American Railway Signaling Principles and Practices

CHAPTER XIII

Light Signals

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Historical.

The semaphore signal has served its purpose very well, but it had its limitations, due to height, length of arms and movable parts. It was also not ideal in that two entirely different aspects were used, one by day and the other by night, and there was a constant effort made to devise some arrangement whereby the same indication could be given for both day and night purposes.

Originally, most of the effort was along the lines of illuminating the semaphore arm to make it visible at night rather than make the colored lights visible during the day, due chiefly to the limitations of oil lamps.

With the advent of electricity and with improved methods of producing incandescent lamps, renewed efforts were made to solve the matter of uniform day and night signaling. Also the necessity of signals for tunnels and subways began to present itself and a light signal was developed to take care of an installation that was then being made.

This light signal was arranged to display practically the same indications as those given by the semaphore signal at night, but as there was no movable arm to change the color of the roundel in front of the light, it was necessary to use individual lamps behind the proper colored lens to give the various indications with the light signal.

While originally used in tunnels and subways, it was soon found that by using lamps of sufficient brilliancy, proper lenses, reflectors and background, light signals could be also used in daylight and give the same indications day and night.

From the fact that light signals required no movable parts other than the relays controlling the different lamps, it was soon recognized that there was a distinct advantage in their use over the semaphore signal, which, on account of the large number of movable parts (motor, cylinder, spectacle, etc.), required considerable labor and material to properly maintain them. Within the past few years light signals have seen material development and extensive use. In fact a number of railroads are installing nothing but light signals for new work and renewals.

At the present time (1930) the use of light signals has become so general and there are so many types that they will be grouped into three general classes as follows: color light, position light and color position light.

Color Light Signals

As the name implies, colors only are used to give the different indications and these are similar to the corresponding night indications given by semaphore signals; that is, red for Stop, yellow for Approach and green for Proceed, with sometimes a conjunctive qualifying light to provide the desired aspect. The feature of the various aspects and indications in use with color light signals is fully covered in Chapter II.

Color light signals may be grouped into two classes: viz., long range and short range.

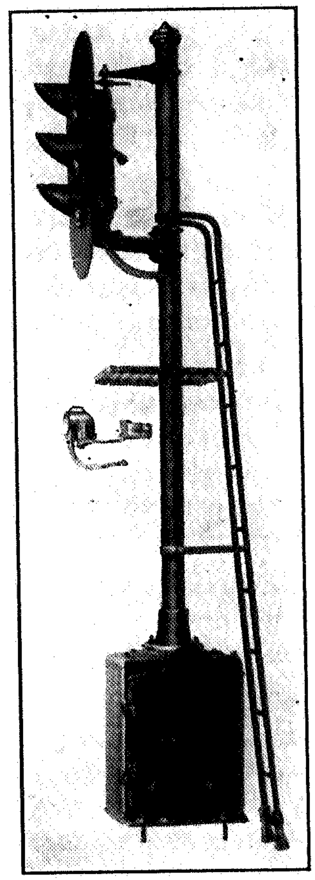


Fig. 1.
Style R, Color Light Signal.

Long range signals.

Long range signals are used generally where high speeds obtain and it is desirable to observe the signal indication governing the movement of the train as far from the signal as possible. Long range signals can be seen from a distance of 2500 to 5000 feet in daylight. This long range vision is obtained by accurate location of the lamp filament at the focal center of the lensing system. Maximum efficiency is secured by the use of lamps having concentrated filaments.

Short range signals.

Short range signals can be seen from a distance of 1200 to 2500 feet and are used generally in tunnels, subways, slow-speed inter-urban traffic and for dwarf signals. The range and spread of a light signal vary considerably with the type of lamp used. The more distributed the filament, the greater the spread and the shorter the range. Generally, an 8⅜ inch lens is used for long range signals while a 6⅜ inch lens is used for short range signals.

As with the semaphore type of signal to meet various requirements and for economical reasons there are a number of different types of color light signals manufactured.

