals. Interest in standardization and uniformity has brought about general acceptance of the bell and gate. Limited use is made of the rotating STOP sign, and the vertical or horizontal illuminated STOP sign is seldom used on new installations. Necessity for uniformity limits the use of any adjunct except where it has essential value. It should be kept in mind that the wig-wag or flashing light signal is the basic protection and the other devices are adjuncts which supplement the basic protection.

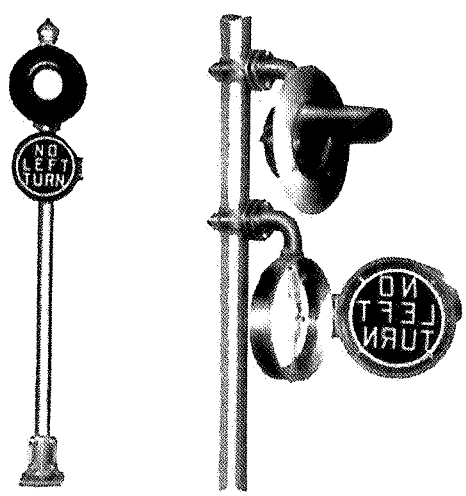
The first of the adjuncts described herein is the rotating STOP sign, illustrated in Fig. 4.



(A) (B)

Fig. 4

The rotating STOP sign, although not in universal use, is employed in certain states. Figure 4 (A) shows the position of the sign when the signal is not indicating the approach of a train. Figure 4 (B) illustrates the sign when the flashing light signals are operating, indicating the approach of a train to a crossing. The STOP sign itself is similar in shape and color to signs used on through highways and street intersections. A theory behind the use of the



(A) (B)

Fig. 5

rotating STOP sign when it was introduced, was to provide for a statutory stop. It is used only when required by a regulatory agency.

Another device, the NO RIGHT TURN or NO LEFT TURN signal, is illustrated in Fig. 5. This signal is sometimes used where streets which closely parallel the track intersect the street for which the basic protection is provided. It consists of two light units mounted vertically on a mast. Referring to Fig. 5 (A), the top unit, when in operation, displays a flashing yellow aspect, while the lower unit displays the legend NO RIGHT TURN or NO LEFT TURN. The legend is visible only when illuminated. Figure 5 (B) shows a close-up view of the component parts and the method of mounting. Oftentimes additional flashing light units are used in lieu of the NO TURN signal.

Automatic Gates

A commonly used adjunct to the flashing light signals at multiple main track crossings where both vehicle and train traffic is heavy and train speeds are high is the automatic gate shown in Fig. 6. The gate as shown is often referred to as "short arm" to indicate that the gate arm extends only over the approach lane of highway traffic, thereby providing an exit route for the vehicles which are on the tracks when the gates begin to lower.

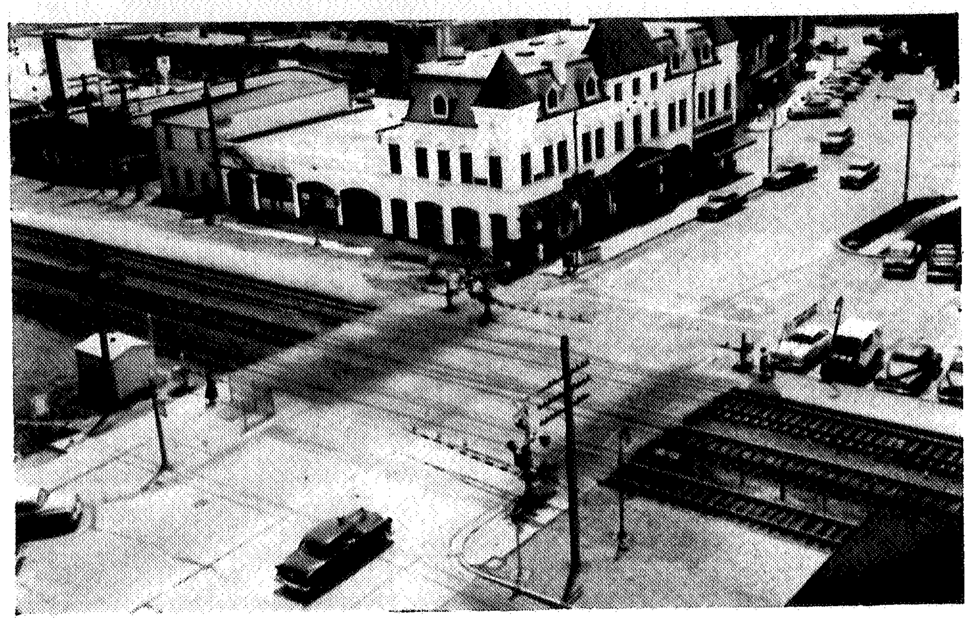
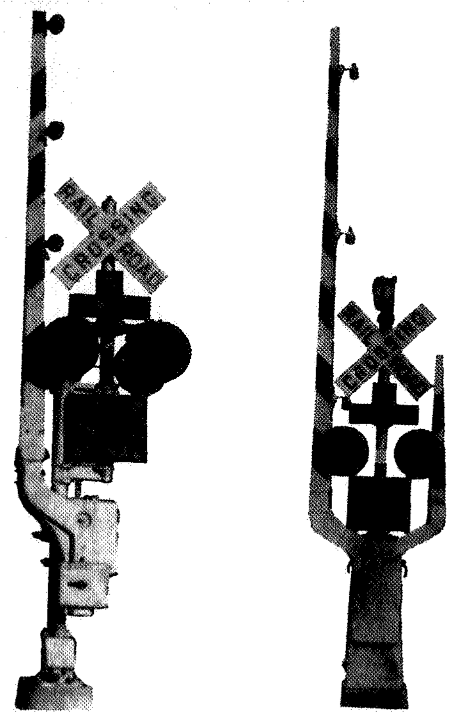


Fig. 6

The short-arm gate is used for the purpose of trying to prevent the impatient or absent-minded driver from entering the crossing area immediately after one train has passed if another train is approaching the crossing. The control of the gate operation is such that the flashing light signals operate sufficiently in advance of the lowering of the gates to enable those close to the tracks as well as those on the tracks to continue over the crossing without obstruction. Inasmuch as the gates are not the basic protection, controls for their operation provide that they be in the horizontal position only before the train reaches the crossing.

There are two general types of short-arm gate assemblies in common use, the mast-mounted type shown in Fig. 7 (A) and the pedestal type shown in Fig. 7 (B).



(A) (B)

Fig. 7

The assembly consists of the gate arm, gate arm lights, gate mechanism, and counterweights. When indicating the approach of a train, the light nearest the tip of the arm is steadily illuminated and the remaining two lights flash alternately. When the gates are in the vertical position, considerable downward torque is present so that the gate arm will lower by gravity when required. In addition to the force of gravity, some mechanisms power-drive down to the 45-degree position. Torque is provided by design of the gate arm supports and counterweights which may be adjusted for different length gate arms. The controlling circuits are designed to the extent practicable, that interruption of the circuit will cause the gate arm to lower.

Typical Locations of Crossing Signals

The degree of effectiveness of crossing protection is influenced considerably by its location. At one time it was considered good practice to install signals in the center of the street and, from the standpoint of providing an indication to the driver, such a location was effective. However, as the number of vehicles increased along with their speed, accidents became frequent where the vehicle struck the signal. Outside of extraordinary conditions, signals are now located adjacent to the approach lane of traffic. It is imperative that the driver has a clear and unobstructed view of the crossing signal. Therefore, in addition to properly locating the signal, consideration should also be given to removal of any obstruction which obscures the view of the driver as he approaches the crossing. Figures 8 through 19 show typical locations of signals with respect to the highway and track for different situations.

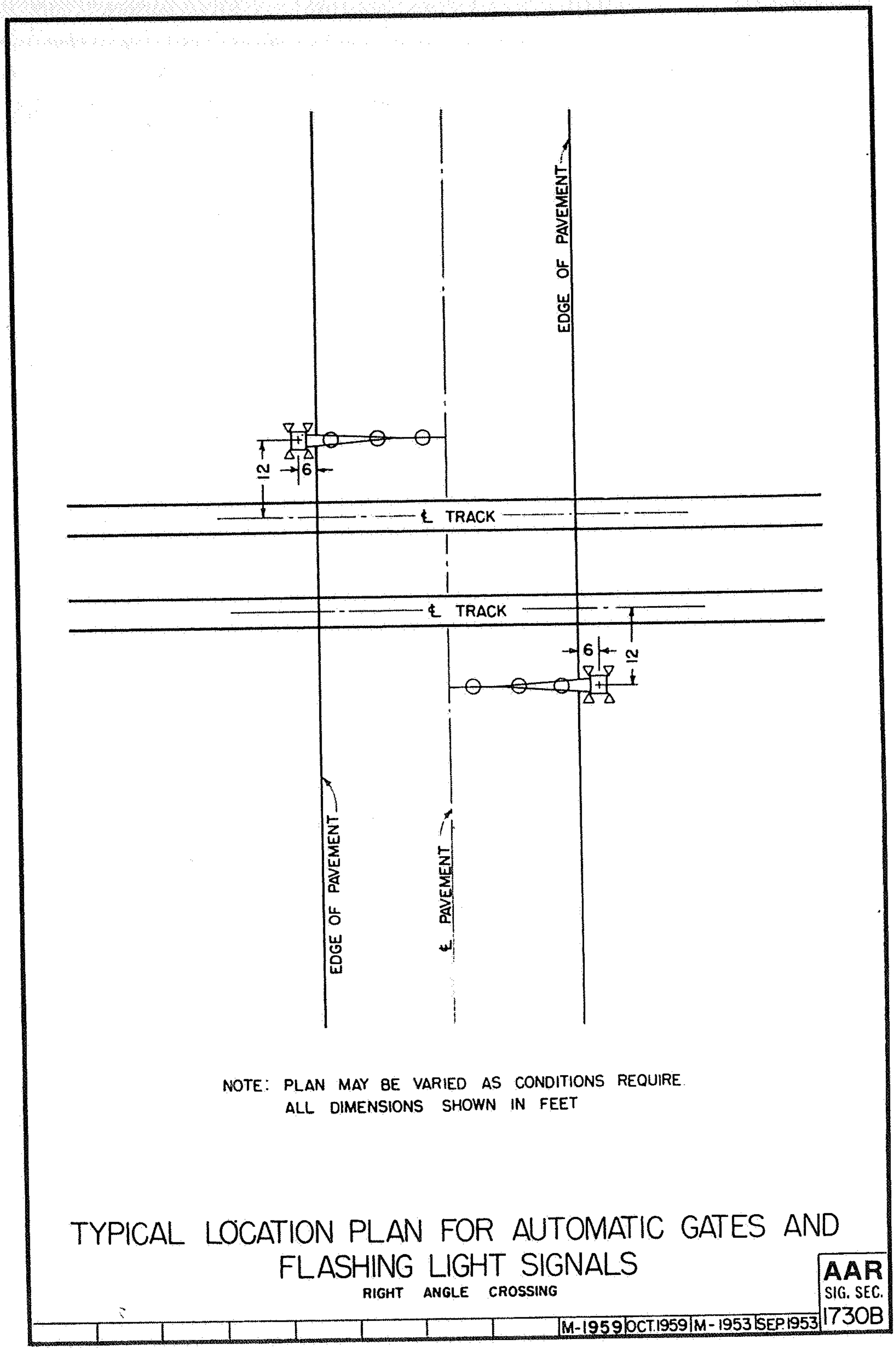
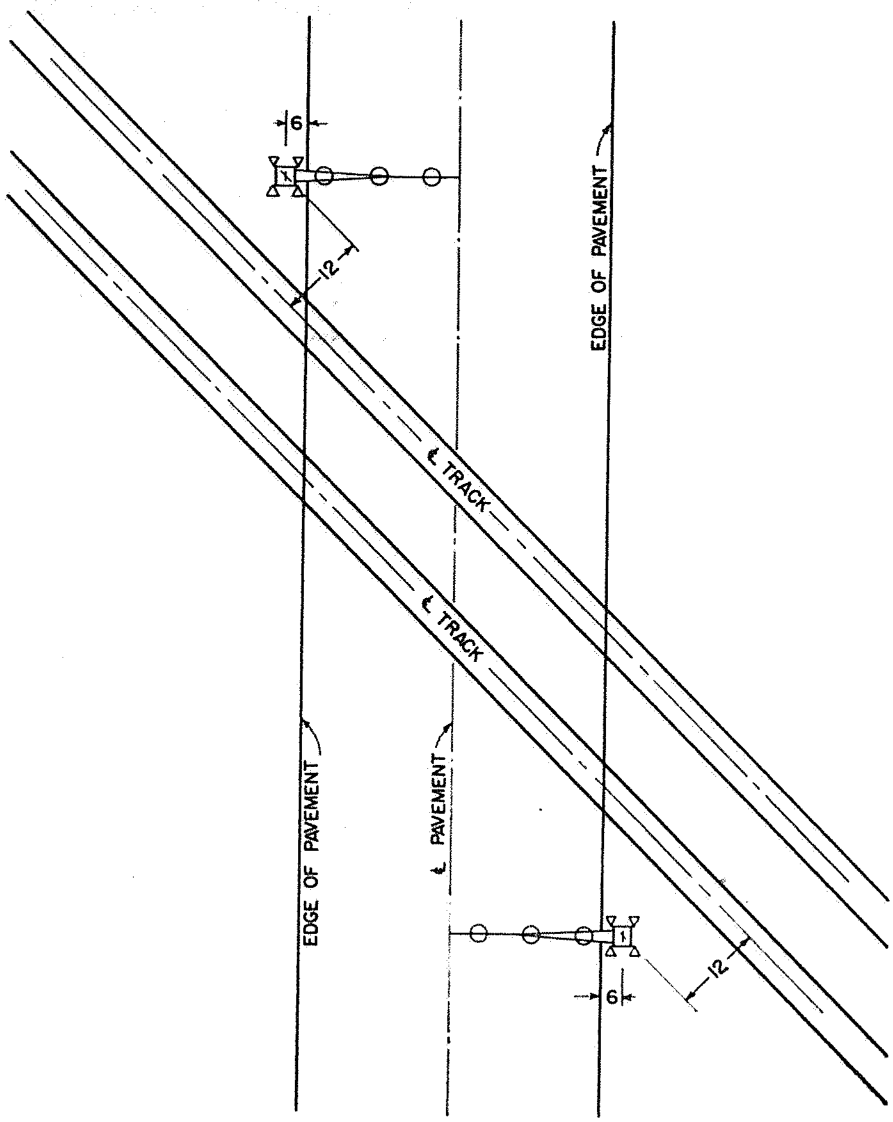

EDGE OF PAVEMENT
12
6
℄ TRACK
℄ TRACK
6
12
EDGE OF PAVEMENT
℄ PAVEMENT
NOTE: PLAN MAY BE VARIED AS CONDITIONS REQUIRE.
ALL DIMENSIONS SHOWN IN FEET
TYPICAL LOCATION PLAN FOR AUTOMATIC GATES AND FLASHING LIGHT SIGNALS
RIGHT ANGLE CROSSING
AAR
SIG. SEC.
1730B
M-1959 OCT.1959 M-1953 SEP.1953

Fig. 8



NOTE: PLAN MAY BE VARIED AS CONDITIONS REQUIRE.
ALL DIMENSIONS SHOWN IN FEET

TYPICAL LOCATION PLAN FOR AUTOMATIC GATES AND FLASHING LIGHT SIGNALS

ACUTE ANGLE CROSSING

AAR SIG. SEC.

M-1959 OCT.1959 M-1953 SEP.1953 1731B

Fig. 9

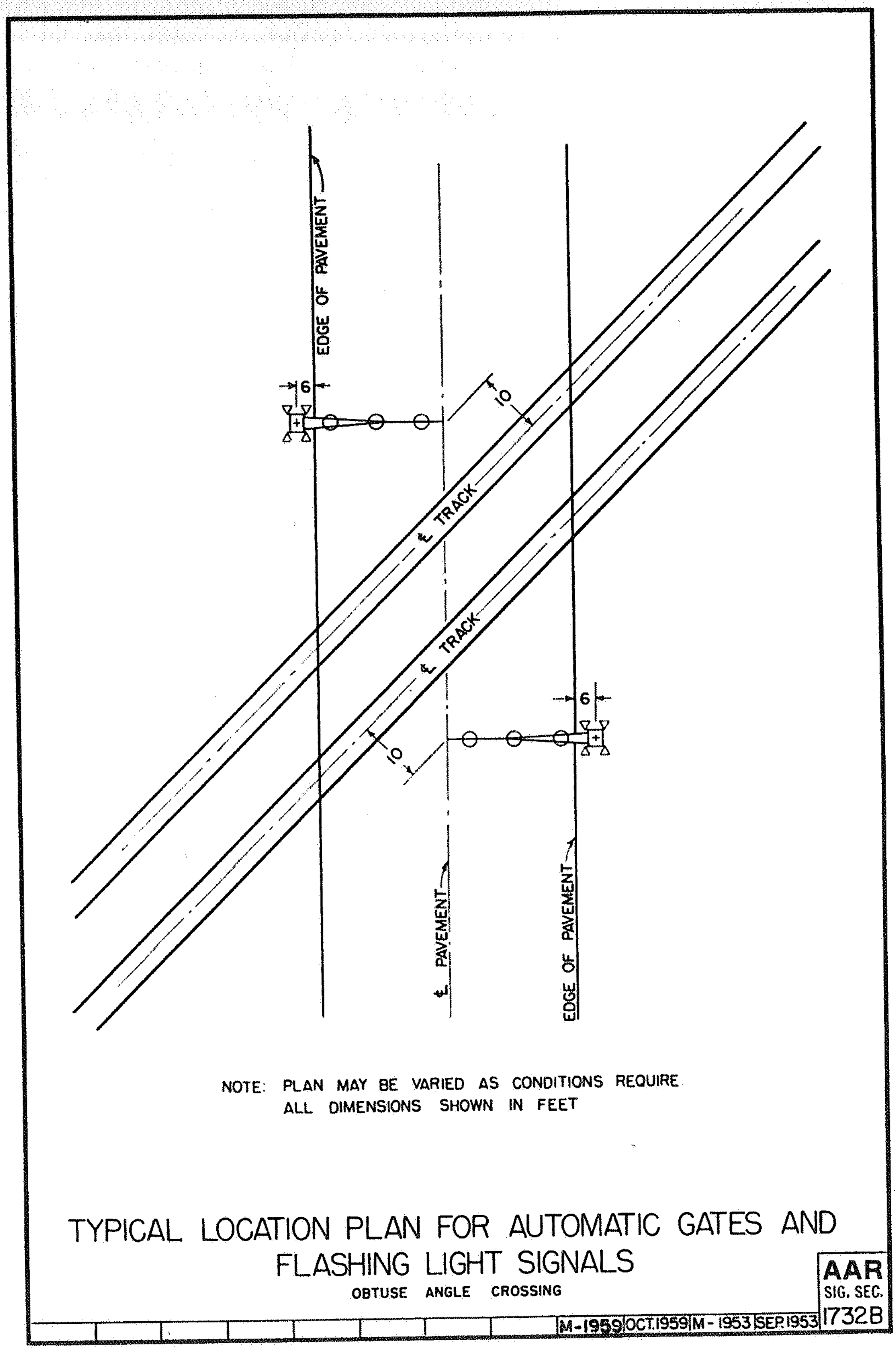

EDGE OF PAVEMENT
6
10
℄ TRACK
℄ TRACK
6
10
℄ PAVEMENT
EDGE OF PAVEMENT
NOTE: PLAN MAY BE VARIED AS CONDITIONS REQUIRE
ALL DIMENSIONS SHOWN IN FEET
TYPICAL LOCATION PLAN FOR AUTOMATIC GATES AND
FLASHING LIGHT SIGNALS
OBTUSE ANGLE CROSSING
AAR
SIG. SEC.
1732B
M-1959 OCT.1959 M-1953 SEP.1953

Fig. 10

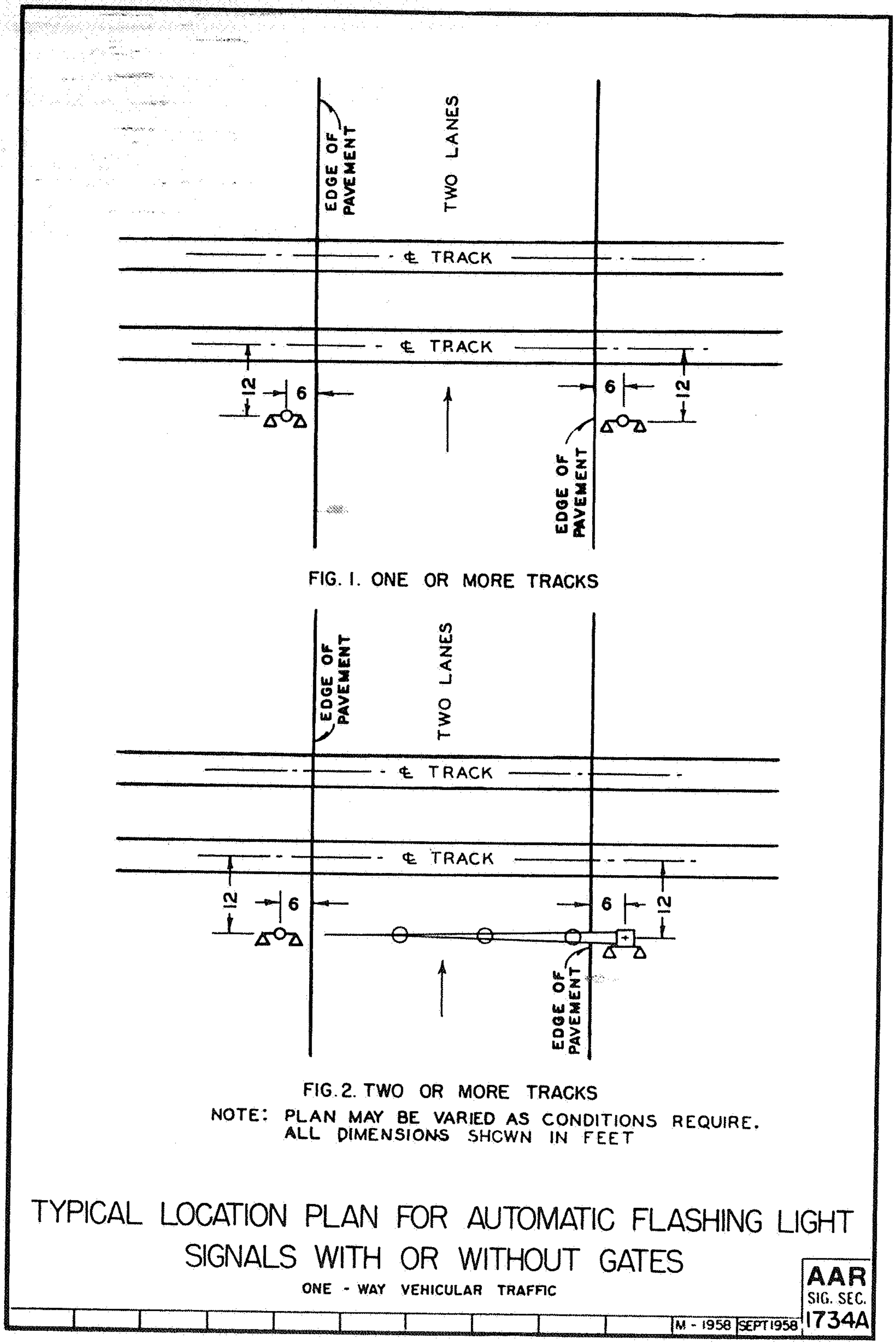

EDGE OF PAVEMENT
TWO LANES
℄ TRACK
℄ TRACK
12
6
6
12
EDGE OF PAVEMENT
FIG. 1. ONE OR MORE TRACKS
EDGE OF PAVEMENT
TWO LANES
℄ TRACK
℄ TRACK
12
6
6
12
EDGE OF PAVEMENT
FIG. 2. TWO OR MORE TRACKS
NOTE: PLAN MAY BE VARIED AS CONDITIONS REQUIRE.
ALL DIMENSIONS SHOWN IN FEET
TYPICAL LOCATION PLAN FOR AUTOMATIC FLASHING LIGHT SIGNALS WITH OR WITHOUT GATES
ONE - WAY VEHICULAR TRAFFIC
AAR
SIG. SEC.
1734A
M - 1958
SEPT 1958

Fig. 11

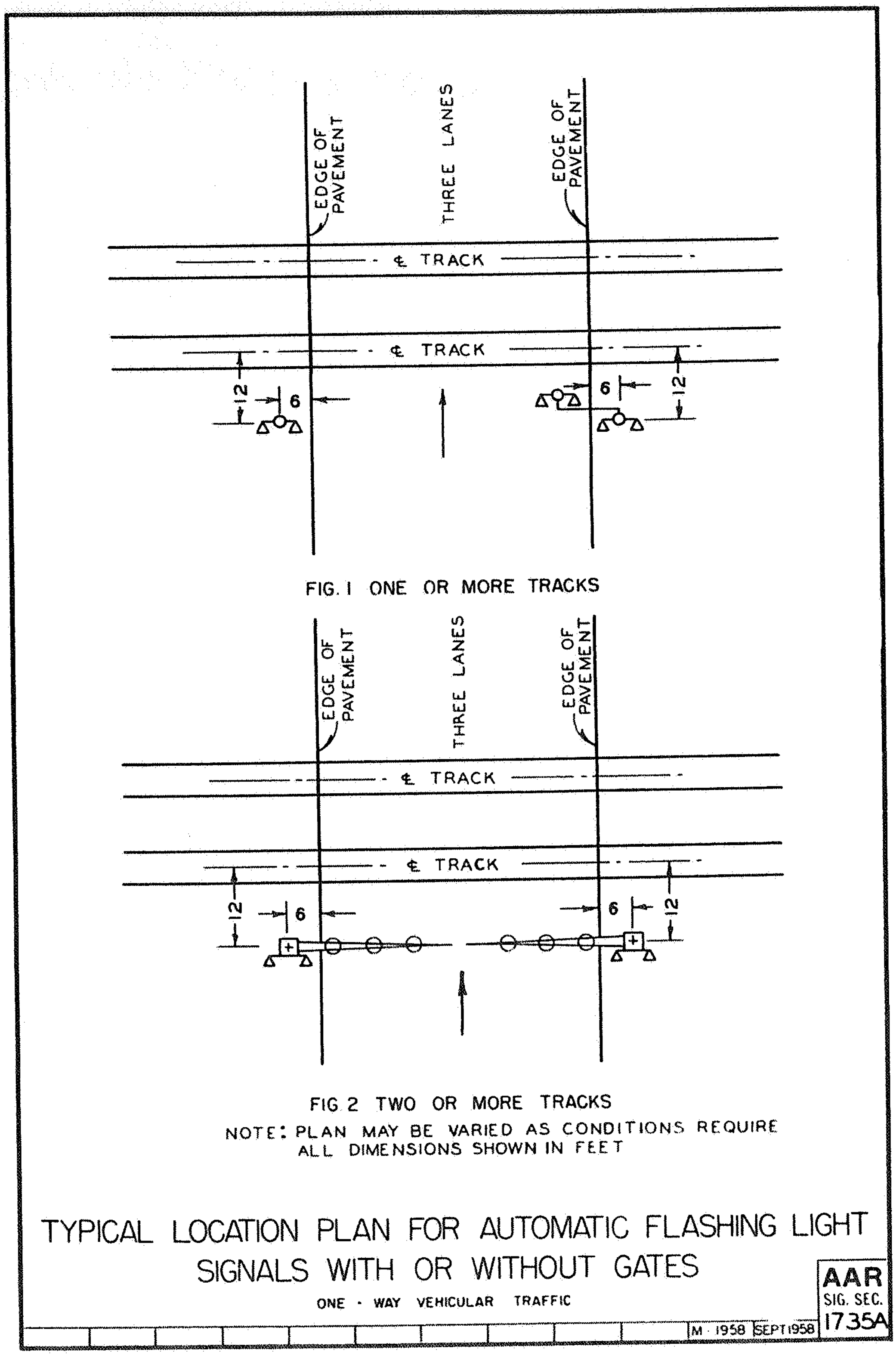

EDGE OF PAVEMENT
THREE LANES
EDGE OF PAVEMENT
℄ TRACK
℄ TRACK
12
6
6
12
FIG. 1 ONE OR MORE TRACKS
EDGE OF PAVEMENT
THREE LANES
EDGE OF PAVEMENT
℄ TRACK
℄ TRACK
12
6
6
12
FIG 2 TWO OR MORE TRACKS
NOTE: PLAN MAY BE VARIED AS CONDITIONS REQUIRE
ALL DIMENSIONS SHOWN IN FEET
TYPICAL LOCATION PLAN FOR AUTOMATIC FLASHING LIGHT
SIGNALS WITH OR WITHOUT GATES
ONE - WAY VEHICULAR TRAFFIC
AAR
SIG. SEC.
1735A
M · 1958
SEPT 1958

Fig. 12

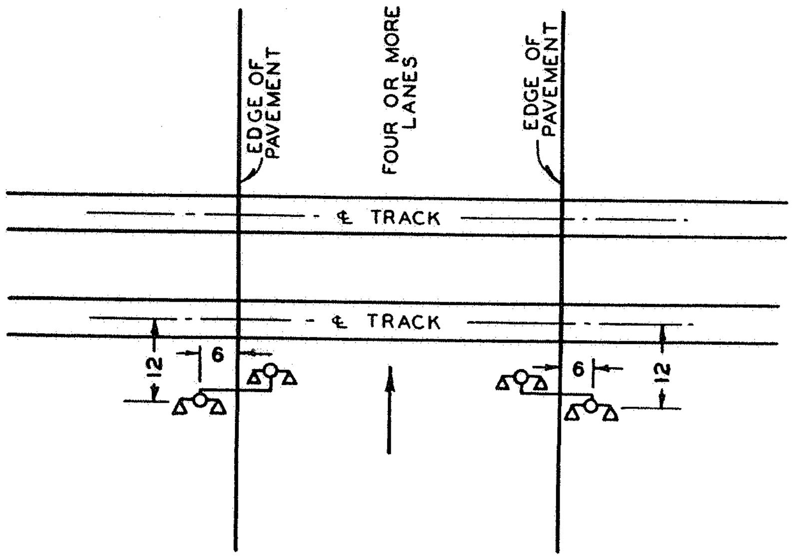


FIG. 1. ONE OR MORE TRACKS

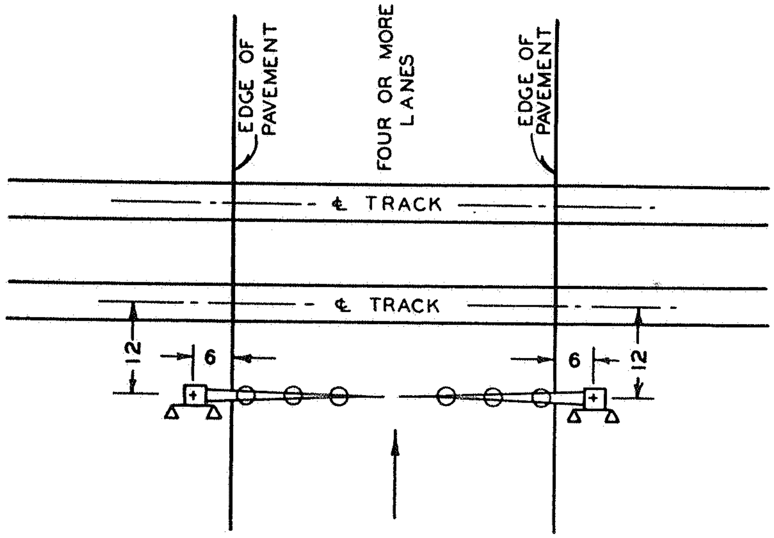


FIG. 2 TWO OR MORE TRACKS

NOTE: PLAN MAY BE VARIED AS CONDITIONS REQUIRE.
ALL DIMENSIONS SHOWN IN FEET

TYPICAL LOCATION PLAN FOR AUTOMATIC FLASHING LIGHT SIGNALS WITH OR WITHOUT GATES

ONE - WAY VEHICULAR TRAFFIC

AAR SIG. SEC. 1736A

M - 1958 | SEPT 1958

Fig. 13

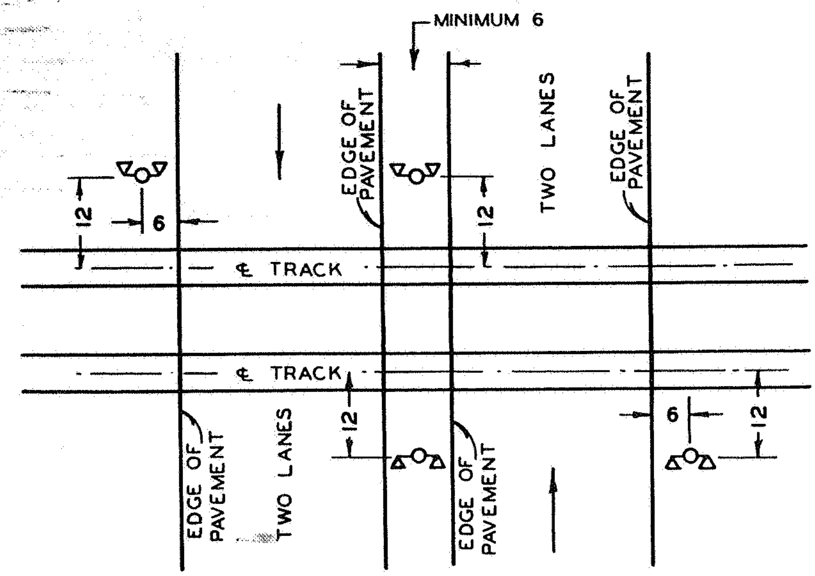


FIG. 1. ONE OR MORE TRACKS

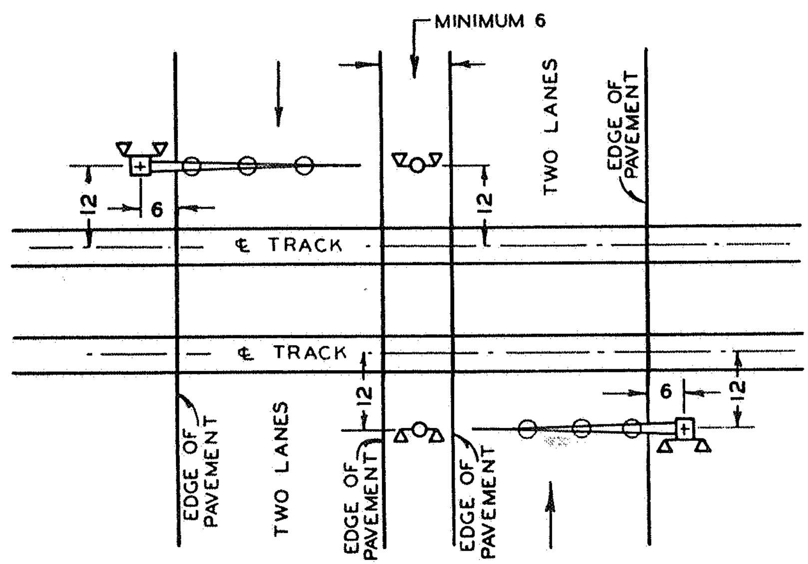


FIG. 2 TWO OR MORE TRACKS

NOTE: PLAN MAY BE VARIED AS CONDITIONS REQUIRE.
ALL DIMENSIONS SHOWN IN FEET

TYPICAL LOCATION PLAN FOR AUTOMATIC FLASHING LIGHT SIGNALS WITH OR WITHOUT GATES

DIVIDED HIGHWAY

AAR SIG. SEC. 1737 A

M-1958 SEPT 1958

Fig. 14

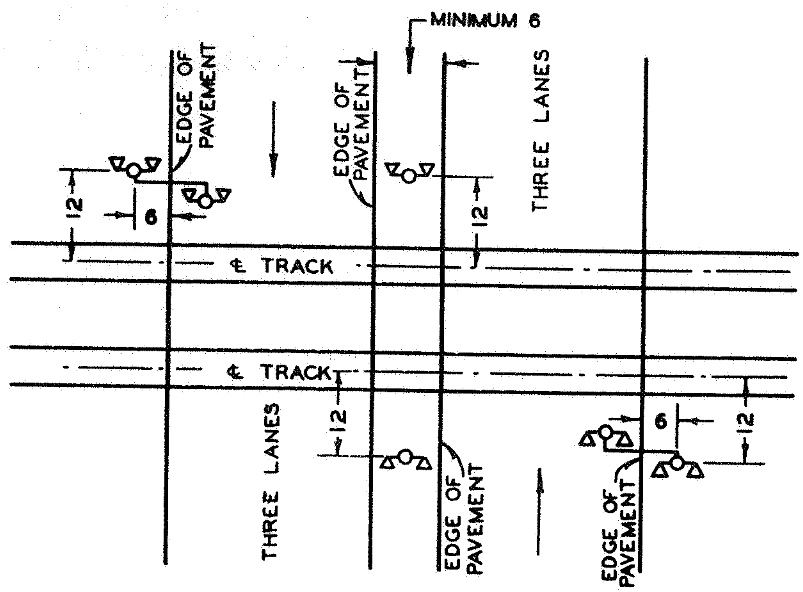


FIG. 1. ONE OR MORE TRACKS

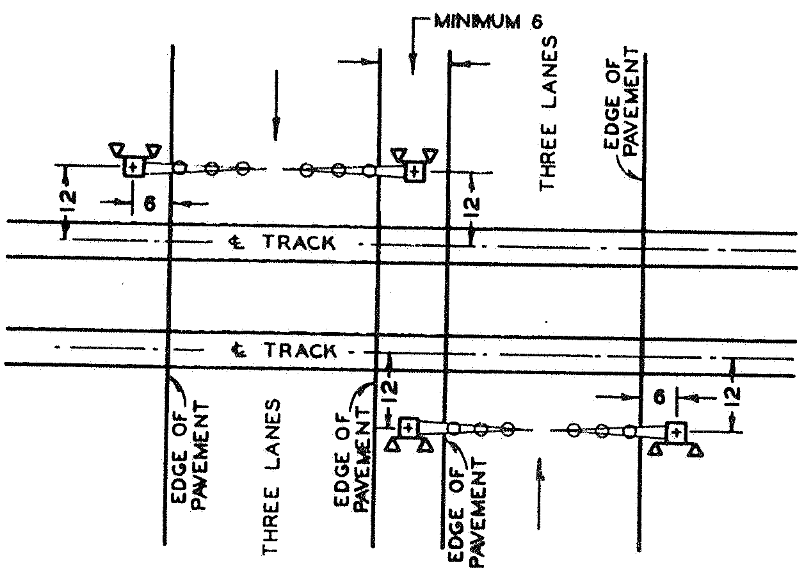


FIG. 2. TWO OR MORE TRACKS

NOTE: PLAN MAY BE VARIED AS CONDITIONS REQUIRE.
ALL DIMENSIONS SHOWN IN FEET

TYPICAL LOCATION PLAN FOR AUTOMATIC FLASHING LIGHT SIGNALS WITH OR WITHOUT GATES

DIVIDED HIGHWAY

M - 1958 | SEPT 1958 | AAR SIG. SEC. 1738A

Fig. 15

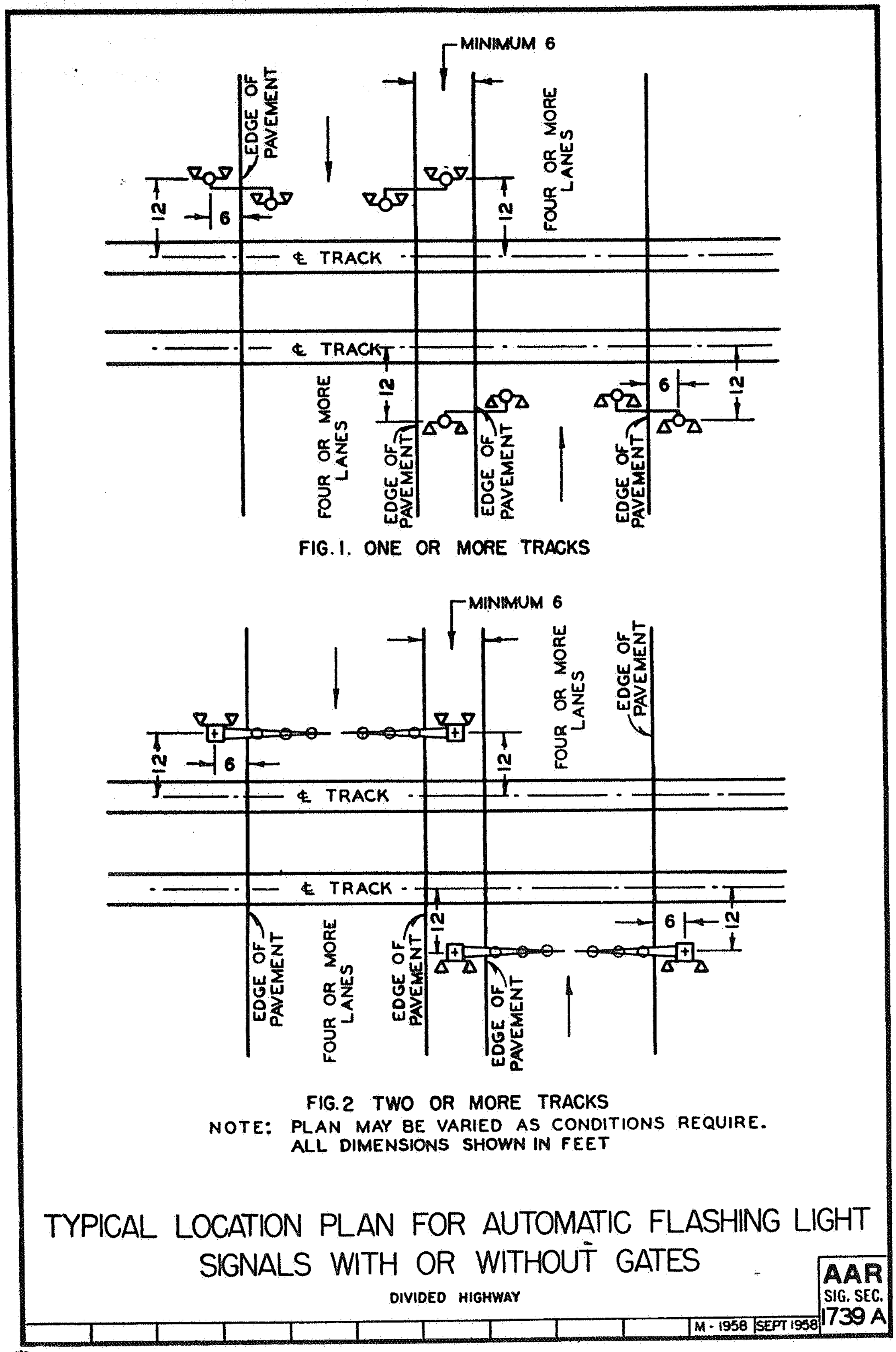

MINIMUM 6
EDGE OF PAVEMENT
FOUR OR MORE LANES
12
6
℄ TRACK
℄ TRACK
FIG. 1. ONE OR MORE TRACKS
FIG. 2 TWO OR MORE TRACKS
NOTE: PLAN MAY BE VARIED AS CONDITIONS REQUIRE.
ALL DIMENSIONS SHOWN IN FEET
TYPICAL LOCATION PLAN FOR AUTOMATIC FLASHING LIGHT SIGNALS WITH OR WITHOUT GATES
DIVIDED HIGHWAY
AAR
SIG. SEC.
1739 A
M - 1958
SEPT 1958