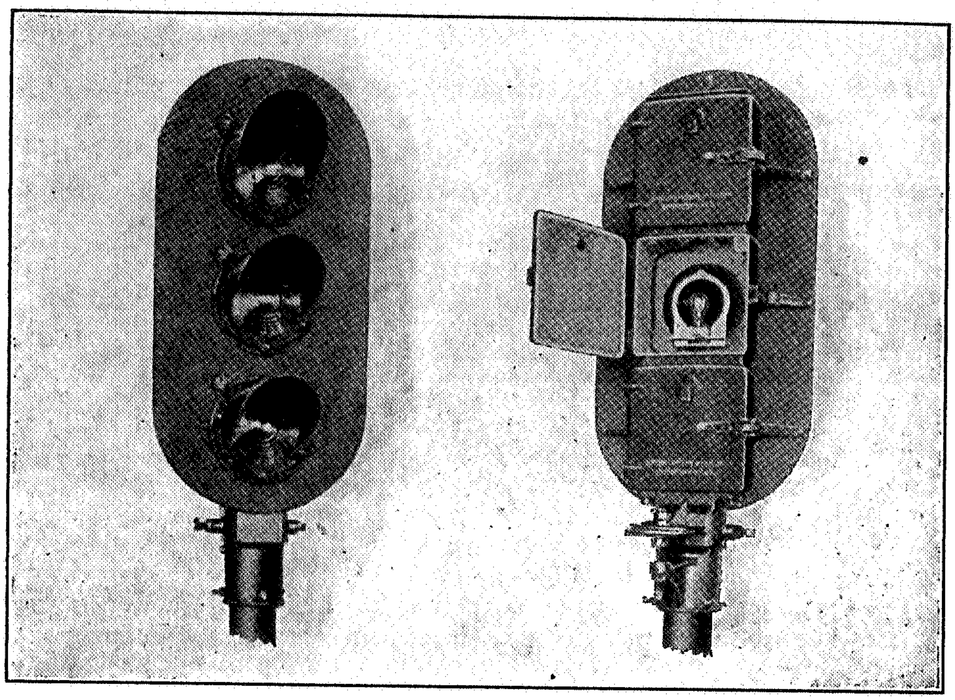


Fig. 2.
Style D, Color Light Signal.

Lamp units.

The lamp units are contained in iron cases for mounting on ground or bridge masts, the individual units being arranged vertically, horizontally or triangularly. In addition to the cases containing the lamp units, there are supporting brackets or a socket for attaching the case to the mast.

Figures 1 and 2 illustrate the vertical type, the lamp units being arranged vertically, one above the other, and spaced about 12 inches center to center. The usual arrangement is green on top, yellow in the middle and red on the bottom.

Doublet lens.

From Fig. 2 it can be seen that each lens unit is contained in a separate case and the cases bolted together, one above the other. Each unit has what is known as a doublet lens, which is a combination of two special lenses, by means of which a considerable angle of divergence or spread of the light rays is secured. This makes the signal aspect more effective on curves than would be the case with optical lenses. The doublet lens unit is illustrated in Fig. 3.

From this figure it is seen that the corrugations or stepped surfaces of the lenses face each other and that the lenses are enclosed in a dust-proof compartment with the smooth surfaces exposed. This