Fig. 16

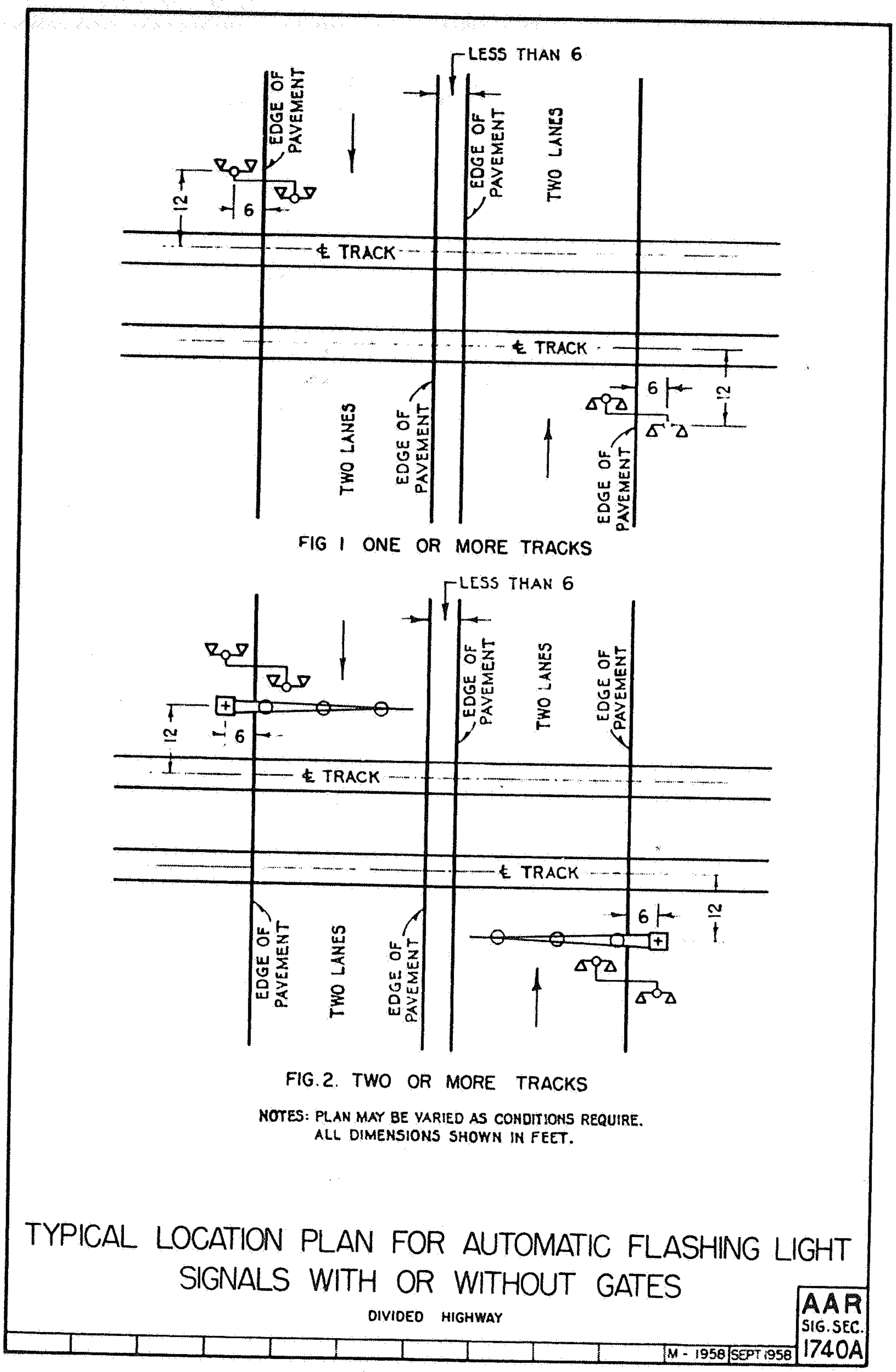

LESS THAN 6
EDGE OF PAVEMENT
TWO LANES
12
6
℄ TRACK
FIG 1 ONE OR MORE TRACKS
FIG. 2. TWO OR MORE TRACKS
NOTES: PLAN MAY BE VARIED AS CONDITIONS REQUIRE.
ALL DIMENSIONS SHOWN IN FEET.
TYPICAL LOCATION PLAN FOR AUTOMATIC FLASHING LIGHT SIGNALS WITH OR WITHOUT GATES
DIVIDED HIGHWAY
AAR
SIG. SEC.
1740A
M - 1958
SEPT 1958

Fig. 17

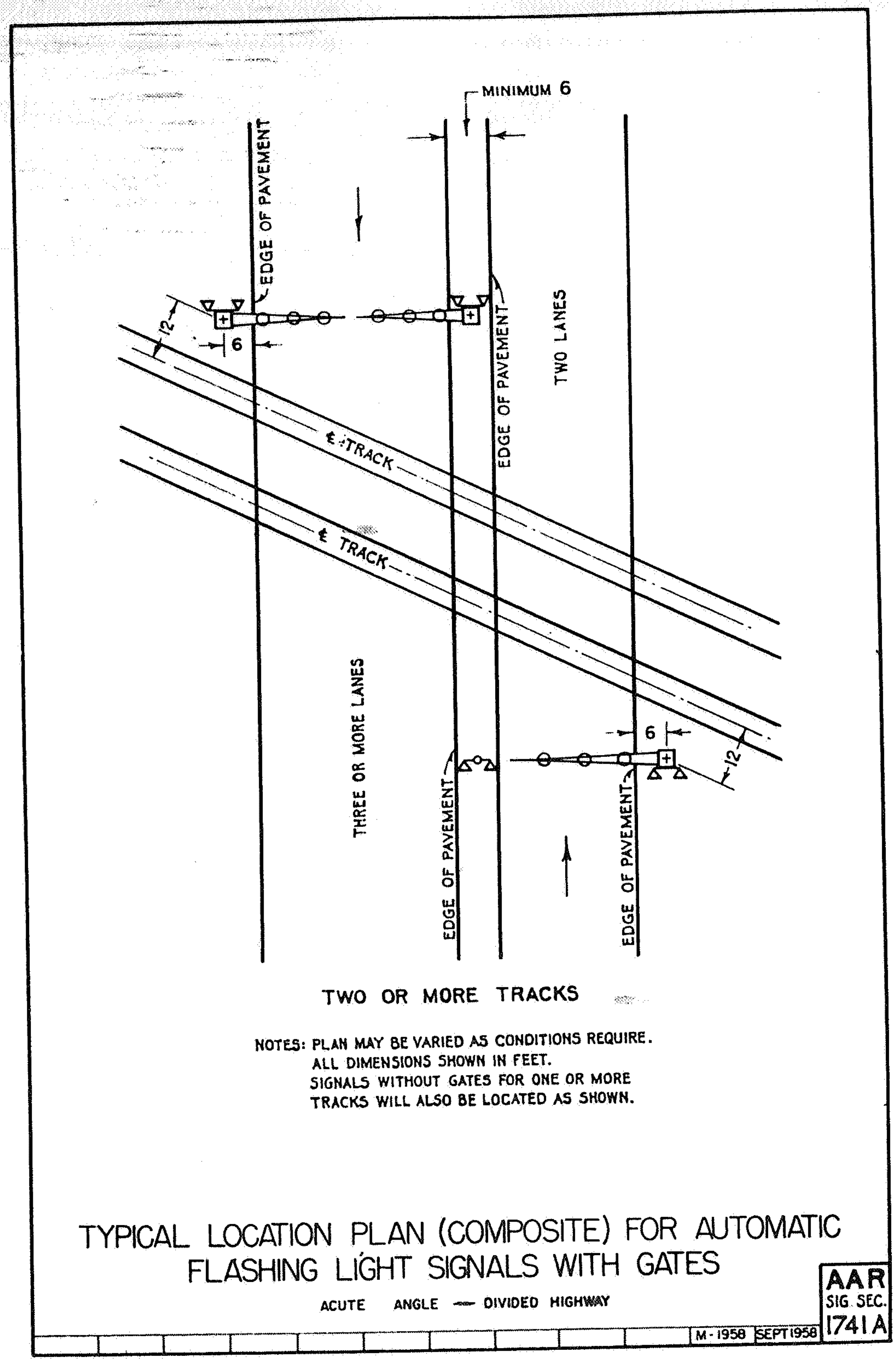
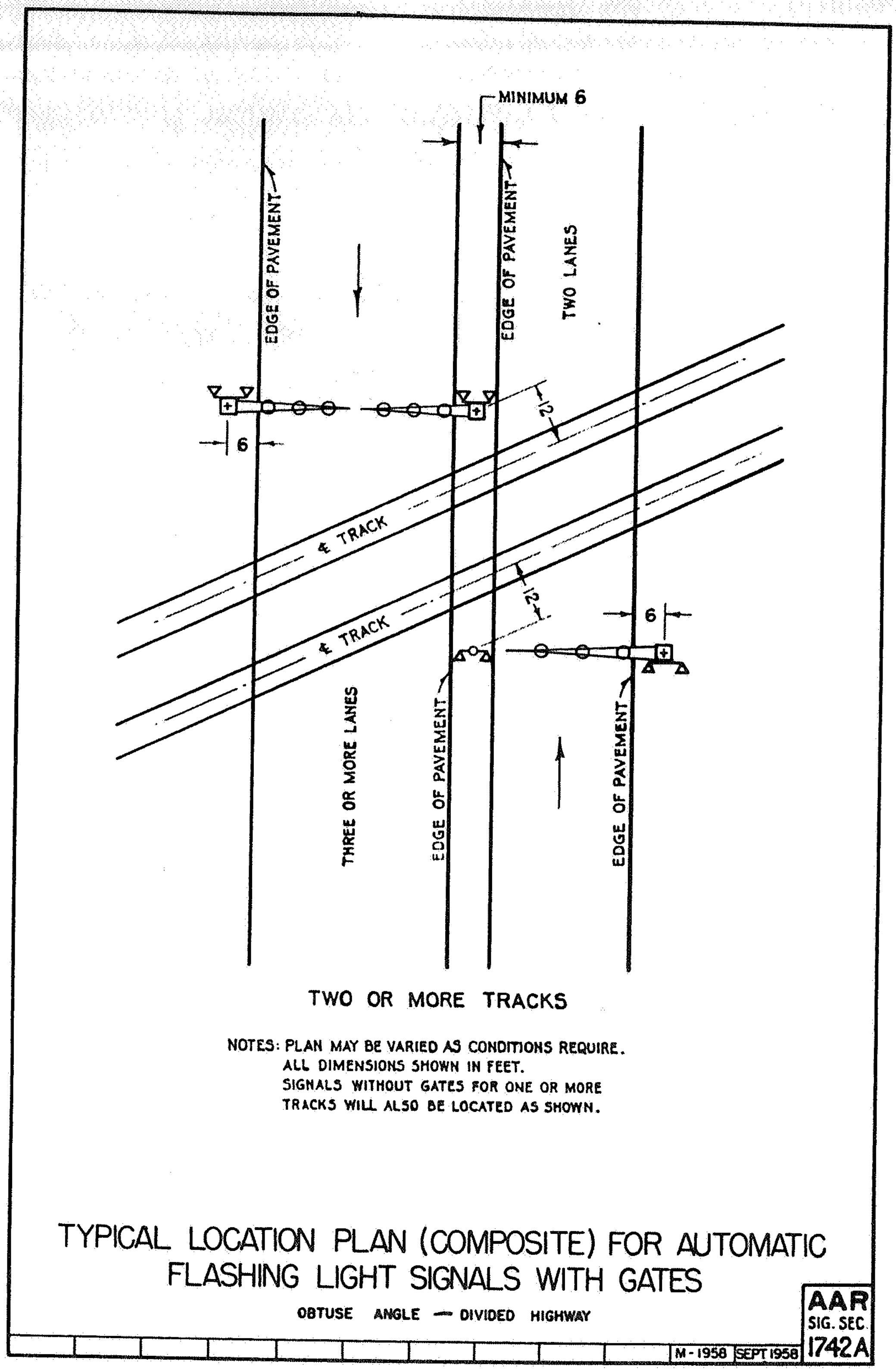

MINIMUM 6
EDGE OF PAVEMENT
EDGE OF PAVEMENT
TWO LANES
12
6
℄ TRACK
℄ TRACK
THREE OR MORE LANES
6
12
EDGE OF PAVEMENT
EDGE OF PAVEMENT
TWO OR MORE TRACKS
NOTES: PLAN MAY BE VARIED AS CONDITIONS REQUIRE.
ALL DIMENSIONS SHOWN IN FEET.
SIGNALS WITHOUT GATES FOR ONE OR MORE TRACKS WILL ALSO BE LOCATED AS SHOWN.
TYPICAL LOCATION PLAN (COMPOSITE) FOR AUTOMATIC FLASHING LIGHT SIGNALS WITH GATES
ACUTE ANGLE — DIVIDED HIGHWAY
AAR SIG. SEC. 1741 A
M-1958 SEPT 1958

Fig. 18


MINIMUM 6
EDGE OF PAVEMENT
EDGE OF PAVEMENT
TWO LANES
6
12
℄ TRACK
℄ TRACK
12
6
THREE OR MORE LANES
EDGE OF PAVEMENT
EDGE OF PAVEMENT
TWO OR MORE TRACKS
NOTES: PLAN MAY BE VARIED AS CONDITIONS REQUIRE.
ALL DIMENSIONS SHOWN IN FEET.
SIGNALS WITHOUT GATES FOR ONE OR MORE
TRACKS WILL ALSO BE LOCATED AS SHOWN.
TYPICAL LOCATION PLAN (COMPOSITE) FOR AUTOMATIC
FLASHING LIGHT SIGNALS WITH GATES
OBTUSE ANGLE — DIVIDED HIGHWAY
AAR
SIG. SEC.
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M-1958
SEPT 1958

Fig. 19

While the illustrations cover, in general, the types of crossings encountered variation in location of the signals and special arrangement of the lights is sometimes required. Where it is necessary to mount the lights overhead for clearance and other reasons, the cantilever type signal illustrated in Fig. 20 is used.

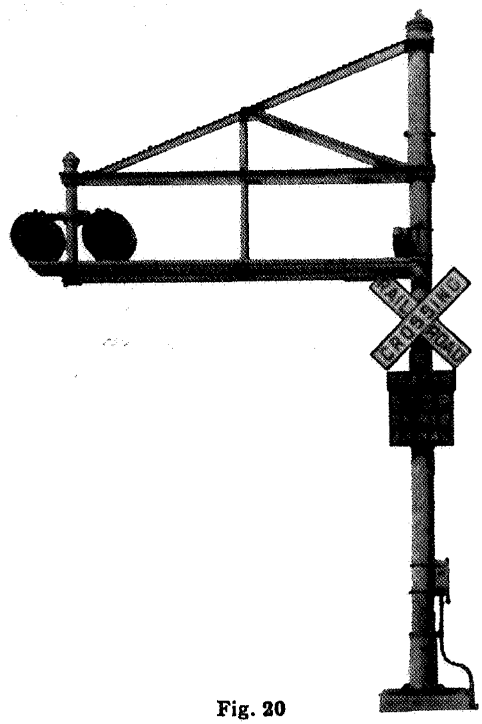


Fig. 20

This type of signal is available in various lengths (top frame) from 6 to 12 feet. Frequently, additional lights are used on the main mast for supplemental indications.

Light Units

The light unit is the arresting part of the flashing light signal and is shown in Fig. 21.

Light units are manufactured by several companies and while there are slight differences in their assembly, they meet the basic requirements.

The main components of the light unit are the hood, background, roundel, lamp, lampholder, reflector and housing. The provision for the white light located at right angles to the red roundel is optional.

The background, which is 20 inches in diameter, and the hoods are painted a nonreflecting black to provide a contrast for the red light. The roundel, which is highway crossing red in color, is 8⅜ inches in diameter. The assembly permits of easy access to the reflector and lamp. The unit when closed is weathertight, and ventilators are provided for free circulation of air. Each unit is focused by the manufacturer using a signal precision lamp to provide maximum range and efficiency.

A typical roundel or glass is illustrated in Fig. 22. Different roundels are used to obtain a particular light distribution pattern to meet the needs at a given crossing. The "spreadlight" roundel distributes light uniformly through the entire angle indicated on the glass, one-half the angle being on each side of the beam axis. A common example of such roundel is the 30-degree horizontal spread. A deflecting roundel directs a portion of the light from the beam to one side of the axis in the direction indicated on the glass. A roundel

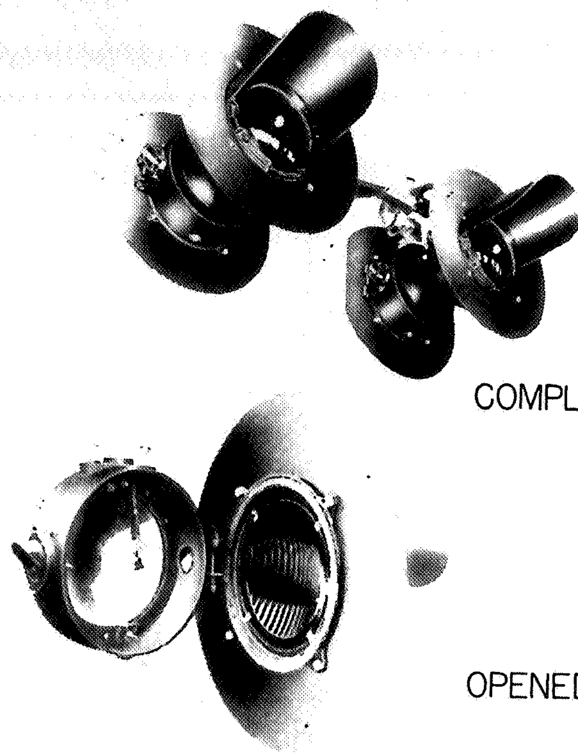


Fig. 21

having both spreadlight and deflecting features is so designed that the deflection is at right angles to the spread. An example of such roundel is the 30-degree horizontal spread 15-degree downward deflection illustrated in Fig. 22. A roundel using a 20-degree spread and 32-degree downward deflection is used on cantilever type signals. The identification of the characteristics of each is molded in the glass and it is important that the same kind be used in replacement.

Coupled with the location of the signal, proper alignment of the flashing light unit is also required to provide the desired range and visibility. A method of aligning light units equipped with 30-degree spreadlight and 15-degree downward deflecting roundels in both front and back lights when two men are available is illustrated in Fig. 23.

The procedure is as follows:

1. Procedure for front light units.
   (a) Continuously light one lamp.
   (b) Open door wide so clear beam is displayed.
   (c) Adjust light unit vertically to align axis of beam 5 feet 6 inches above pavement at 400 feet in approach to the signal.
   (d) Adjust light unit horizontally to align axis of beam to center of approach lane at 400 feet in approach to the signal, maintaining vertical alignment, as in 1 (c).
   (e) Tighten clamps and close door.
   (f) Repeat 1 (a) to 1 (e), inclusive, on other front light units.
2. Procedure for back light units where used.
   (a) Continuously light one lamp.
   (b) Open door wide so clear beam is displayed.

(c) Adjust light unit vertically to align axis of beam 5 feet 6 inches above pavement at a point 50 feet in approach to the signal on opposite side of track.

(d) Adjust light unit horizontally to align axis of beam to a point 50 feet in approach to the signal on opposite side of track and in center of approach lane, maintaining vertical alignment, as in 2 (c).

(e) Tighten clamps and close door.

(f) Repeat 2 (a) to 2 (e), inclusive, on other back light units.

3. Procedure for front light units on cantilever.

(a) Continuously light one lamp.

(b) Open door wide so clear beam is displayed.

(c) Adjust light unit vertically to align axis of beam 12 feet 0 inches above pavement at 400 feet in approach to the signal.

(d) Adjust light unit horizontally to align axis of beam to center of approach lanes at 400 feet in approach to the signal, maintaining vertical alignment, as in 3 (c).

(e) Tighten clamps and close door.

(f) Repeat 3 (a) to 3 (e), inclusive, on other front light units.

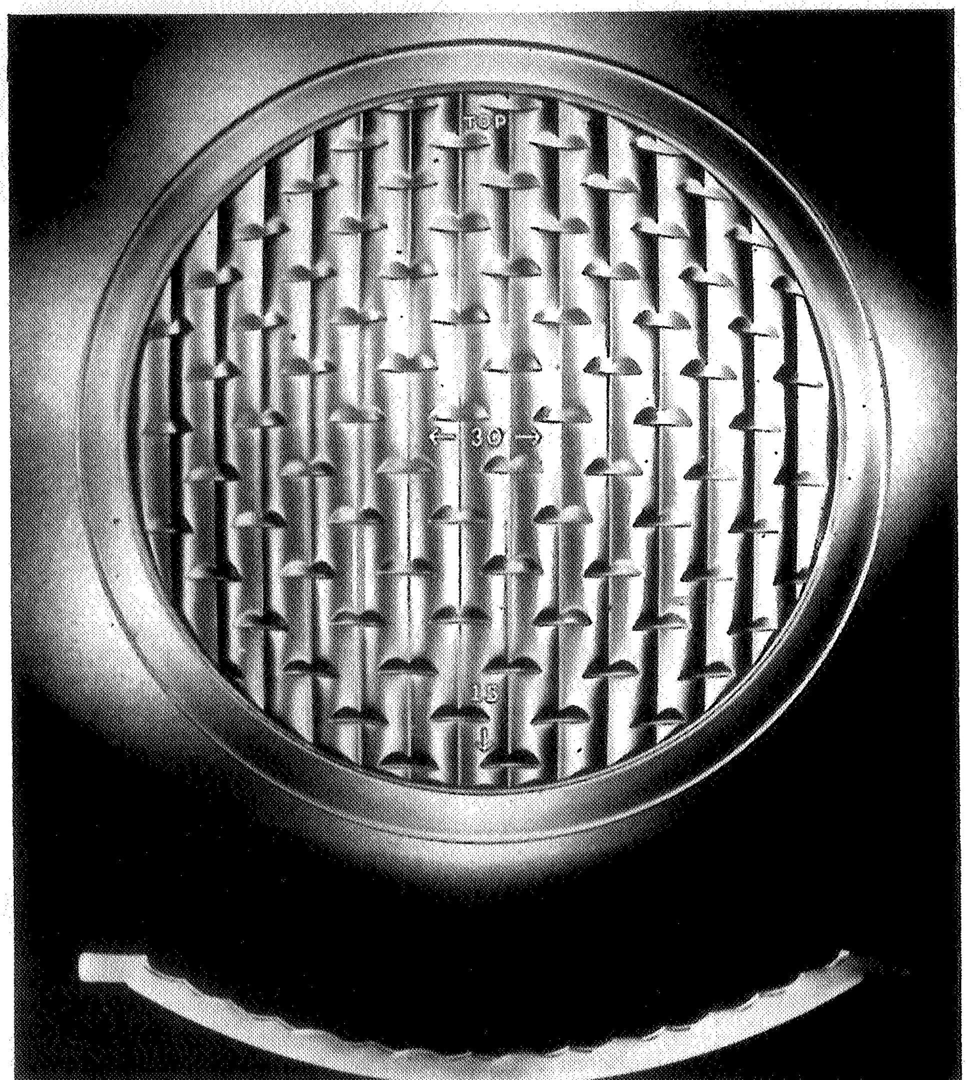
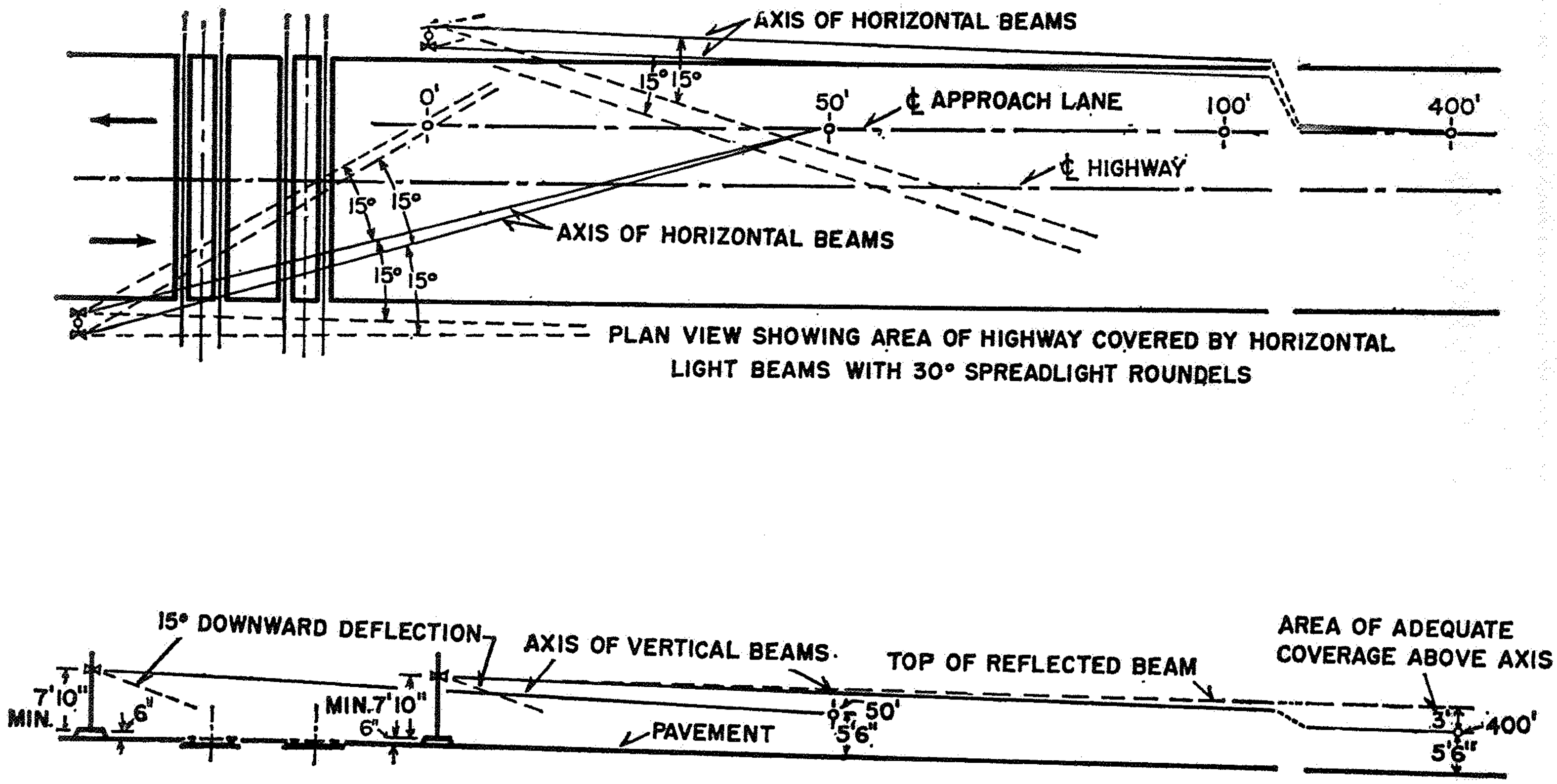


Fig. 22



PLAN VIEW SHOWING AREA OF HIGHWAY COVERED BY HORIZONTAL LIGHT BEAMS WITH 30° SPREADLIGHT ROUNDELS

ELEVATION VIEW SHOWING 15° DOWNWARD DEFLECTION

Fig. 23

4. After units have been aligned, clamps tightened and doors closed, check with lights flashing and lamps burning at recommended voltage to make certain that maximum visibility is obtained. Replacement lamps must be in accordance with instructions.

5. Local conditions which limit the speed of approaching traffic or the distance at which the signals can be seen by drivers of vehicles approaching the crossing may make it desirable to align the signal light units in a manner differing from that shown herein. In such cases, the matter should be referred to the proper authority and roundels used and alignment made as instructed.

Audible Signals

At crossings where additional pedestrian protection is desired, a bell is generally installed, similar to the one illustrated in Fig. 24.

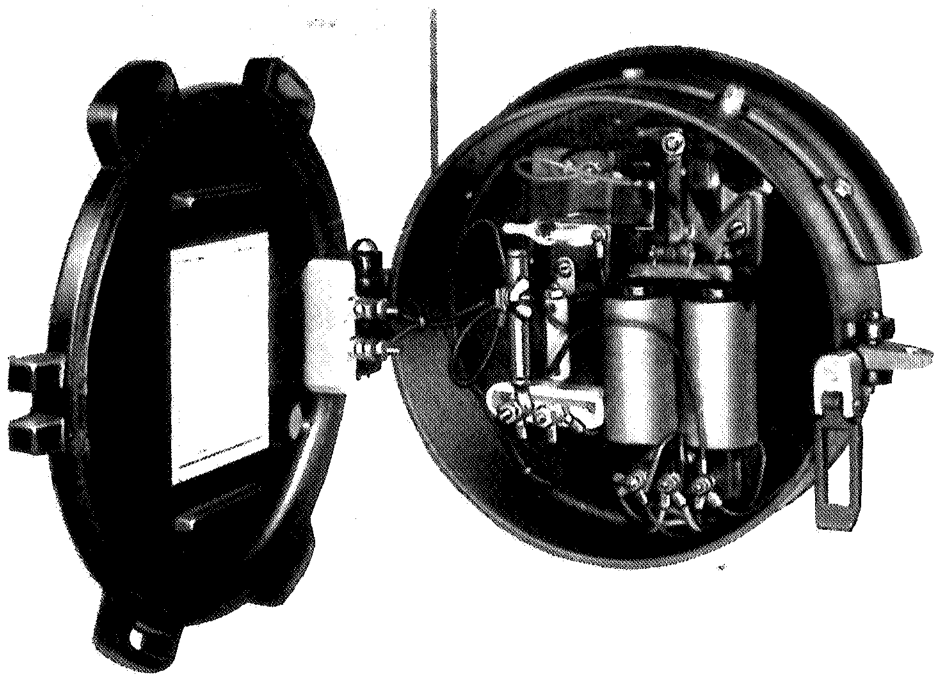


Fig. 24

There are many different kinds of bells available. The major variations are size, degree of loudness, and operating voltages. The most commonly used bell is one that operates on direct current at approximately 10 volts. Generally, the bell is mounted on top of the supporting mast of the flashing light signal in place of the pinnacle. Maximum loudness of the bell emanates from the rim of the gong and for that reason the bell is oftentimes mounted so that the gong is parallel to the sidewalk or street.

Component parts of the bell are the door, operating coils, armature and linkage, circuit breaker, adjustable resistor, hammer, gong, and rain shield. The door is provided with a gasket to seal the mechanical and electrical parts from the weather.

Figure 25 is a drawing which shows clearly the relationship of the individual parts to each other. The operation is simple in that the hammer is connected directly to the armature through the linkage. The circuit breaker is likewise connected to the linkage. In operation, the coils become energized when con-

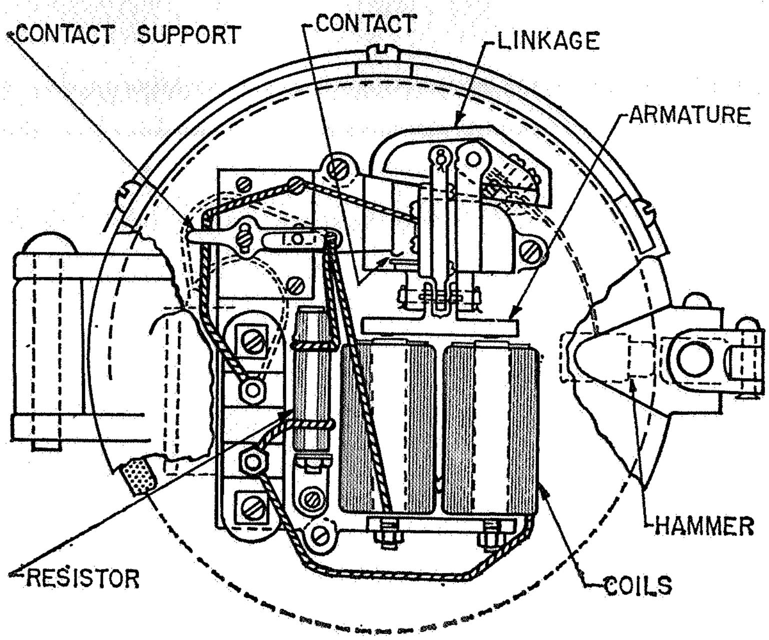


Fig. 25

tacts of the circuit breaker are closed, which causes the armature to be attracted to the core of the coils. When the armature moves toward the core the contacts are opened and the coil becomes de-energized. The weight of the hammer then causes the armature to move away from the core which in turn recloses the contacts of the circuit breaker and the coils. This operation continues at the approximate rate of 200 strokes per minute as long as electrical energy is applied. In some areas the sound of the bell may be a source of annoyance to those living nearby, and to minimize the annoyance, either soft-tone or smaller bells are sometimes used.

Control

Equally important with the type and location of railroad crossing protective devices is their control. For dependability, the control circuit is designed on the fail safe principle, which means closed circuit design insofar as it can be applied.

Before proceeding with the description of the control circuits, a brief review of the track circuit, the detecting portion of the control circuit, is desirable.

Figure 26 depicts the fundamental track circuit (unoccupied) used in all signal functions including the control of crossing signals. The current leaves the positive post of the battery, passes through the limiting resistor, which controls the amount of current desired, to the bottom rail. It continues through the rail, as confined by the insulated joints, to the coils of the track relay. After going through the coils of the relay, it passes through a relay series resistor, where used, to the top rail. It returns through this rail, back to the negative post of the battery. The circuit is thus completed, energizing the track relay, causing its front contacts to close. The light circuit is thus completed and the green light is lighted. It readily can be seen that any interruption of this circuit will cause the track relay to become de-energized.

Figure 27 shows the same circuit when occupied by a train. This illustration shows how the wheels and axles of the train cause the track relay to open

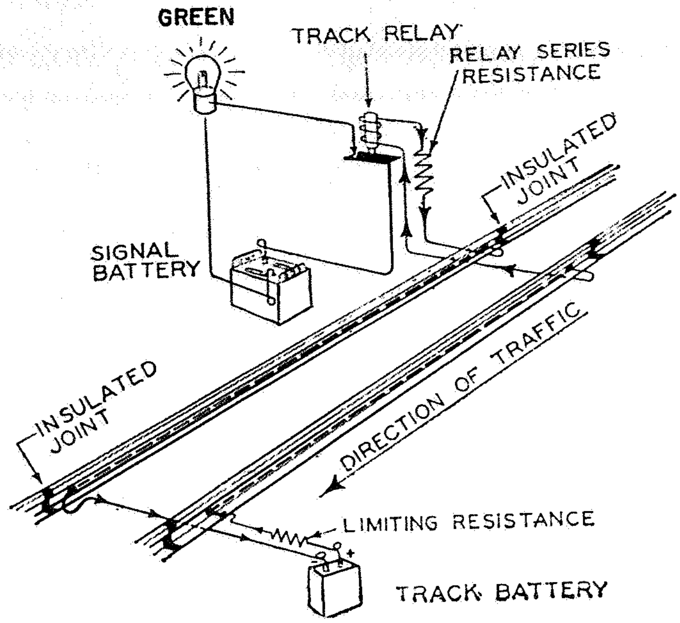


Fig. 26

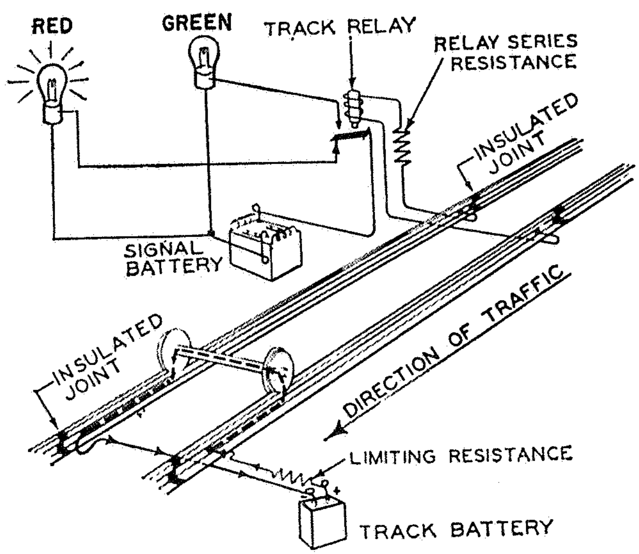


Fig. 27

its front contact. The current is not "cut off" but part of it is "short circuited" or "shunted." Part of the current now flows through the wheels and axles of the train. Under the conditions shown, the relay has been "robbed" of the current required for its coils to be sufficiently energized to hold its contacts up and, consequently, the front contact opens. Now the current, which formerly fed the green light through the front contact of the track relay, feeds the red light through the back contact. What has actually happened is that most of the current has taken a path of lower resistance through the wheels and axles of the train, instead of a path of higher resistance through the relay coils and the series resistor.

Another type of track circuit, of comparatively recent development, known as an overlay circuit, is also used in control of grade crossing signals in addition to being used in other signal functions. Its operation in detecting the presence of a train is similar to the conventional track circuit described in the foregoing, the principal difference being that instead of applying direct current from a battery to the rails to energize the track relay, an audio frequency carrier, sometimes modulated, in the range of 1 kc to 5 kc is used.

In place of the battery, a transmitter is used to feed a carrier current to the rails. At the relay end, a receiver, which is inductively coupled to the rails, receives the signal and through its associated apparatus transmits the signal in the form of direct current to the track relay.

With a train on the circuit, the carrier current is shunted through the wheels and axles of the train the same as described for the conventional circuit and with the receiver receiving no energy from the rails, the track relay releases.

This type of circuit is often used in welded rail territory in that it does not require insulated joints and therefore eliminates the necessity of cutting the rail. Also, while the circuit is used in ordinary applications, it is particularly adaptable in automatic signal territory where it can be used without interference to existing track circuits. The track relay in the following circuit diagrams is identified by the letters "TR."

Included in the control circuits are certain special relays: the interlocking relay, the flasher relay, and the time relay. While these relays are used in other signal functions, they predominate in grade crossing protection.

Interlocking Relay

The first of the special relays, the interlocking relay, has its mechanical interlocking features illustrated in Fig. 28.

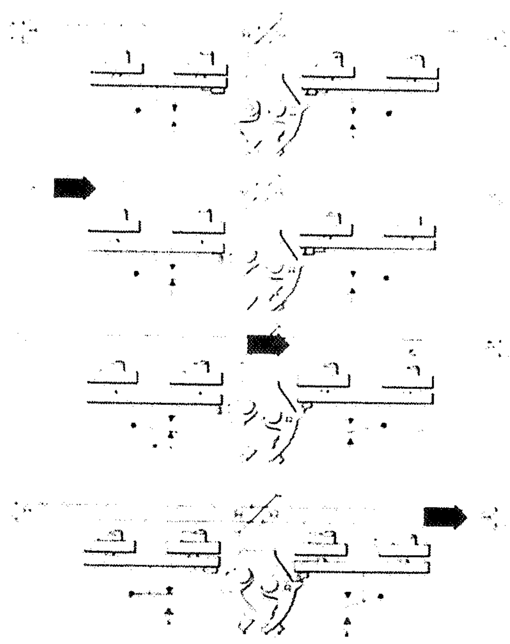


Fig. 28

The interlocking relay is used to start the operation of the crossing signals on approach of the train and to stop operation of the signals after the train has cleared the crossing. The top illustration shows the mechanical linkage of the interlocking mechanism when a train is not on the controlling track circuits. Note that both armatures are in the energized position and cams L and R are at rest.

The sequence of operation is shown in the three remaining illustrations when a train (shown as an arrow) approaches, passes over and recedes from the crossing. As the train enters the track circuit, the left-hand armature drops and closes its back contacts. At the same time, a projection on the armature bears on cam L, turning it so that the foot of cam L is in a position to block the rotation of cam R. As the train passes over the highway grade crossing and into the receding track section, the right-hand armature drops, opening its front contacts.

The back contacts of the right-hand armature are not made (closed) because of mechanical interference of the foot on cam L which is resting against the leg of cam R. Since the back contacts cannot be made on the right-hand armature, the highway grade crossing signals will cease flashing as soon as the left-hand armature picks up and the last car of the train clears the crossing. Even after the left-hand armature picks up, the right-hand armature is still prevented from making its back contacts because the weight of the right-hand armature is still holding cam R against the foot of cam L. The toe on the foot of cam R prevents cam L from dropping off the end of cam R. There is also a stop to prevent cam R from revolving more than a predetermined distance, which means that cam R cannot revolve enough to cause the right-hand armature to make its front contact. After the train leaves the receding track section the right-hand armature picks up allowing both cams to return to their normal position.

Similar action takes place for a train approaching from the opposite direction. Some circuit arrangements require that one or more front contacts be made when in the half-drop or locked position, and such contacts are called "flagman" contacts.

Flasher Relay

Figure 29 shows a schematic diagram of the magnetic structure and operating circuit for a flasher relay used in crossing protection. It is to be noted that the armature is so mounted that it may oscillate by being pivoted in the center and is so arranged that the magnetic flux produced by one coil acts upon one end of the armature, while the magnetic flux produced by the other coil acts on the other end of the armature. When the relay is de-energized, the armature assumes a position to close a coil control contact. It is here assumed to be the left-hand contact. The coil control contacts are so connected that the right and left-hand coils will be alternately shunted as the armature oscillates from one position to the other. This alternate shunting of the coils not only transfers the driving force to act on the end of the armature that is open by removing the shunt from the coil on that side of the relay, but also introduces a considerable amount of slow release to the opposite side of the relay by applying the shunt to the coil on that side.

The slow release provided by the shunted coil plays a major part in fixing the flashing rate at a level usable for highway grade crossing signals. When voltage is applied to the relay as indicated by arrows in Fig. 29 (a), the left-hand coil is energized and the armature will tip and coil contacts will move to a position as shown in Fig. 29 (b). The movement of the coil contacts from left to right throws a shunt across the left coil, and energizes the right coil as indicated by the arrows in Fig. 29 (b). The energizing of the right coil will cause armature to tip and coil contacts to make as indicated in Fig. 29 (a), the original position. As long as energy is supplied to the operating coils, the armature will rock from side to side alternately opening and closing the flashing contacts on the armature as indicated on Figs. 29 (a) and 29 (b). As these contacts make and break, the current lighting the lamps is interrupted and causes the lamps to flash alternately.

An appreciable further adjustment of the rate of flashing is possible by changing the number of copper washers on the center leg of the magnetic circuit. These copper washers tend to further retard the rate at which the magnetic flux changes in the legs of the magnetic circuit upon which are located the relay coils and, therefore, tend to decrease the rate of oscillation of the armature. One or more of these washers may be removed to increase the flashing rate, or one or more may be added to decrease the flashing rate.