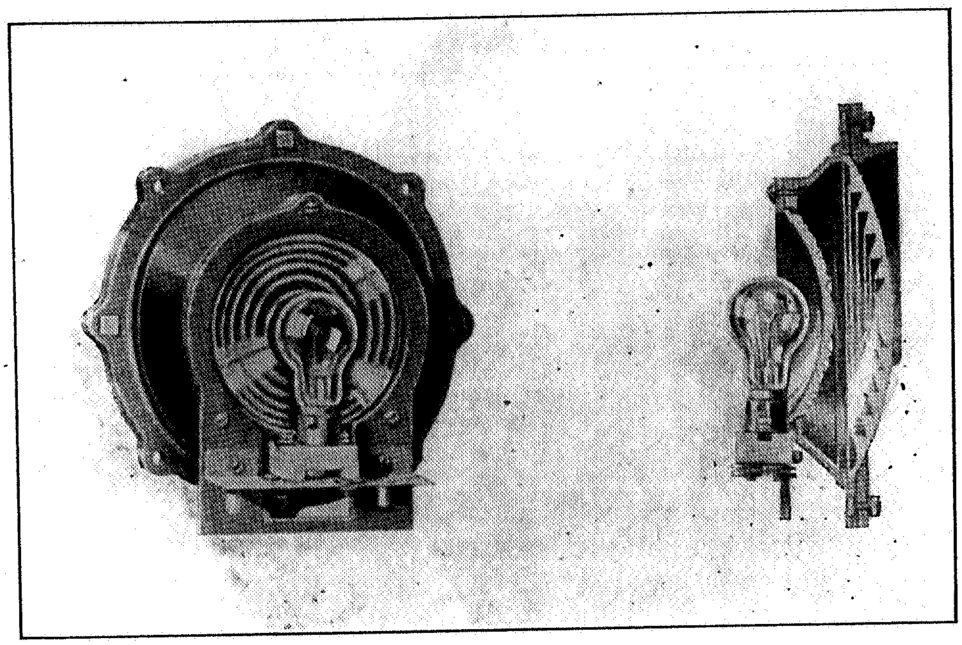


Fig. 3.
Doublet Lens.

arrangement makes it very easy to keep the lens surface clean and efficient for light transmission. The outer lens is clear glass while the inner one is colored.

The lamp receptacle or socket is supported in a fixed relationship to the lenses in order that the lamps, which are accurately based, may be interchangeable. Thus the lamp filament is brought to the exact focal point of the lens system and the range of the signal is not altered when a new lamp replaces an old or burned out one.

Possibly the doublet lens unit can be better described by quoting, in part, from a bulletin of one of the manufacturers, as follows: "The effective light from both filaments of a tungsten concentrated double filament lamp is placed in the focal center of a doublet lens, the outer lens being 8⅜ inches in diameter, with a 4-inch focal length, and the inner lens 5½ inches in diameter, with a 2½ inch focal length. Due to the short focus on the inner lens, the lamp is well within the lens which collects practically all the effective light from the front of the lamp. The bezel rings and cast-iron frame, which hold the two lenses, are accurately machined so that when the unit is assembled the lenses will align and be held exactly in their correct positions. The doublet lens, with lamp and receptacles as shown in Fig. 3, may be removed as a unit, or either lens or lamp may be removed and replaced without changing the focal adjustment."

Background and hood.

From a further study of Figs. 1 and 2 it will be seen that the signals are equipped with a background and each unit with a hood.

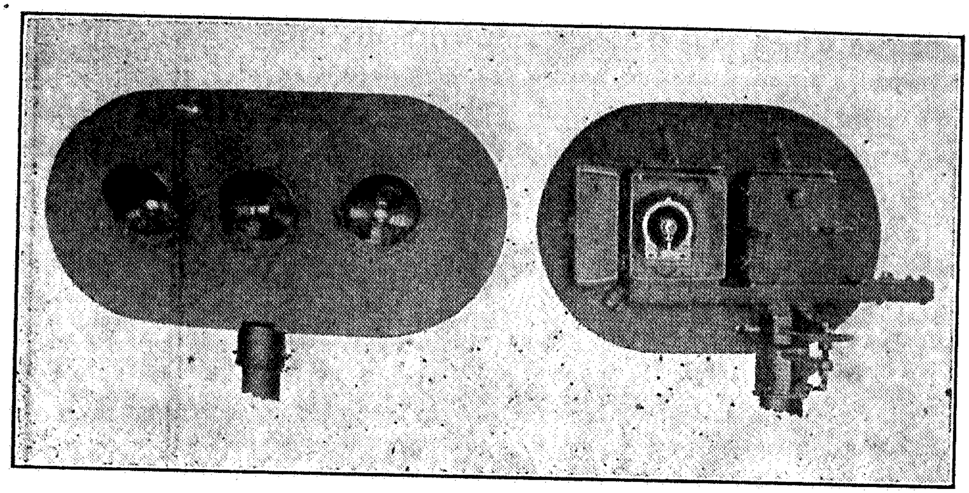


Fig. 4.
Style E, Color Light Signal.