Figure 29 also shows a typical lighting circuit used with this relay. It will be noted that the lamps in this circuit are alternately shunted to produce a flashing aspect. Shunting the lamps alternately in lieu of opening the circuit to them, increases the life of the lamp control contacts because they are not

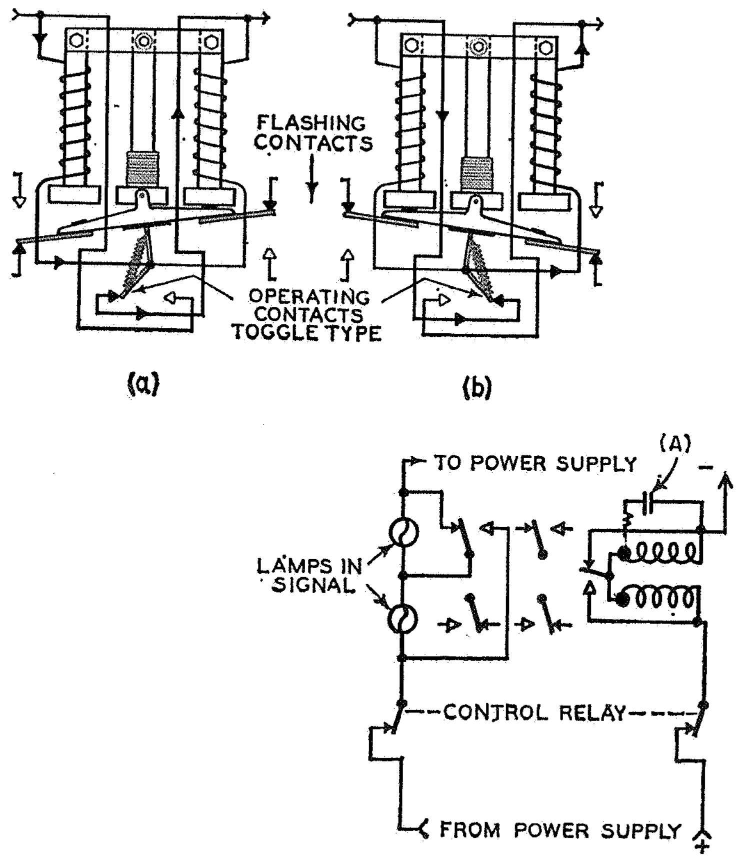


Fig. 29

required to break as much current, which greatly reduces the arcing and burning and also results in somewhat less radio interference. Radio interference elimination is obtained by the addition of a capacitor and resistor (A) connected in parallel with one of the operating coils. This capacitor reduces the arcing produced by the operation of the control contact as it changes shunt from one coil to the other. The resistor limits the flow of current as the capacitor is discharging when shunted.

Time Relay

The operating diagram for one type of motor-driven time relay is shown in Fig. 30. Other types are described in Chapter VI—Direct Current Relays.

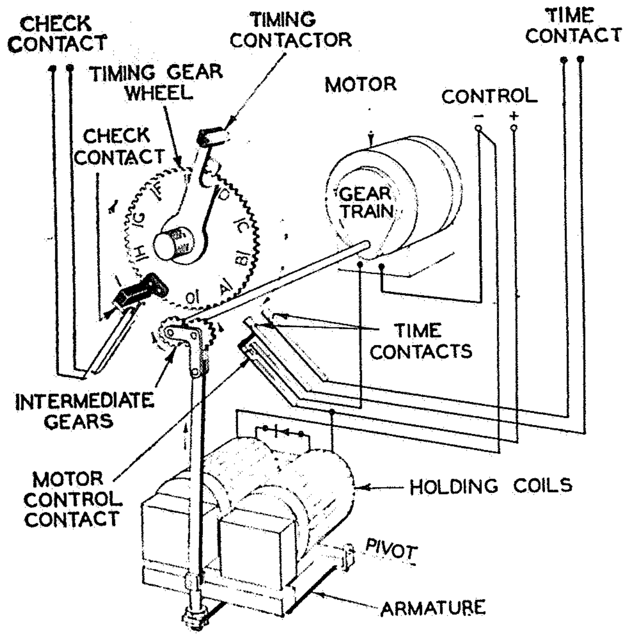


Fig. 30

Energizing the controls starts the constant speed motor, which energizes the holding coils, and picks up the armature. This connects the motor, through a gear train, pinion, and intermediate gear, to the calibrated timing gear wheel. This wheel carries two contact arms. As the wheel begins to rotate, one contact arm opens the check contact and the other closes the timing contact and opens the motor contact after the full operating time has elapsed.

The timing gear wheel remains in the full-time elapsed position (with timing contact closed) until the holding coils are de-energized, at which time the armature drops and disengages the intermediate gear from the timing gear wheel, permitting it (the timing gear wheel) to restore to normal, opening the timing contact and closing the motor contact and the check contact. A time delay is imposed on the drop-away of the armature by copper slugs on the core to bridge the change of its control circuit from a front to a back contact, or vice versa, of ordinary acting relays in its control circuit.

The check contact being open from the start of rotation of the timing gear wheel until its return to normal (de-energized) position, by the dropping of the armature, insures that the predetermined time interval is available for the next operation.

Positive armature drop-away and consequent disengaging of the intermediate gear from the timing gear wheel at the time the relay is de-energized is assured by the adequate dead weight armature torque provided. The timing gear wheel is returned to its normal position and held there by means of a spiral-coiled spring. To prevent rebound and consequent reopening of the check contact at time of closure, a mechanical snub is provided. The time settings are obtained by the positioning of the movable portion of the timing contactor in the following manner: The circumference of the calibrated timing gear wheel is provided with gear teeth which are engaged by the intermediate gear when the holding coils are energized. It is through this engagement that the timing motor drive is transmitted to the check and timing contacts. The greater the distance the intermediate gear has to travel along the circumference of this wheel, the greater the length of operating time before the timing contact closes. Hence, adjusting the movable portion of the timing contactor along the circumference of the timing gear wheel shortens or lengthens this distance and correspondingly decreases or increases the operating time. The contactor is solidly attached to, but insulated from, the timing gear wheel. Because the check contact opens slowly, it should not be used for interrupting high-voltage circuits or low-voltage circuits carrying more than 0.5 ampere. The timing calibrations are clearly visible through the transparent cover.

Control Circuits

There are two types of directional control circuits in general use with highway grade crossing protection. One uses the interlocking relay and the other uses the "stick" relay arrangement to provide for the starting and stopping of the crossing signals. The directional stick relay arrangement has wider acceptance since it has circuit design advantages and the interlocking relay generally requires more maintenance.

Both types of control are described herein starting with simple applications and concluding with more complex circuits. The first illustration, Fig. 31, shows a simple control circuit utilizing a track interlocking relay with flagman

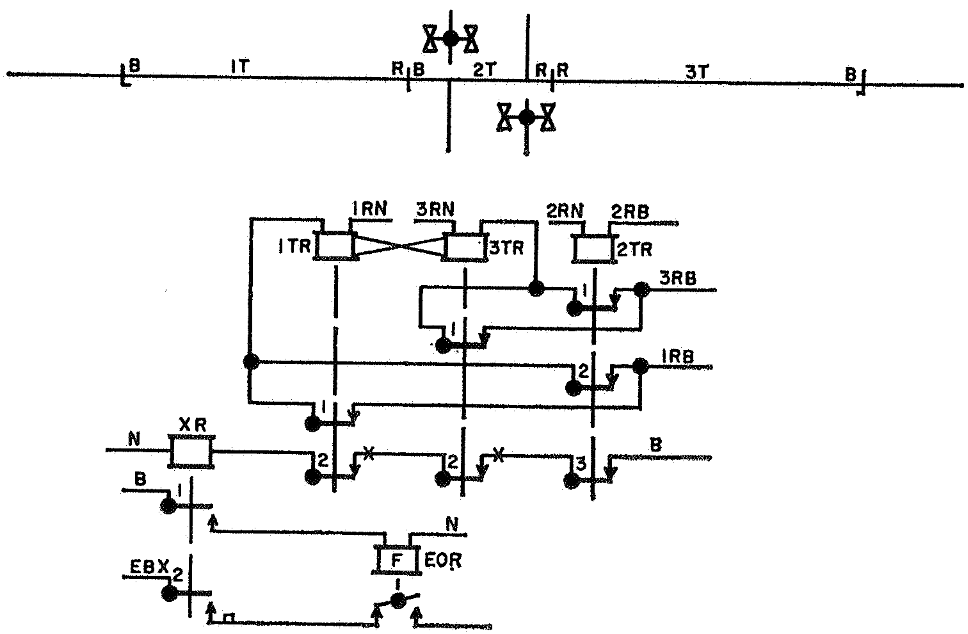


Fig. 31

contacts. The crossing signals begin to operate when the train enters track circuit 1T or 3T. The location of the insulated joints where the track battery is fed to the rail is such as to provide proper warning time before the train reaches the crossing. As soon as the rear of the train clears 2T in either direction, the signals cease operation. For the purpose of this description, assume a train is about to enter track section 1T at the left of the illustration, and will continue to progress over track sections 2T, 3T and off the circuit.

The crossing control relay XR is energized through front contact 3 of 2TR, front contact 2 of 3TR and front contact 2 of 1TR. When the train enters 1T, 1TR is de-energized and front contacts 1 and 2 open, thereby de-energizing XR. The XR, de-energized, allows current to flow to the coils of EOR (flasher relay) through its back contact 1 and the flasher relay commences to operate. Energy EBX is fed to the flasher contacts of EOR, through back contact 2 of XR, and the lights in the signal flash on and off. When the train enters 2T, 2TR is de-energized and its front contacts 1-2-3 open. When the train enters 3T, 3TR is de-energized, opening its front contact 1. Front contact 2 of 3TR does not open, since it is a flagman contact as shown by the symbol X. Now, with the train in 1T, 2T and 3T, 1TR is de-energized and its front contacts open; 3TR is de-energized, its front contact 1 is open and its front contact 2 remains closed; and 2TR is de-energized and its front contacts open.

When the rear of the train leaves 1T, the position of the relays remains the same since 1TR can only become energized through front contact 2 of 2TR. When the rear of the train leaves 2T, 2TR becomes energized and 1TR becomes energized through front contact 2 of 2TR. The lights in the signal will cease to flash at this time because XR has become energized even though 3TR is de-energized, since its number 2 contact did not open. When the train leaves 3T, 3TR becomes energized and in doing so releases the mechanical locking device, and all relays are in their normal position. For trains proceeding through in the opposite direction the sequence of operation is the same except 3TR will go to full drop position, 1TR will go to half drop, and flagman contact 2 of 1TR will remain closed.

Figure 32 shows an interlocking relay control arrangement in which the interlocking relay is controlled over line. It also illustrates a method of control without the use of flagman contacts. It will further be noted that this illustration shows more than one track circuit in the approach area. The WXR (west approach control relay) is energized through the front contacts of 1TR,

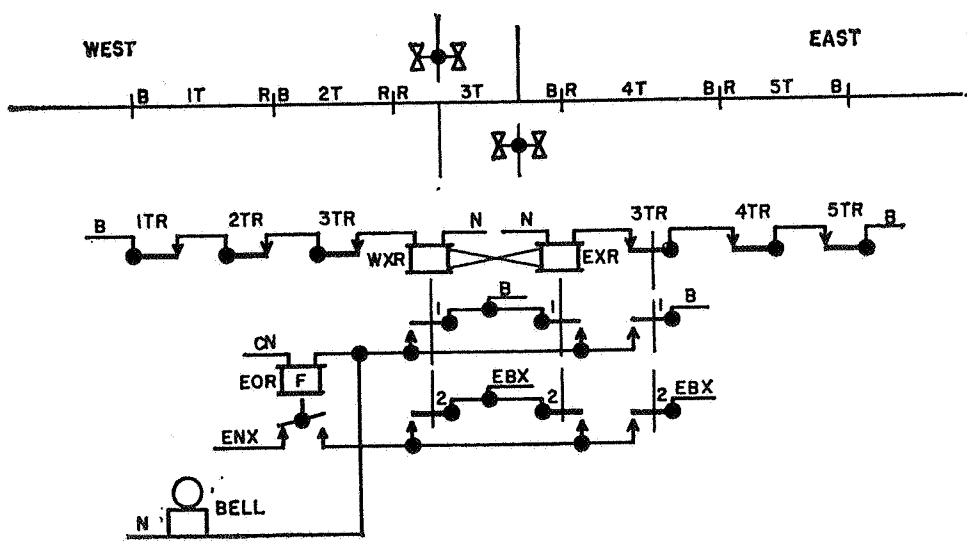


Fig. 32

2TR and 3TR. Likewise, the EXR (east approach control relay) is energized through the front contacts of 3TR, 4TR and 5TR. When a train enters 1T, 1TR is de-energized and current flowing to WXR is cut off when front contact of 1TR opens. The WXR becomes de-energized and its contacts 1 and 2 go to full drop position, closing its back contacts. Current then flows through back contact 1 of WXR to the coils of flasher relay EOR. Also, current flows through back contact 2 of WXR, to the flasher relay contacts and the crossing signals begin operating. As the train progresses into 2T, WXR circuit remains open by reason of front contact of 2TR being open. When the train enters 3T, WXR still remains in the de-energized position because of front contact of 3TR being open. At the same time, EXR becomes de-energized since the energy to this relay is interrupted at 3TR. However, since EXR is mechanically interlocked with WXR, the armature can only drop half way and its back contacts 1 and 2 are not made. Therefore, as the rear of the train clears 3T, the signals will cease operation. It will be noted that in this illustration the flasher relay circuit and the lighting circuit utilize the back contacts of relays WXR, EXR and 3TR. This arrangement does not require the use of an XR or control relay. However, when rotating stop signs or short-arm gates are used, the use of the XR relay and flagman contacts are required.

If a bell is to be used, it operates during the time the flasher signals are operating by receiving its energy from the same source as the EOR.

Figure 33 illustrates another type of interlocking track relay circuit which is sometimes referred to as the "staggered joint arrangement." This scheme does not use a center section or "island" track circuit, but does provide for

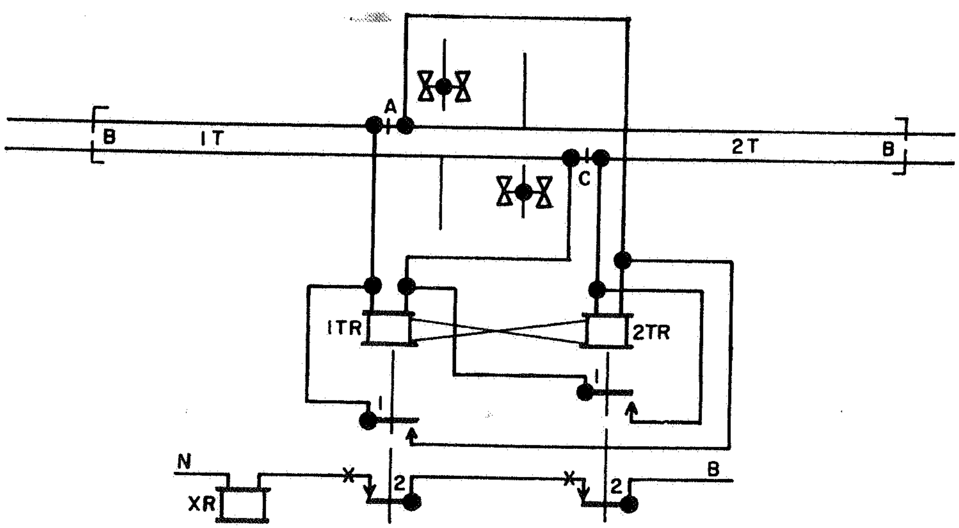


Fig. 33

signal operation until the rear of the train clears the crossing, by spanning the insulated joints through the interlocking relay back contacts. When the train enters 1T, 1TR is de-energized and crossing signals go into operation as previously described because XR has been de-energized. At the same time, back contact 1 of 1TR is made. This back contact provides a circuit around insulated joint A which in reality makes the top rail a continuous path for current to flow and the track shunt is maintained until the rear of the train clears the far side of the crossing at insulated joint C. For movements in the opposite direction, back contact 1 of 2TR will span insulated joint C and 2TR will remain de-energized until rear of train has cleared crossing at insulated joint A.

So far, the description of control circuits has covered those utilizing only one interlocking relay. While the single interlocking relay provides control in many installations, sometimes two interlocking relays are used. Figure 34 shows a circuit using two interlocking relays.

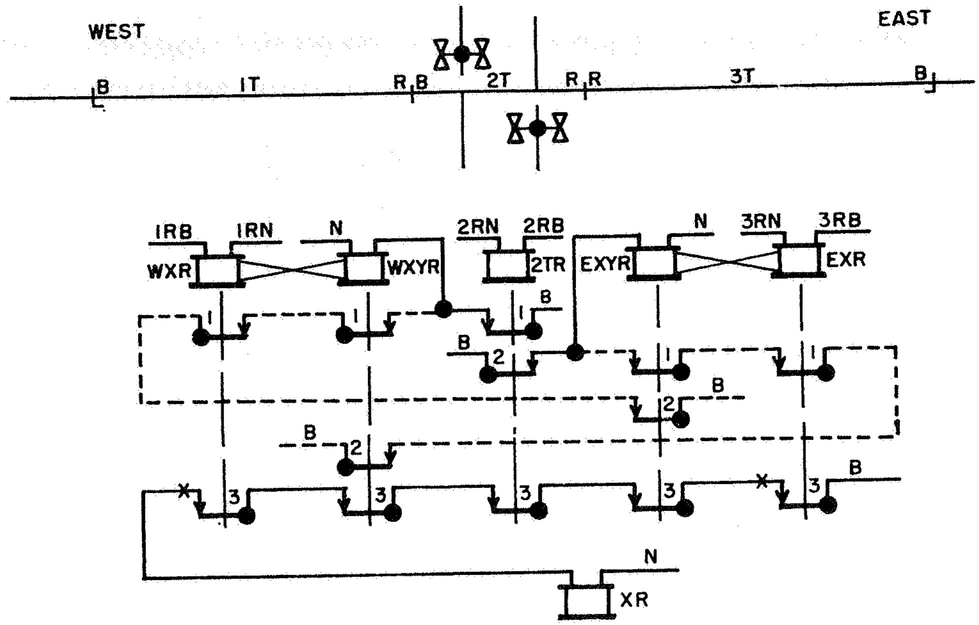


Fig. 34

An advantage of using two interlocking relays is that each approach is independent of the other, which is not the case with a single interlocking relay. In Fig. 34, WXR is the track relay of circuit 1T and is mechanically interlocked with WXYR (westward crossing slot relay) which is energized through front contact 1 of 2TR. Likewise, EXR is the track relay of circuit 3T and is mechanically interlocked with EXYR (eastward crossing slot relay) which is energized through front contact 2 of 2TR. When a train enters 1T, WXR is de-energized, its armature goes to full drop, allowing its number 3 contact to open, thereby de-energizing relay XR, causing crossing signals to begin operating.

When the train enters 2T, 2TR is de-energized, WXYR becomes de-energized and its armature goes to half drop position. The EXYR also becomes de-energized since current stops flowing to its coils when front contact 2 of 2TR opens. Its armature goes to the full drop position. As the train proceeds and enters 3T, EXR is de-energized, and its armature being interlocked with the armature of EXYR can only go to half drop. The XR remains down due to its control being open by contact 3 of 2TR and contact 3 of EXYR. As the rear of the train clears 2T, 2TR becomes energized, which in turn causes WXYR and EXYR to become energized. The signals stop operating at this time since all relays are energized except EXR. The XR circuit is completed through flagman contact 3 of EXR. In this circuit it can be noted that operation of WXR is independent of condition of 3T and operation of EXR is independent of condition of 1T. It can be seen, however, that should 2TR become de-energized, both WXYR and EXYR would become de-energized and their armatures would go to full drop. Where it is desired to eliminate such condition, a second source of energy is sometimes supplied to WXYR and EXYR as shown in dashed lines. The WXYR in addition to receiving current through front contact 1 of 2TR also receives current through its own front contact 1, front contact 1 of WXR and front contact 2 of EXYR. With this arrangement, even though 2TR should drop out, WXYR will remain energized and the same holds true for EXYR.

Figure 35 illustrates a simple directional stick circuit used for control of highway grade crossing signals. ("Stick circuit" is a term applied to a circuit used to maintain a relay or similar unit energized through its own contact.)

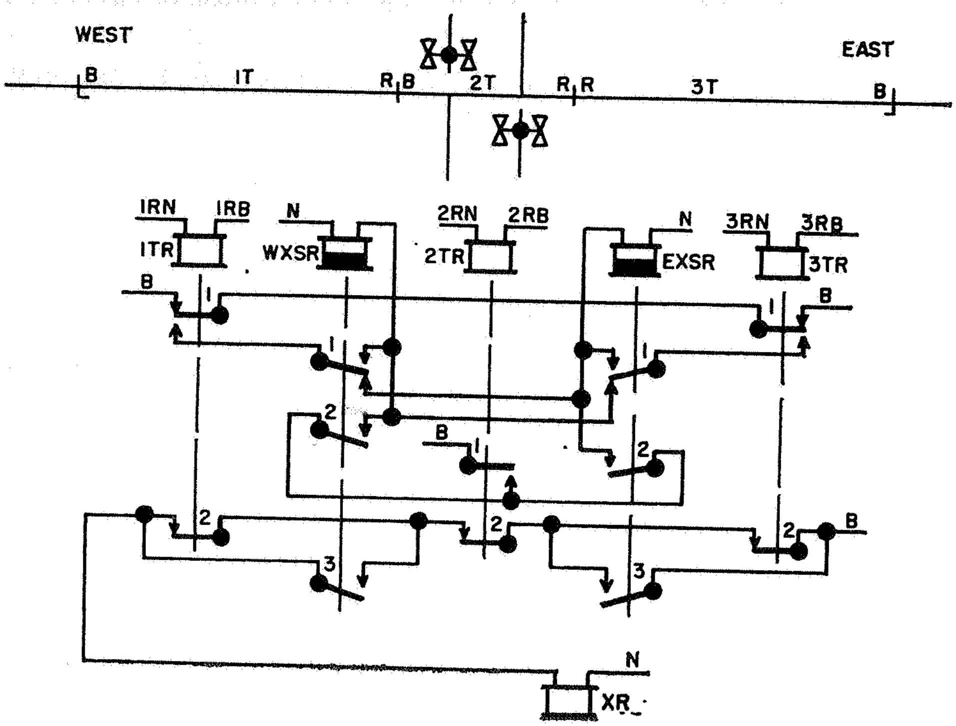


Fig. 35

Relays 1TR and 3TR are ordinary track relays. If the approaches consisted of more than one track section, line relays would be used and they would be called WXR and EXR, respectively. The WXSR (westward crossing stick relay) and EXSR (eastward crossing stick relay) are slow release relays and 2TR is an ordinary track relay. For purpose of explanation, assume a train movement from west to east entering the control territory in 1T and leaving it at 3T. When the train enters 1T, 1TR is de-energized, opening its front contact 2, which causes XR to become de-energized and crossing signals begin operating. Simultaneously, current flows through front contact 1 of 3TR, through back contact 1 of 1TR, through back contact 1 of WXSR to the coils of EXSR, causing EXSR to be energized and closing its front contacts. When the train enters 2T, 2TR is de-energized, opening its front contact 2 in the XR circuit and closing its back contact 1.

A stick or holding circuit results from current now flowing to the coils of EXSR through its own front contact 2 and back contact 1 of 2TR. As the train enters 3T, 3TR is de-energized and EXSR is held energized through back contact of 2TR only. When the rear of the train leaves 1T, 1TR is energized and current now will flow through front contact 1 of 1TR, through back contact 1 of 3TR, through front contact 1 of EXSR to its coils. When the train leaves 2T, 2TR is energized and current will flow to XR through front contact 3 of EXSR, through front contact 2 of 2TR and through front contact 2 of 1TR, and signals cease operating.

As soon as the train leaves 3T, 3TR is energized which opens the circuit to EXSR, causing it to become de-energized. Sequence of operation for a train entering at 3T is similar, except that WXSR is energized when the train enters 3T.

Another type of stick circuit is shown in Fig. 36, and is different from the circuit shown in Fig. 35 in that the stick relays WXSR and EXSR are not conditioned to cut out the signals until the train reaches the track section extending over the crossing. This type of circuit is often used in localities where switching takes place in the approach track sections and where greater flexibility in control is desired. Here again it is assumed that a train enters 1T, proceeds through 2T and into 3T, and off the circuit.

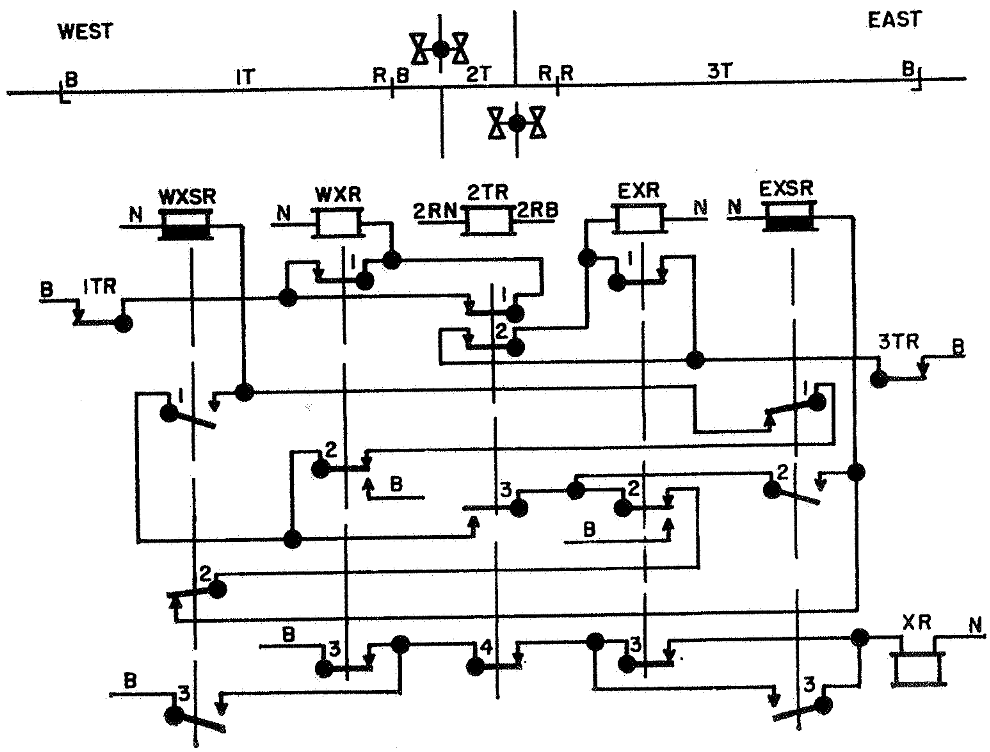


Fig. 36

When the train enters 1T, 1TR is de-energized and likewise WXR. The XR circuit is opened when front contact 3 of WXR opens and crossing signals begin operation. When the train enters 2T or the center section, XR circuit remains open and signals continue to operate. Also, at this time, current is fed through back contact 2 of WXR, through back contact 3 of 2TR, through front contact 2 of EXR, through back contact 2 of WXSR, and energizes EXSR. The EXSR now is conditioned to cause signals to cease operation as soon as 2T is unoccupied by virtue of front contact 3 in EXSR.

As train progresses into 3T, current is fed through back contact 2 of EXR, through front contact 2 of EXSR, thereby keeping EXSR energized as the train recedes in 3T. Note that even though center section relay 2TR only may be de-energized, neither the WXR nor the EXR will be de-energized since each one is held up by its own front contact 1 and the front contact of 1TR and 3TR.

Special Circuits

The control circuits described up to this point provide for operation of the crossing signals where most of the trains are through movements. However, there are many locations where trains stop in the approaches to the crossing for switching, station stops, etc. Under these conditions, in order to prevent the signals from operating unnecessarily for long periods of time, special circuits are added to the fundamental circuits. Where these special circuits are used in automatic block signal territory, their functions are usually interconnected with the wayside signal circuits to check their integrity.

There are various types of special circuits used to minimize the unnecessary operation. These are essentially grouped into four main categories; namely, the switch stick circuit, time cut-out, selective speed timing, and manual operation or supervision. In this chapter only the first three categories are described since experience has proven that automatic controls are superior to manual control in both reliability and uniformity. Manual control or supervision (including watchmen) is now employed only under unusual conditions where automatic control may not be feasible.

The first of these special controls is the switch stick circuit illustrated in Fig. 37. Whenever switch A is reversed, RWSR (reverse switch stick relay) is

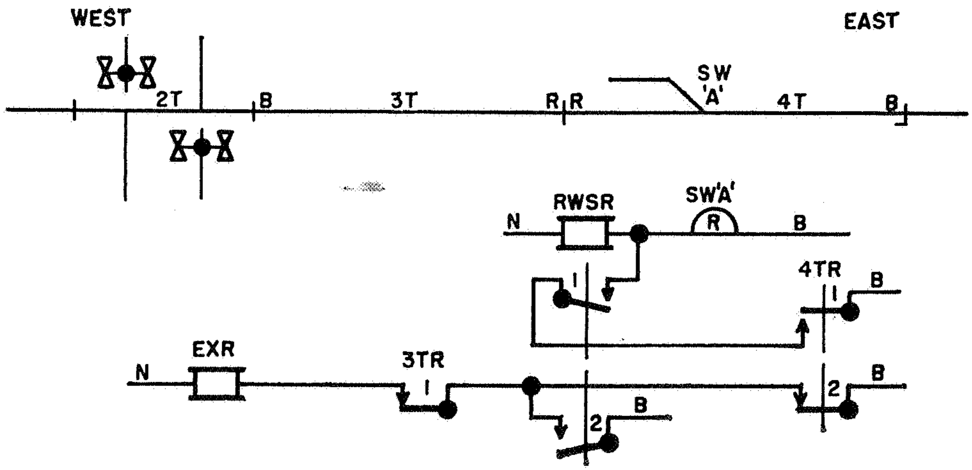


Fig. 37

energized. Once energized it remains energized through back contact 1 of 4TR and its own front contact 1.

The control of EXR breaks through front contact 1 of 3TR and front contact 2 of 4TR. When a train enters section 4T, EXR will be de-energized and crossing signals will begin operation. However, should the train stop in 4T and reverse switch A, RWSR will be energized and current will flow to the EX circuit through front contact 2 of RWSR and the signals will cease operation. Likewise, if a train enters 4T through switch A, the crossing signals will not operate. If after RWSR is energized, the train proceeds westward toward the crossing, signals will begin operation when the train enters track section 3T.

Another commonly used method of preventing unnecessary operation of crossing signals is by the time cut-out circuit, such as shown in Fig. 38.

The EXR is energized through 3TR and 4TR. In this scheme, if a train stops in 4T, time element relay TER begins timing through back contact 2 of 4TR and back contact 1 of TESR (time element stick relay). When TER completes its time cycle (a predetermined time), it will through its timing contact energize TESR. The TESR will remain energized through back contact 2 of 4TR and its own front contact 1. When TESR is energized its back contact 1 opens control of TER. TER is slow acting and returns to its normal position shortly after TESR is energized. With TESR energized, current flows to the EX circuit through front contact 2 of TESR and through checking contact of TER to insure that the TER has returned to its normal position. At this

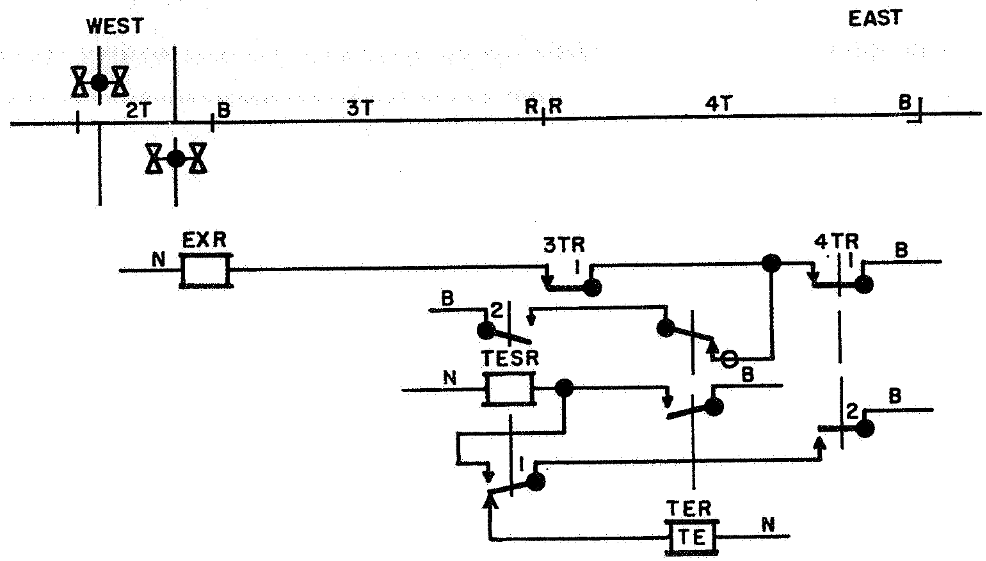


Fig. 38

time the signals will cease operating. When the train proceeds toward the crossing and enters 3T, the signals again operate when circuit is interrupted by the opening of front contact 1 of 3TR.

Figure 39 shows a circuit which provides selective timing. Such timing is used at crossings where heavy train and highway traffic exist and there is a considerable variance in train speeds approaching the crossing. The advantage of this circuit is that more uniform warning time is obtained, which reduces delays to highway traffic.

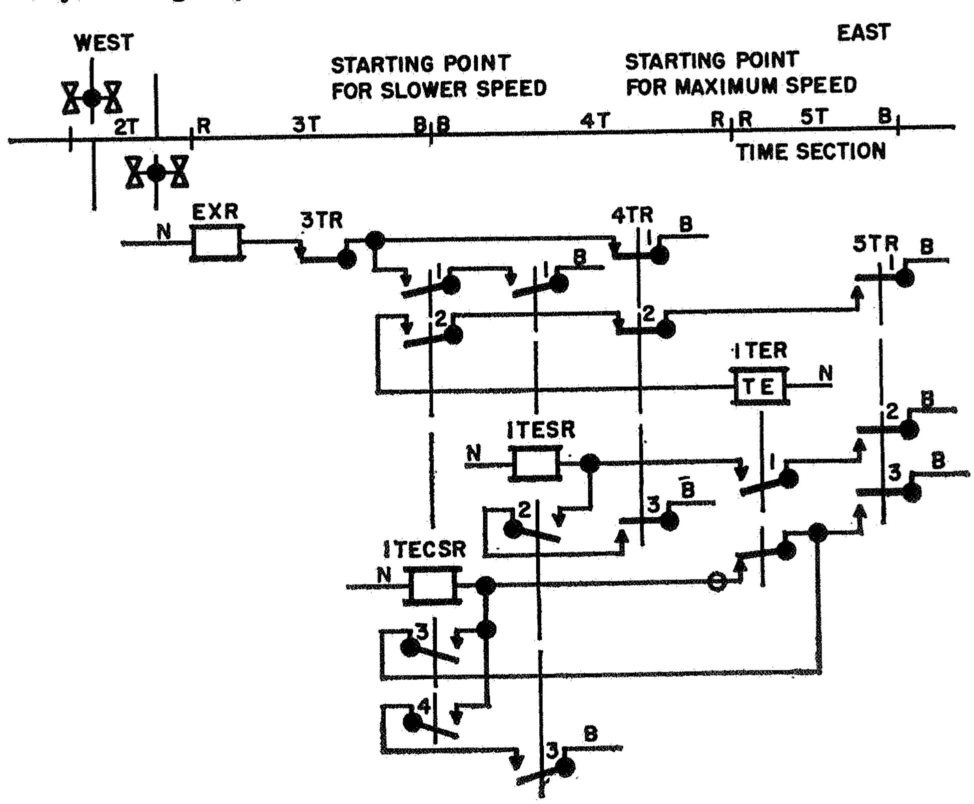


Fig. 39

Here again the EXR is energized through front contacts of 3TR and 4TR. The timing section 5T has a length usually determined by local conditions such as existing cut-sections and speed at which the selective control is to be effective. For the purpose of explanation, it is assumed that the length of 5T is 600 feet, that the maximum authorized speed in this area is 60 miles per hour, and that the starting point for maximum speed is located 2000 feet from the crossing; also, that it is preferable to forestall the operation of the crossing signals if the speed of the train is less than 30 miles per hour.

The start for the slower speed would then be placed about 1000 feet from the crossing. Keeping these assumed distances in mind, the time that TER will operate to close its time contact is determined as follows: At 30 miles per hour, the train travels 44 feet per second. The timing section is 600 feet long, therefore, TER time contacts would close if it takes a train longer than 13.6 seconds (600 divided by 44) to travel through 5T.

Assume a westward train enters 5T at a speed of 25 miles per hour. 5TR will be de-energized and its back contacts 1, 2 and 3 will be made. Current will then flow through back contact 3 of 5TR and through the check contact of 1TER, which will energize time element check stick relay 1TECSR. Once energized, the 1TECSR will remain energized through back contact 3 of 5TR and its own front contact 3. At the moment 1TECSR is energized, current flows through back contact 1 of 5TR, front contact 2 of 4TR, and front contact 2 of 1TECSR, to the coils of 1TER, and it begins timing. At 25 miles per hour, the train will not reach the maximum starting section 4T until 16.3 seconds have elapsed, since it is traveling only 36.7 feet per second. As soon as 13.6 seconds have elapsed, the timing contact of 1TER closes and 1TESR is energized through the timing contact and back contact 2 of 5TR. At this time, current will flow to the EX circuit, through front contact 1 of 1TESR and front contact 1 of 1TECSR regardless of position of front contact 1 of 4TR. With 1TECSR and 1TESR thus energized, the crossing signals will not operate until the train enters 3T since these relays are held up through 4TR down.

From this explanation, it can be seen that should a train pass through 5T in less than 13.6 seconds, 1TER will not have completed its time cycle, because current to its coils would be cut off when train enters 4T, causing 4TR to open its front contact 2.

The sole function of 1TECSR is to make certain that the check contact of 1TER has returned to its normal position before it goes into time operation.

Local Control Circuits

The foregoing descriptions covered line control circuits and the following descriptions apply to the local controls of the signals. Figure 40 illustrates a method of control for flashing light signals and bell. This description begins with the XR or control relay referred to in previous circuit explanations.

With relay XR de-energized, current flows through its back contact 1 to the bell, through its back contact 2 to flasher relay EOR coils, and through its back contacts 3 and 4 current is fed to the lights. From the study of the flasher relay, it is known that when current flows in its coils its armature operates, first closing lighting contacts X and Y and then lighting contacts XI and Y1 at a rate of 30 to 45 times per minute. The armature of the flasher relay is either mechanically or electrically biased so that upon de-energization one or

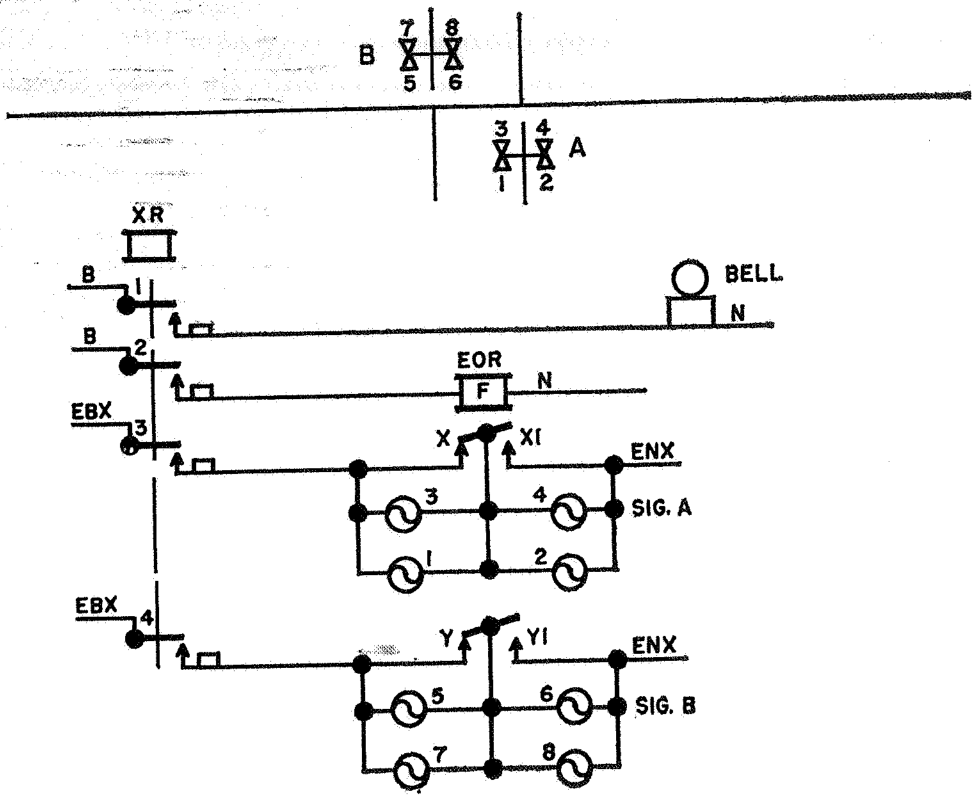


Fig. 40

the other set of contacts is closed. This illustration shows when the XR relay is de-energized current from the power supply will flow through its back contact 3, through flasher contact X, to lights 2 and 4 and thence back to the power supply. When the armature is in the opposite position, current will flow through back contact 3 of XR through lights 3 and 1, through flasher contact XI and back to the power supply. In each position the non-lighted lamps are shunted.

Similar action takes place simultaneously for the light circuit of signal B. The arrangement, as it can be seen, provides for lights 2 and 4 on signal A to be illuminated at the same time as lights 6 and 8 on signal B. This is true also, for lights 1 and 3, and 5 and 7. Lights 1 and 2, and 7 and 8 are often referred to as front lights, and lights 3 and 4, and 5 and 6 are referred to as back lights. Should the flasher relay fail to oscillate, lights 2 and 4, and 6 and 8 would be lighted steadily because the flasher relay is so biased that one set of contacts is closed. It also can be seen that with this method of wiring, when the armature is oscillating there is a period of time when neither flasher contact X nor XI is made. At this time light 3 is in series with light 4, and 1 in series with 2. This reduces the voltage across the armature contacts to about one-half the normal lighting voltage. This feature reduces the arc at the flasher contacts, which prolongs their life and assists in minimizing radio interference.