The purpose of the hood is to shield the unit from the sun-rays; otherwise, with the sun shining directly on the unit, it would obscure or drown out the lamp, but with the hood the unit has the appearance of being set in a dark well. To further this effect, the flat sheet-iron background is used. If signals could always be located so that there could be a natural dark background to bring out the effect of the lamp, this artificial background would not be required.

Horizontal units.

Figure 4 illustrates the horizontal arrangement of light units, which has the advantage of close spacing between signal units on the same mast. This feature is desirable when locating signals on bridges or where each mast supports two or more three-indication signal units.

The construction details are practically the same as for the vertical type, except that which may be necessary to arrange the light units horizontally instead of vertically.

As can be readily seen, the vertical type requires greater height where two or more three-indication signal units are used as compared with the horizontal type. With the horizontal type a wide variety of aspects may be used to distinguish between interlocking, automatic and other forms of signals, as the location of the red lens in the units can be changed to provide vertical or staggered indications.

Practically all the figures illustrate three-unit signals, but they are also furnished in two units, as under certain conditions only two-colored lights instead of three are required. Illustration on right side of Fig. 4 shows a back view of a two-unit signal.

Marker lights.

Some roads use a marker light with the two or three-indication signal, in which case a single unit, with the proper colored lens, is installed a fixed distance below the signal unit.

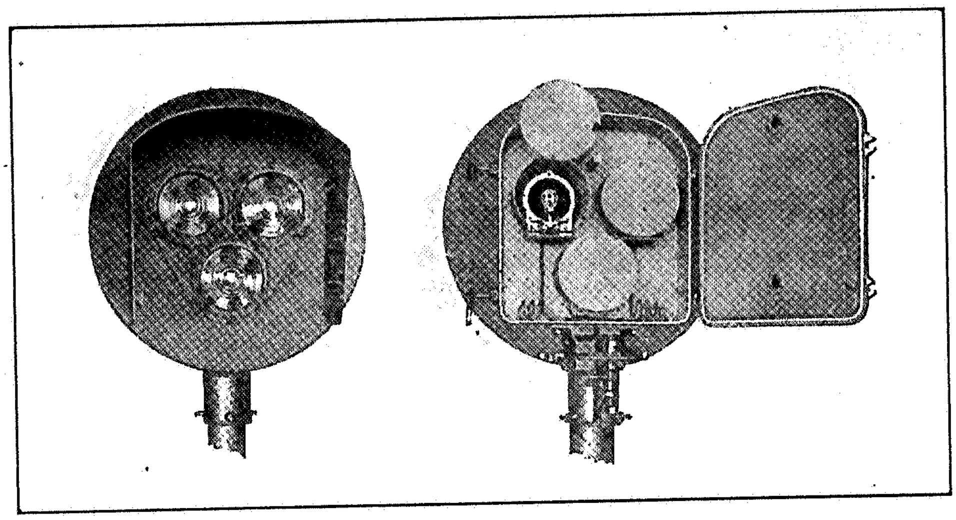


Fig. 5.
Style G, Color Light Signal.

Triangular units.

Figures 5 and 6 illustrate the triangular type of color light signal. This arrangement of units makes it comparatively small in size and well suited for use where clearances are limited or where closer spacing between signal units on the same mast is desired.

The construction details in these units are practically the same as for the vertical and horizontal types, the assembly being a triangular arrangement of the units spaced about 9 inches center to center.

While Fig. 5 indicates a single hood for the three units, individual hoods for each unit, as shown in Fig. 6, may be furnished if desired.

The color and arrangement of these light units may be as desired; that is, the left-hand unit may have a red, the right-hand unit a yellow and the bottom unit a green lens, or any other arrangement may be had.

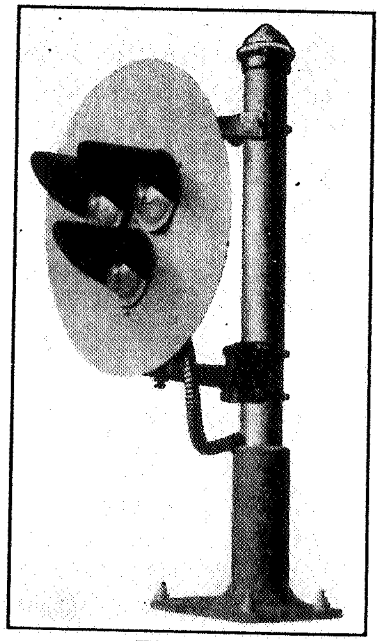


Fig. 6.
Style TR, Color Light Signal.

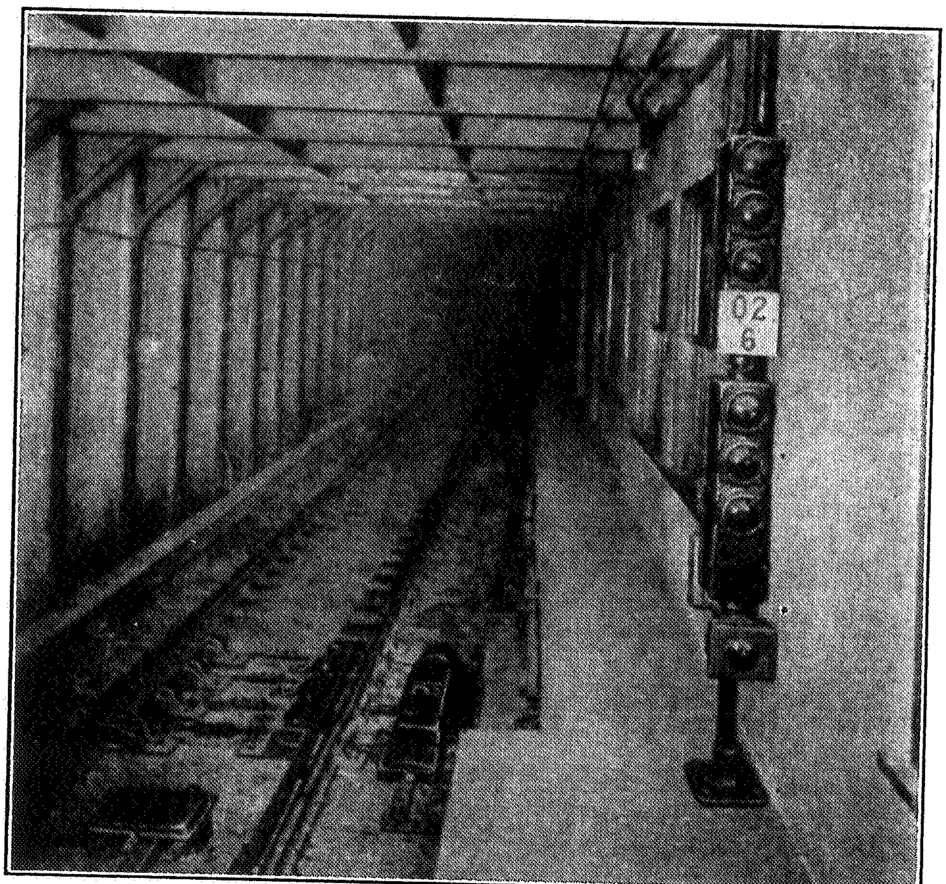


Fig. 7.
Style A, Color Light Signal.

Style A.

Figure 7 illustrates a signal originally designed for subway use, but is suitable, when equipped with doublet lens, for daylight use where a short range signal is all that is desired.

This signal can be used where clearances are limited, the case for a three-indication unit being cast in one piece 2 feet 7½ inches high, 8 inches wide and 10 inches deep. When used in tunnels, the signal is equipped with single 5-inch colored standard optical lenses and concentrated double filament lamps of the medium screw base type,