At crossings where automatic gates are used with flasher signals, additional relays and circuitry must be provided as shown in Fig. 41. At the top of the figure the XR circuit is shown. The XGNR is energized through the front contact of XR and the closed position of a cam-operated contact in each gate

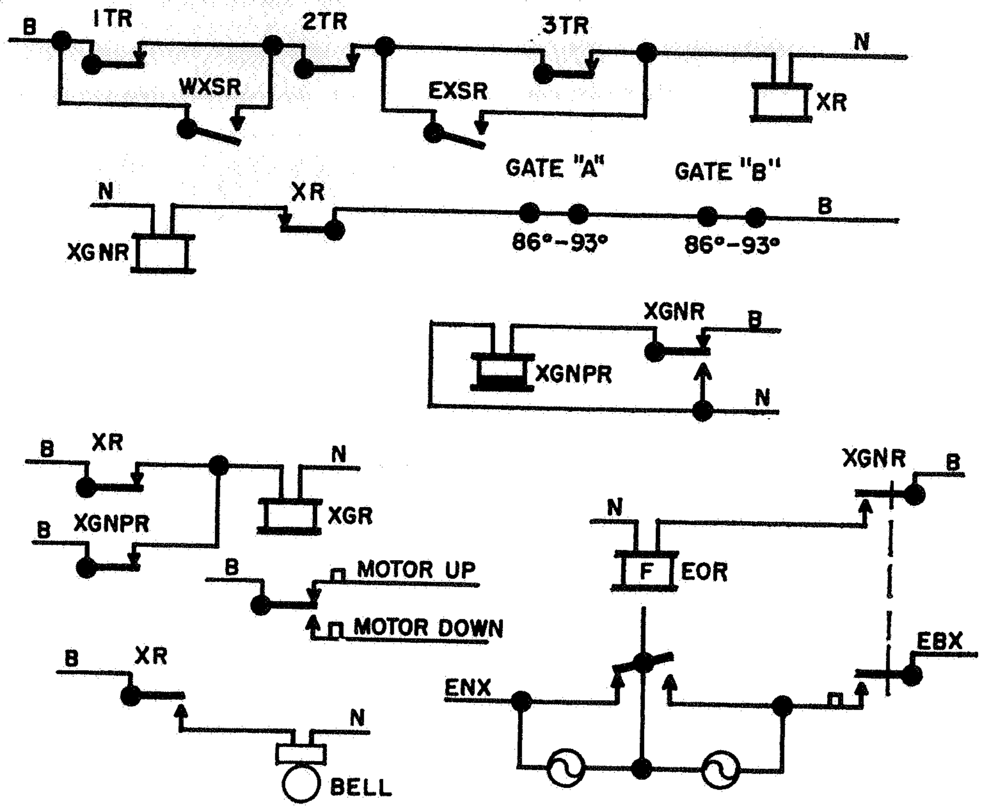


Fig. 41

mechanism. These cam-operated contacts are closed whenever the gate arm is within a few degrees of being vertical. The XGNPR, which repeats the XGNR, is a slow release relay with 3 seconds minimum release time. The XGR, or gate control relay, is energized through the front contact of XR and front contact of XGNPR.

Assume that a train has entered the approach section to a crossing protected by flashers and gates and 1TR is de-energized. The XR, of course, becomes de-energized, which through its front contact, causes XGNR to become de-energized. This action starts the lights flashing, current being supplied to the EOR and its contacts through the back contacts of XGNR. The bell also operates, current being supplied to it through the back contact of XR. The XGR, however, does not become de-energized for a period of at least three seconds after XR is de-energized since it is held energized through the front contact of XGNPR. After expiration of the delay time, XGNPR will become de-energized and likewise the XGR. The XGR on being de-energized, stops the flow of current to the holding coil of the gate mechanism, which allows the gate to descend, and through its back contact allows current to flow to the motor-down circuit of the gate.

After the train has passed over the crossing, the XR is energized, which in turn stops flow of current to the bell and permits current to flow to the XGR through its front contact. When XGR picks up, current flows to the motor-up circuit through its front contacts. The gate then moves from the horizontal to the vertical or clear position. The flashing lights continue to operate since XGNR will not be energized until both gates are within a few degrees of being vertical and the cam-operated contacts are closed.

Figure 42 illustrates a schematic drawing of a wig-wag signal mechanism.

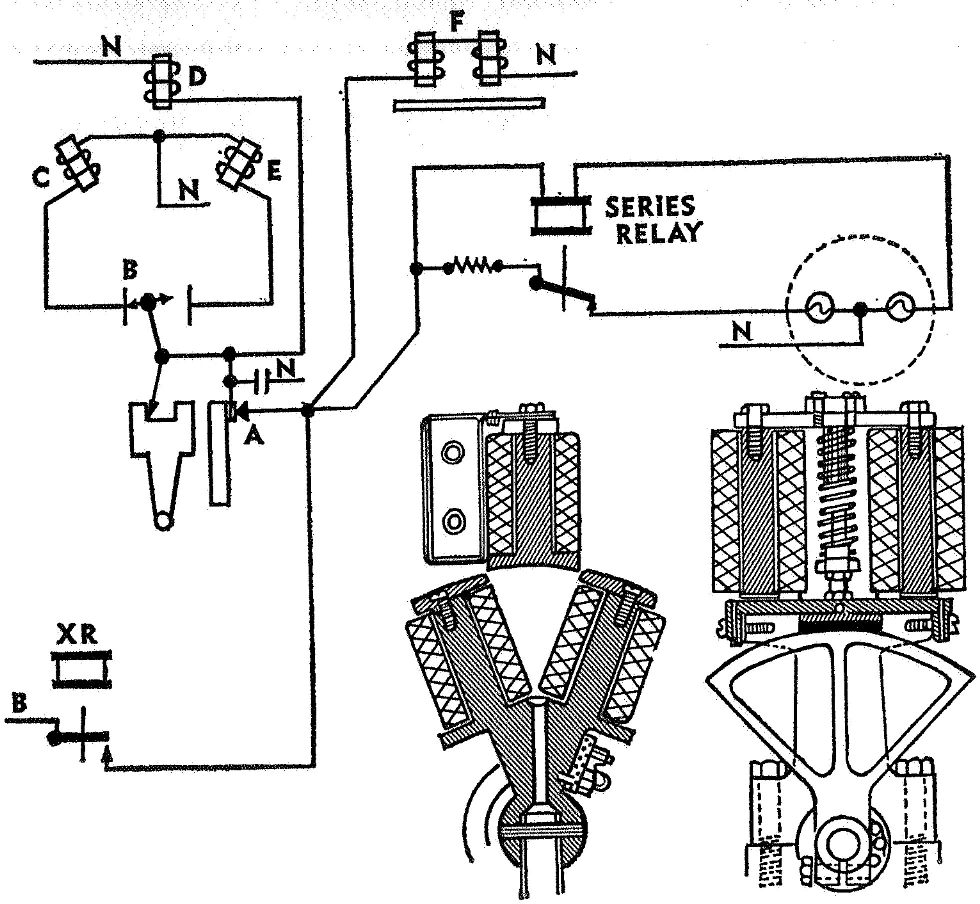


Fig. 42

In operation, when the XR, or control relay, is de-energized upon the approach of a train, current flows through its back contact, through the make and break contacts at A of the wig-wag mechanism, through another cam-operated contact at B, to the left coil at C of the movable portion of the wig-wag to which the banner is attached. At the same time, current also flows through the cam-operated contact at A to the stationary coil at D. The stationary coil is so wound that its core is in opposite polarity to the cores of either of the movable coils C and E. For example, the pole piece on the stationary coil would be of north polarity, and each pole piece of the movable coils would be of south polarity. Poles of opposite polarity attract. When energized, the movable coils are alternately attracted to the stationary coil until current flow in the coils is interrupted by the cam-operated contacts actuated by the swinging banner. While this operation is taking place, the brake shoe coils F are energized, lifting up the brake shoe allowing the banner to swing freely.

Simultaneously, current flows through a series light relay to the light in the banner which provides for nighttime indication. In the event the main light burns out, current will then flow through a reserve circuit of the back contact of the series relay and through a reserve light. After the train has passed over the crossing, XR is energized and all energy to the wig-wag is removed. The capacitor shown is used to reduce arcing at the contact points.

In Fig. 42 the left-hand view shows approximate relationship of the stationary coil with its pole piece, and the right and left coils with their pole pieces; the right-hand view shows the brake mechanism consisting of the coils, the pole pieces, the armature, the brake shoe and the tension spring. It can be seen that the brake shoe rides on the extension of the wig-wag and when the coils of the brake shoes are energized the armature will be attracted to the poles which lifts the brake shoe off the extension and allows the wig-wag to swing freely.

Gate Mechanisms

The remaining circuit descriptions in this chapter deal with gate mechanisms. In this explanation of the gate mechanisms it is well to keep in mind that there are certain fundamental features common to all mechanisms. They are:

1. Their design is such that the weight of the gate arm will cause it to go to the horizontal position whether it is powered down or not.

2. Their operation and circuitry is such that, insofar as practicable, the failure of any part of the circuit will cause the gate to assume the horizontal position.

3. They are provided with mechanical buffers to absorb shock.

4. They operate on low voltage, 10 to 16 volts d-c.

Figure 43 illustrates a schematic wiring diagram of the mechanism used with pedestal mounted gates. The XGR is the gate control relay, which was described in local control circuits for gates, and when its front contact is closed, the gate is in the clear or vertical position, or returning to that position.

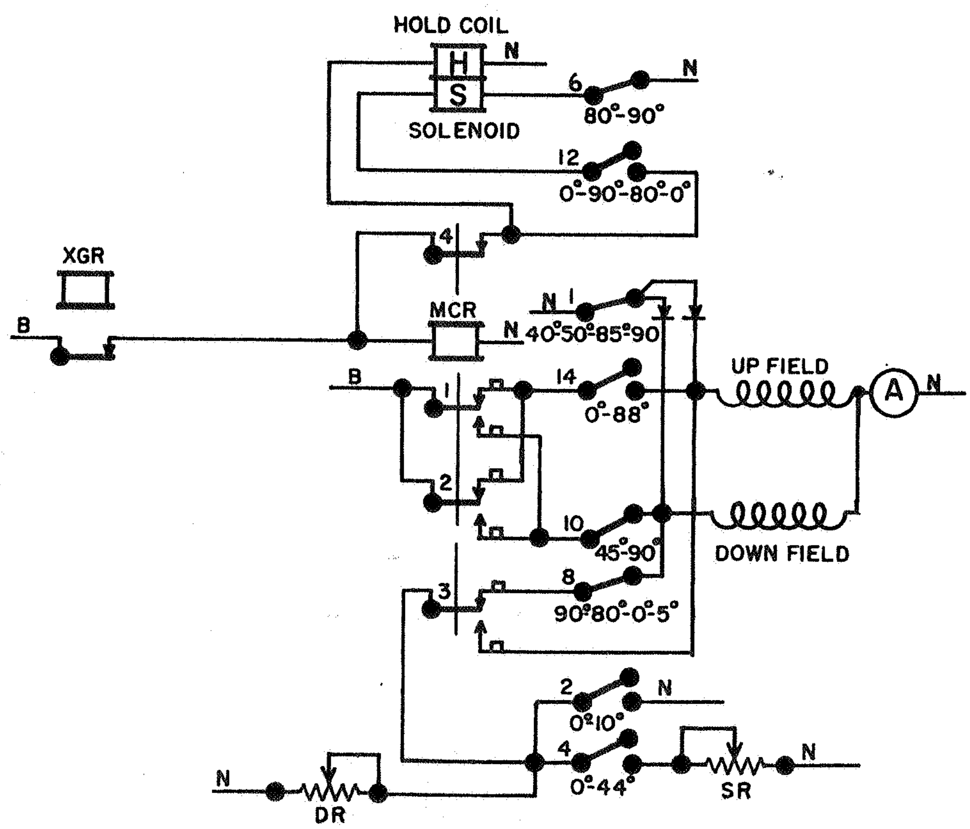


Fig. 43

This illustration shows the position of controller contacts and motor relay MCR contacts corresponding with the gate in the clear or vertical position. It also shows the hold clear coil, the solenoid coil, the up-field, the down-field, armature A of the motor, the snub resistance SR and drive resistance DR.

With the gate arm at rest in the clear position it can be seen that current flows through front contact of XGR, through front contact 4 of MCR to the hold coil H, which through its associated armature holds the gate locked in the vertical position. Current also flows to MCR.

The motor control relay MCR in this illustration is located in the base of the pedestal. On older models, the MCR was part of the hold clear assembly and mechanically held in energized position. Minor modifications of this circuit, therefore, apply to the older models. The following sequence of events takes place when the gate arm moves to the horizontal position.

When XGR is de-energized, such as on the approach of a train, its front contacts open and both the MCR and the hold coil are de-energized. The hold coil upon being de-energized releases its armature, which in turn causes the locking pawl to become disengaged from the ratchet wheel on the motor, and the gate arm is free to lower to the horizontal position by its own weight. The MCR on being de-energized, opens its front contacts and closes its back contacts. Current flows through back contacts 1 and 2 of MCR through controller contact 10, which is closed from 90 degrees to 45 degrees, through the down-field and armature A and thence back to the power supply symbolized by N. The motor is now driving the gate to the horizontal position. However, not all the current now flowing through the down-field goes through the armature. Some of the current flows through the up-field, through back contact 3 of MCR, and through drive resistance DR. This parallel path of current flow provides regulation of speed of descent of gate arm from 90 degrees to 45 degrees. Increasing the resistance in DR will accelerate the descent of the gate arm and, conversely, decreasing the resistance in DR will slow the descent of the gate arm. When the gate arm reaches 45 degrees, controller contact 10 opens and motor-down current to the motor is cut off. Arcing of contact 10 at 45 degrees is prevented by use of a half-wave rectifier bridging the down-field and armature of the motor, through controller contact 1, which is closed at 50 to 40 degrees. With motor-down current cut off, the armature continues to rotate due to the weight of the gate arm. The motor now acts as a generator and motor-generated current flows from the armature through the up-field, through back contact 3 of MCR, through controller contact 4, which is closed from 44 to zero degrees, through snub resistor SR back to the armature. A certain amount of motor-generated current will also flow through resistance DR. This current flows in the armature in the opposite direction from that when being supplied from an external source. This action, of course, slows the armature and by adjusting the snubbing resistance SR the armature will rotate faster or slower.

Increasing the resistance will permit an increase in speed of the armature and decreasing the resistance will slow the armature. When the gate arm is within 10 degrees of the horizontal position, controller contact 2 closes and maximum current will flow due to the minimum resistance of the circuit, causing the armature to almost stop. This snubbing action is used to regulate the descent of the gate arm from 45 degrees to the horizontal position. The final heavy snub at 10 degrees is to prevent shock to the mechanism when the gate arm reaches the horizontal position.

The gate arm now remains in the horizontal position because the gate arm is heavier than the counterweights.

Assuming that the train has passed over the crossing, XGR becomes energized and current flows through its front contact and energizes MCR. With MCR energized, current will also flow through its contact 4 to the hold coil, as previously described. However, the hold clear coil does not produce enough attraction to its armature to pull the hold clear assembly into locking position. Current could also flow through controller contact 12 to the solenoid coil S; however, the circuit is not complete until a path back to the power supply is established through controller contact 6 which is closed from 80 to 90 degrees, therefore the solenoid remains de-energized.

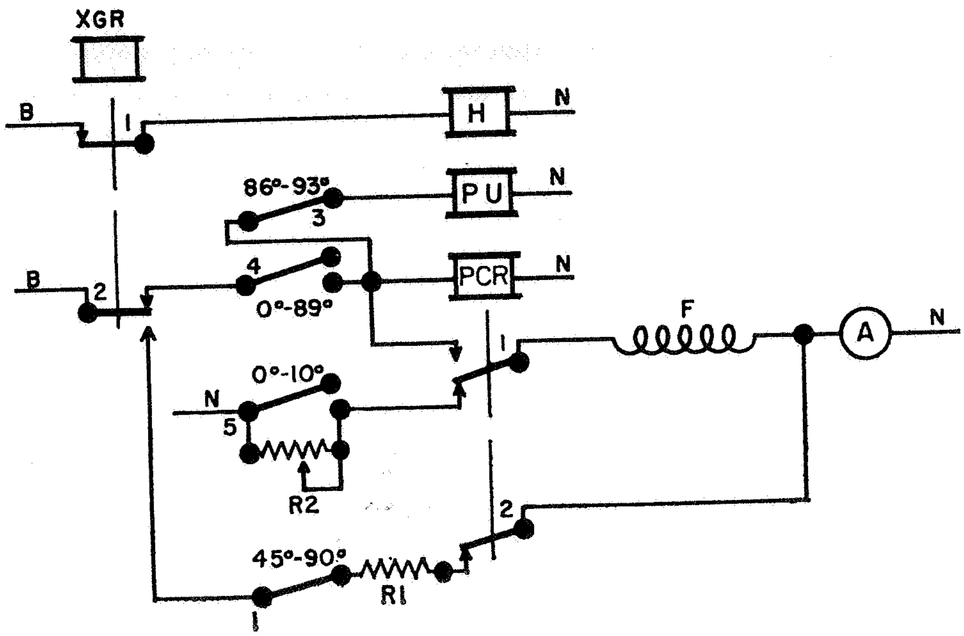
At the time MCR is energized, current also flows through its front contacts 1 and 2, through controller contact 14, through the up-field, and the armature. A certain amount of current will flow from junction between armature and up-field, through down-field, through controller contact 8, which is closed from zero to 5 degrees, through front contact 3 of MCR, through controller contact 2, which is closed from zero to 10 degrees. This parallel path diverts some of the current going to the motor to prevent the gate arm from jerking in starting its upward motion. As soon as the gate reaches 5 degrees above horizontal, all applied energy goes to the motor. The armature is now rotating in the opposite direction to that when the gate arm was descending because the current now flows through the up-field. When the gate arm reaches 80 degrees, controller contact 6 closes. At this time the solenoid is energized since its control circuit is completed through controller contact 12, which is closed from zero to 90 degrees, through front contract 4 of MCR and front contact of XGR. The solenoid coil when energized lifts the hold clear locking assembly to locking position. The hold coil H then holds the locking assembly in the locked position and the solenoid coil is shortly thereafter de-energized when controller contact 12 opens at 90 degrees. At this same interval, that is, when the gate arm reaches 80 degrees, controller contact 8 again closes, thereby establishing a parallel path for current to flow through drive resistance DR. This parallel circuit slows the armature to the extent that the gate arm will not whip or rock when being locked in the vertical position.

A half-wave rectifier bridges the armature and the up-field when controller contact 1 closes 85 to 90 degrees, to provide arc suppression on opening of controller contact 14.

Figure 44 is a schematic wiring diagram of the 3564 mechanism, which is a mast-mounted type.

The XGR is the control relay, which is located in the instrument housing at the crossing. With this scheme, four conductors are required from the instrument house to the gate mechanism for the following circuits: motor-up control, motor-down control, slot or hold coil control, and common. The position of the gates as depicted by the diagram is in the clear or vertical position. The holding coil H and the pick-up coil PU, both energized, exert enough magnetic attraction to pick up the mechanical hold clear assembly and once picked up, the holding coil alone holds the assembly in locked position. The pole change relay PC provides for reversing the current through the field of the motor. The contacts marked in degrees are cam-operated controller contacts and the degrees shown for each one indicate the position of the gate arm when they are closed.

The sequence of operation is as follows: When XGR is de-energized, such as on the approach of a train, current stops flowing to the hold coil H when front contact 1 of XGR opens. The hold coil H releases the hold clear assembly and the gate arm is free to descend to the horizontal position. Simultaneously,



[Fig. 44]

current flows through back contact 2 of XGR, through controller contact 1, which is closed from 90 to 45 degrees, through limiting resistor R1, through back contact 2 of PCR through armature A and thence back to source of supply at N. However, not all the applied energy goes through the armature since part of the current will flow through field F, through back contact 1 of PCR, and through snub resistance R2. Thus the motor is shunt connected and it is now driving the gate toward the horizontal position. When the gate arm reaches a position of 45 degrees, controller contact 1 opens thereby cutting off current to the motor. The gate arm continues to descend to the horizontal position by gravity and being geared to the motor causes the armature to continue rotating.

Now, the motor acts as a generator and the current it generates flows from the armature through field F, through back contact 1 of PCR, through resistance R2 back to the armature at N. The motor-generated current tends to oppose the direction of rotation of armature A. This action slows the armature and, of course, the descent of the gate arm. Increasing the resistance in R2 will permit an increase in the speed of rotation and, conversely, decreasing the resistance in R2 will slow the armature. Uniform regulation of descent of the gate arm is thus accomplished by adjustment of resistor R2.

When the gate arm reaches a position of 10 degrees from the horizontal position, controller contact 5 closes and shunts out the snub resistor. This causes the armature to almost stop as the gate arm nears the horizontal position.

Assuming the train has cleared the crossing, the following sequence of events takes place for the gate to rise to the clear or vertical position: Control relay XGR becomes energized and current will flow through its front contact 1 to the hold coil. The hold coil is thus energized but does not have enough magnetic strength to engage the hold clear assembly. Current will also flow through front contact 2 of XGR, through controller contact 4, which is closed from zero to 89 degrees, and energize PCR. With PCR energized current will also flow through front contact 1 of PCR, through motor-field F, and through armature A. The motor is now series-connected and since the current through the field is in a direction opposite to that of the down circuit, the armature rotates in an opposite direction and the gate arm begins to ascend. When the gate arm reaches 86 degrees, controller contact 3, which is closed from 86 to 93 degrees, closes and current flows through the contact and energizes pick-up coil PU. The holding coil having already been energized through front contact 1 of XGR, the hold clear assembly is pulled into the locking position. When the gate arm reaches 89 degrees, controller contact 4 opens, cutting off current to the motor, the pick-up coil and PCR. In this circuit the mechanical hold clear assembly is not picked up until the gate arm is almost vertical, the same as in the mechanism previously described. This, of course, saves wear on the locking pawl of the assembly. The pick-up coil is de-energized to save current, the resistance of its coils being of relatively low value.

Another type of mast-mounted mechanism, known as the 3566, is illustrated in Fig. 45.

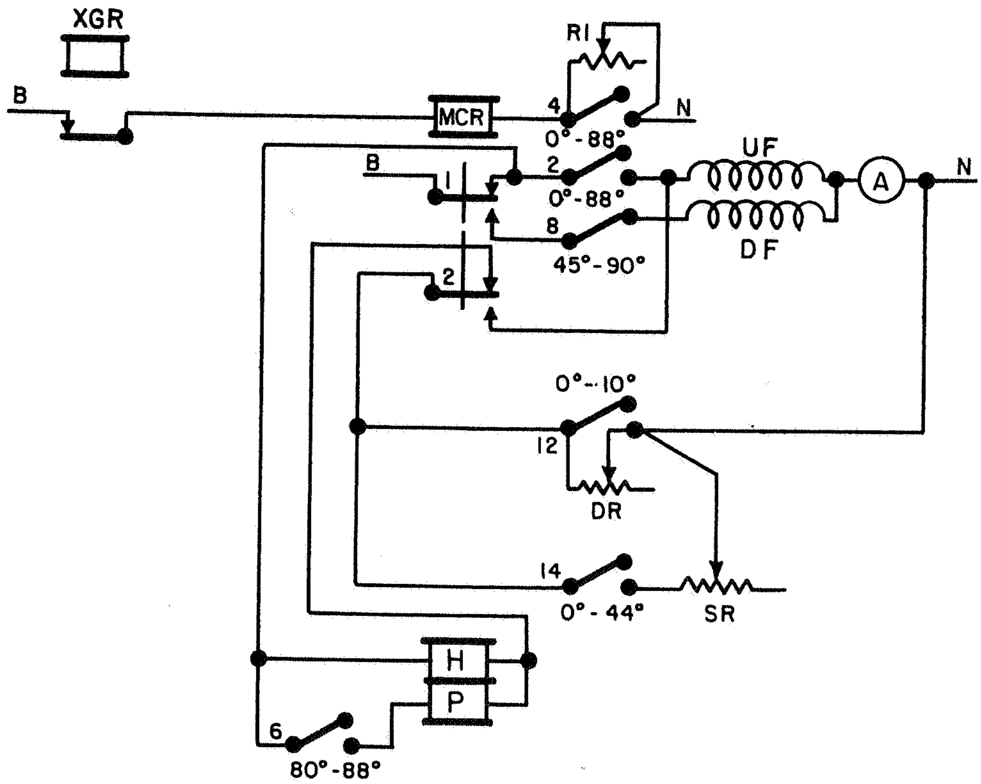


Fig. 45

This illustration also shows the XGR control relay, which is located in the instrument housing at the crossing. Three conductors from the instrument house to the gate mechanism are required for operation of the gate; namely, the control circuit, and the power supply wires (positive and negative). The control wire may be No. 14 copper but the power supply conductors have to be larger to avoid a large voltage drop. The wiring diagram shows the gate in the clear or vertical position. The circuit controller contacts are marked to show the travel of the arm in degrees during which time each contact is closed.

The sequence of events for the gate to assume the horizontal position is as follows: First, XGR is de-energized and when its front contact opens, current is cut off from the MCR relay in the gate mechanism. The MCR drops, opening the circuit to the holding coil H, which releases the hold clear assembly and the gate is free to descend to the horizontal position. Simultaneously, current flows through back contact 1 of MCR, through controller contact 8, which is closed from 90 to 45 degrees, through down-field DF and armature and thence back to the power supply at N. Not all the current flowing through the down-field goes through the armature. Some of it flows through the up-field UF, back contact 2 of MCR and drive resistance DR. The gate arm is counter-weighted so that it will start down as soon as the hold clear assembly releases. The circuit just described will cause the motor to regulate the speed of descent of the gate arm from 90 to the 45-degree position and will provide drive-down torque if required. Increasing the resistance in DR will accelerate the descent of the gate arm and decreasing the resistance in DR will slow the descent of the gate arm. When the gate arm reaches 45 degrees, controller contact 8 opens and motor-down current is cut off. The armature continues to rotate due to the weight of the gate arm. The motor now acts as a generator and motor-generated current flows from the armature through up-field UF, back contact 2 of MCR, controller contact 14, through snub resistor SR and back to the armature. A certain amount of the motor-generated current will also flow through resistor DR. This dynamic snubbing action governs the speed of the motor armature. Increasing the resistance of SR will permit the speed of the armature to increase and decreasing the resistance will slow the armature. When the gate arm is within 10 degrees of the horizontal position, controller contact 12 closes and shunts resistors DR and SR. This reduction in snub circuit resistance produces a heavy snub at 10 degrees, which causes the motor armature to rotate quite slowly. This prevents a shock to the mechanism when the gate arm reaches the horizontal position.

Counterweighting is such that the gate arm will remain in the horizontal position.

After the train has passed over the crossing, XGR becomes energized permitting current to flow through its front contact to energize MCR. With MCR up, the circuit to the H coil is closed through front contact 1 of MCR, front contact 2 of MCR and controller contact 12. The H coil, however, does not produce enough attraction to its armature to pull the hold clear assembly into locking position. Also, when MCR picks up, current flows through front contact 1 of MCR, controller contact 2, to the up-field and armature of the motor. The motor now operates to raise the gate arm.

When the gate arm reaches 80 degrees, controller contact 6 closes and connects H and P windings of hold clear in multiple. These windings acting together pull the hold clear assembly into locking position and the locking dog ratchets on the toothed hold clear disc until the motor cuts off at the 90-degree position.

When the gate arm reaches the clear position, (a) controller contact 2 opens the motor circuit, (b) controller contact 6 opens the winding circuit P, and (c) controller contact 4 opens and puts variable resistor R1 in series with MCR. The energy in winding H is enough to maintain the hold clear in the locking position to keep the motor from turning in the down direction. Resistor R1 is adjusted to keep the current in MCR above its drop-away but below its pick-up values.

Controller contacts 2 and 4 are closed from zero to 88 degrees when the gate is clearing and are closed from 75 to zero degrees when the gate is descending. If the XGR should drop momentarily and pick up again, MCR would drop but would not pick up at once, due to the adjustment of resistor R1. When the gate arm reached 75 degrees, controller contacts 2 and 4 would close, MCR would pick up and the motor would be energized to clear the gate. This circuit design is made so that under the described condition, the motor will have to be turning in the right direction before the hold clear can pick up at 80 degrees.

Figure 46 illustrates a schematic wiring diagram of the Model S mechanism and includes the control relay XGR. The diagram shows the position of the controller contacts and the motor control relay MCR contacts with the gate in the clear position. The illustration also shows the hold clear coil H, the pick-up coil PU, the motor field, motor armature A, the limiting or drive resistor R1 and the snub resistor R2.

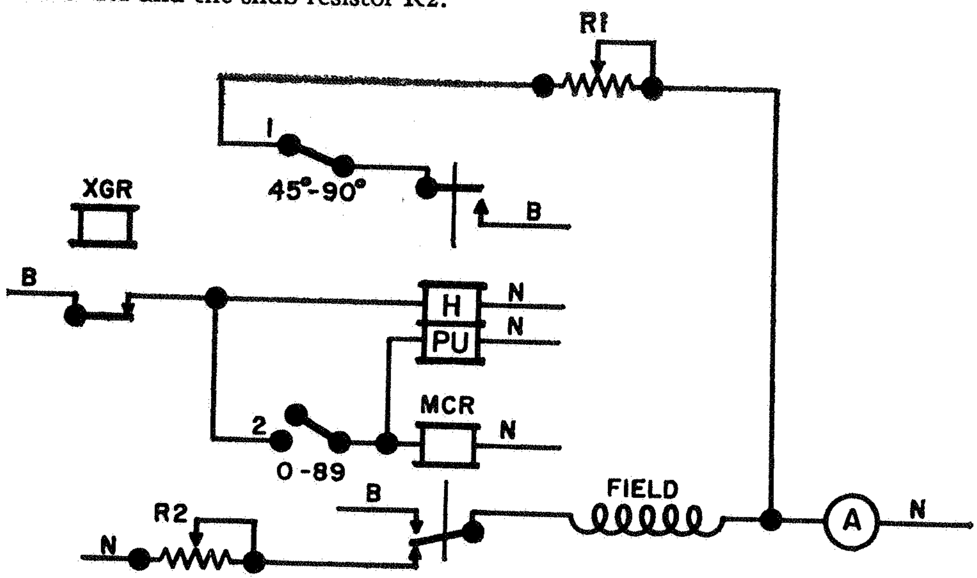


Fig. 46

With the gate arm in the clear or vertical position, current flows through the front contact of XGR to the hold coil H. The hold coil has attached to its armature a locking device which prevents the gate arm from lowering whenever the armature is held up or in the energized position. A contact is also attached to the hold clear armature for the power-down circuit.

Assume a train has entered the approach circuit and causes XGR to be de-energized. When the front contact of XGR opens, the hold coil is de-energized, and its armature drops. The armature in dropping disengages the locking device, which allows the gate to descend by gravity to the horizontal position. Simultaneously, current flows through the hold clear armature back contact, through controller contact 1, which is closed from 90 to 45 degrees, through resistor R1, to the motor. In the motor the current flows in two paths, one through armature A and the other through the field, through the back contact of MCR and through resistor R2. The motor is shunt-connected and now drives the gate toward the horizontal position.

Adjustment of R1 regulates the speed of descent of the gate arm between 90 and 45 degrees. Increasing the resistance will slow the descent and decreasing the resistance will increase the speed of the gate arm. When the gate arm reaches 45 degrees or half-way down to the horizontal position, controller contact 1 opens, thus cutting off current to the motor. The armature, however, continues to spin or rotate because of the weight of the gate arm. The motor now acts as a generator and current generated flows from the armature through the field, through the back contact of MCR, through resistor R2 to the opposite side of the armature at N. This current is utilized to regulate the speed of descent of the gate arm from 45 degrees to the horizontal position. This is accomplished by adjustment of resistor R2. The current generated returns to the armature of the motor in a way to oppose the direction of rotation of the armature when the gate is in downward motion. Therefore, increasing the resistance in R2 will result in allowing it to turn faster; conversely, less resistance in R2 will cause the armature to run slower.

In raising the gate, the first step occurs when XGR becomes energized. Current will flow through the front contact of XGR to hold coil H, and through controller contact 2, which is closed from zero to 89 degrees, to pick-up coil PU and motor control relay MCR.

The hold coil H and pick-up coil PU, on being energized, lifts its armature, which in turn opens its back contact and engages the locking device to the motor shaft. The locking device, however, is not effective in locking the gate when it is returning to its vertical position since it has an overrunning clutch. The MCR, when energized, closes its front contact and current flows through the field, through the armature and thence back to the power supply. Current is now flowing through the field in the opposite direction to that when the motor was driving the gate down. This reversal in direction of field current causes the armature to rotate in the opposite direction to that when the gate was lowering, so the gate arm rises to the vertical position. When the gate arm reaches 89 degrees, or almost vertical, controller contact 2 opens, and both the MCR and pick-up coil become de-energized. The MCR opens its front contact and current to the motor is cut off. The hold coil H now holds the armature locked and the gate arm remains in the vertical position.

Stand-by Power

Unlike ordinary street intersection traffic lights, which are operated solely by commercial power, railroad-highway grade crossing signals are inherently required to have two sources of power in the event of failure of the commercial source. This requirement means that additional apparatus is needed to provide an alternate source of power whenever the commercial power fails. Figure 47 shows a typical arrangement of a power transfer circuit.

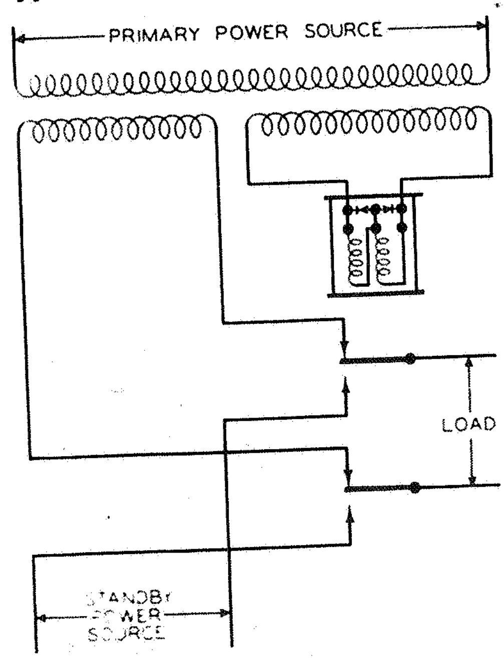


Fig. 47

This illustration shows the primary and secondary windings of the transformer and the power transfer relay.

The power transfer relay is connected to the low-voltage side of a transformer, the primary of which is permanently connected to the 115 or 230-volt a-c power source. The mechanical and electrical construction of a power transfer relay is in general similar to a regular neutral direct current relay with half-wave rectifiers added across each of the operating coils of the relay.

It is important that the power transfer relay should not be connected across the same transformer taps that carry the lamp load. Should it be necessary to connect the relay across taps already carrying a load, those taps should be selected whose load is almost constant and unaffected by the operation of the power transfer relay. This should be kept in mind to prevent oscillating or pumping action of the armature and burning contacts due to variation in lamp-load demand.

The illustration shows the stand-by power source (usually storage battery) terminating at the back contacts of the power transfer relay. Normally, (with a-c power on) alternating current from the secondary winding is fed to the load circuit through the front contacts of the power transfer relay. However, in the event of loss of energy from the transformer, the armature by force of gravity drops and closes its back contacts thereby connecting the lamp circuit to the stand-by power source which carries the load until a-c power is restored.

During one-half of each a-c cycle, current flows through one relay coil and that leg of the rectifier in parallel with the second relay coil, while during the second half of each cycle current flows through the second relay coil and that leg of the rectifier in parallel with the first relay coil.

Notwithstanding this alternating action, the relay is quiet at all impressed voltages since the mutual inductive coupling of the two legs, and the inductance and low resistance of each leg of the circuit, causes the current flowing therein to have a direct current component. Although the current through each coil pulsates, the sum of the currents in both coils is practically constant. This means that the electromagnetic flux acting on the armature is practically constant, therefore there is no tendency for the armature to vibrate and the effect is equivalent to action of direct current.

The necessity of depending on battery stand-by power for grade crossing signals limits the wattage of the lamps used.

Signs and Markings

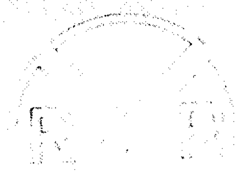
Railroad Crossing Sign

Generally, automatic protective devices are used at crossings of relatively heavy traffic, both highway and rail, along with consideration of other factors. However, at many crossings, protection is afforded by an "X" shaped sign with the legend "RAILROAD CROSSING." In view of general agreement that uniformity of size, shape and color of signs increases their effectiveness, the "X" shape of the railroad crossing sign is reserved for the special purpose of providing protection at railroad crossings.

Advance Warning Sign

Of particular importance in providing protection for the motorist at grade crossings is the matter of giving the driver advance notice that he is approaching such crossing.

One method of providing advance warning is through the use of a yellow circular sign 36 inches in diameter with the symbol X and letters RR appearing in black. The sign is placed in advance of the crossing at a distance of 100 to 750 feet depending on the speed of the vehicles on that particular thoroughfare. This sign is illustrated in Fig. 48.



ADVANCE WARNING SIGN
Background—Highway Yellow
Border, Symbol, and Lettering—Black
Fig. 48

The application of this sign is described in section 1C-31 of the Manual on Uniform Traffic Control Devices for Streets and Highways*, which reads:

IC-31 Railroad Advance Warning Sign

The Railroad Advance Warning sign shall be a yellow disk 36 inches in diameter, carrying a 90-degree crossbuck X and the letters RR in black.

The sign shall be used in advance of every railroad crossing, even if protected by crossbucks, signals, gates, or flagmen, except in the following instances:

1. At a minor siding or spur which is infrequently used and which is guarded when in use by a member of the train crew.

2. In the business districts of large cities where the crossings are fully protected and the physical conditions are such that even a partially effective display of the sign is impossible.

On a divided highway it may be desirable to erect a supplemental sign on the left of the roadway. In residence or business districts where low speeds are prevalent, the sign may be placed a minimum distance of 100 feet from the crossing. If there is a street intersection within 100 feet, an additional sign or signs should be so placed as to warn traffic approaching the crossing from each intersected street.

Railroad Advance Warning signs are usually off the railroad right-of-way and are properly the responsibility of the public authorities.

Markings

Another method for giving advance warning to the motorist is through marking the pavement in a different manner than other pavement markings. The provisions contained in the Manual under section 2B-23 read:

2B-23 Approach to Railroad Crossing

Pavement markings consisting of a cross, the letters RR, a no-passing zone marking, and certain transverse lines shall be placed on all paved

* Hereinafter referred to as the Manual.

approaches to railroad crossings, except at minor sidings in urban areas where other protection is afforded. Such markings shall be white except for the no-passing barrier line, which shall be yellow.

The design of railroad crossing pavement markings shall be essentially as illustrated in figure 2-9*. The symbol and letters are elongated to allow for the low angle at which they are viewed.

While these markings have value as a means of attracting the attention of the driver to the proximity of a railroad grade crossing, because they are distinctively different from all other pavement markings, they are only auxiliary to the standard Railroad Advance Warning sign and the Crossbuck sign, which must be used in every case, and crossing signals or gates.

Stop Signs

Stop signs requiring a statutory stop are used at some railroad crossings along with the crossbuck sign. While their use has been somewhat limited, generally secondary roads, the favorable results thus far obtained indicate that considerate use of this sign will materially reduce the number of accidents at crossings, especially those accidents where the vehicle strikes some part of the train. The application of the stop sign at railroad crossings is described in section 11-702 of the Uniform Vehicle Code quoted on page 6 of this chapter.

Traffic Signals Near Grade Crossings

Since grade crossing signals are in themselves traffic regulating devices, coordination with other agencies involved in highway design and traffic engineering is desirable.

At some locations highwaygrade crossing signals and traffic signals are installed relatively close to each other. To avoid confusion and to eliminate to the extent practicable, the hazard of vehicles becoming stacked on the track, careful consideration and planning for coordination of the traffic lights with the crossing signals is essential.

The provisions covering pre-emption of the traffic lights are contained in section 3B-25 of the Manual, which reads:

3B-25 Traffic Signals Near Grade Crossings

> At some street and highway intersections, railroad tracks pass within or near the intersection area, and the grade crossing thus formed is protected by train-approach signals. At such intersections it is essential that the control of the street traffic signal be pre-empted from the signal controller upon approach of trains to avoid conflicting aspects of the traffic signal and train-approach signal. Such an arrangement requires a closed electrical circuit between the control relay of the train-approach signals and the pre-emptor in order to establish and maintain the pre-empted condition during the time that train-approach signals are in operation.
>
> Traffic signals shall not be used in lieu of railroad grade crossing

* Not reproduced herein.

protection devices. There are, however, some crossings where train movements are regulated to the extent that train-approach signals are not required. In such cases pre-emption at the adjacent signalized intersections may be desirable to permit nonconflicting highway traffic to proceed during the time the crossing is blocked by a train. Except under unusual circumstances the interconnection should be limited to the traffic signals within 200 feet of the crossing.

There is a great diversity of configuration of intersection patterns involving railroad tracks. At some locations one or more tracks directly traverse the intersection area. At other locations the trackage cuts across one or more approaches. There are all degrees and combinations of vehicle volume, train frequencies, and waiting times.

There is, however, one fundamental requirement which must be observed in all cases. The pre-emption sequence initiated when the train first enters the approach circuit shall at once bring into effect a signal display which will permit all vehicles to clear the tracks before the train reaches the intersection.

To increase the safety factor at the railroad crossing, the normal sequence (no trains involved) of the traffic signals should be so designed that vehicles are not required to stop on the tracks even though in some cases this will increase the waiting time.

The exact nature of the signal display and location of the signals to accomplish this will depend on the physical relationship of the trackage to the intersection area. It is imperative, however, that the first stage of the pre-emption sequence be designed to clear vehicles from the tracks.

At the completion of the first stage of the pre-emption sequence, a second stage will come into effect which will persist until the pre-emption signal from the railroad control circuit ceases. The nature of this stage will depend upon the geometrics of the intersection and the nature and importance of the traffic flow, but will in all cases prohibit movements over the tracks. This stage may be steady red or flashing red. It may permit by arrow indications certain vehicle movements which do not cross over the tracks, and there may even be some transfer of nonconflicting rights-of-way during the pre-emption period. Naturally the probable duration of this period is a factor in all of the above.

When the train clears the crossing it is necessary to return the signal to a designated phase, this being the final stage of the pre-emption sequence.

When the green indication is pre-empted by train operation, a yellow clearance interval must be inserted in the signal sequence in the interests of safety and smoothness. To avoid misinterpretation during the time that the clear-out signals are green, consideration should be given to the use of 12-inch red lenses in the signals which govern movement over the tracks.

Careful consideration needs to be given the control of all intersections involving train movements. The plan for signal control must be based on the specific factors that prevail at each intersection involved. The pre-emption equipment tends to be special for each case and frequently of considerable complexity.

Maintenance

Proper maintenance is, of course, necessary for highway grade crossing protective devices in providing protection for the motorists. In this respect, each railroad prescribes method of maintenance on its property. Obviously, maintenance practices could not be developed on a universal basis, such development being precluded by the many variables attendant to maintenance requirements. These variables include geographical location, urban or rural areas, volume and nature of vehicular traffic, frequency of train movements, type of highway, type of equipment, etc.

American Railway Signaling Principles and Practices

QUESTIONS ON

CHAPTER XXIII

Railroad-Highway Grade Crossing Protection

QUESTIONS ON CHAPTER XXIII

RAILROAD-HIGHWAY GRADE CROSSING PROTECTION

1. What are the two types of visible warning signals in general use?

2. What other devices are used with the flashing light signals?

3. Why does the short-arm gate extend over the approach lane only, and what purpose does it serve?

4. What is the diameter of the standard red roundel used in flashing light signals?

5. What constitutes one cycle of the banner on the wig-wag?

6. In number of degrees, what are the "spread" and deflection characteristics of roundels used with cantilever type signals?

7. What are the two types of control circuit generally used for control of the crossing signals?

8. For what purpose is selective speed timing used?

9. What is the frequency of flashes of the flasher signal?

10. How can the rate of flashing the lights be varied?

11. What is the advantage in shunting the lamps in the flasher signal in lieu of opening their circuit?

12. What is the purpose of the check contact in the time relay?

13. Upon what principle is the control circuits for grade crossing protective devices based?

14. What four fundamental features are common to all gate mechanisms?

15. What is the purpose of the hold coil in the gate mechanism?

16. What device is used to vary the speed of descent of the gate arm?

17. Describe the operation of the stand-by power facility.

18. Describe two methods by which motorists are given advance information that they are approaching a railroad grade crossing.

AMERICAN RAILWAY SIGNALING PRINCIPLES AND PRACTICES

Following are the titles comprising this series of educational chapters: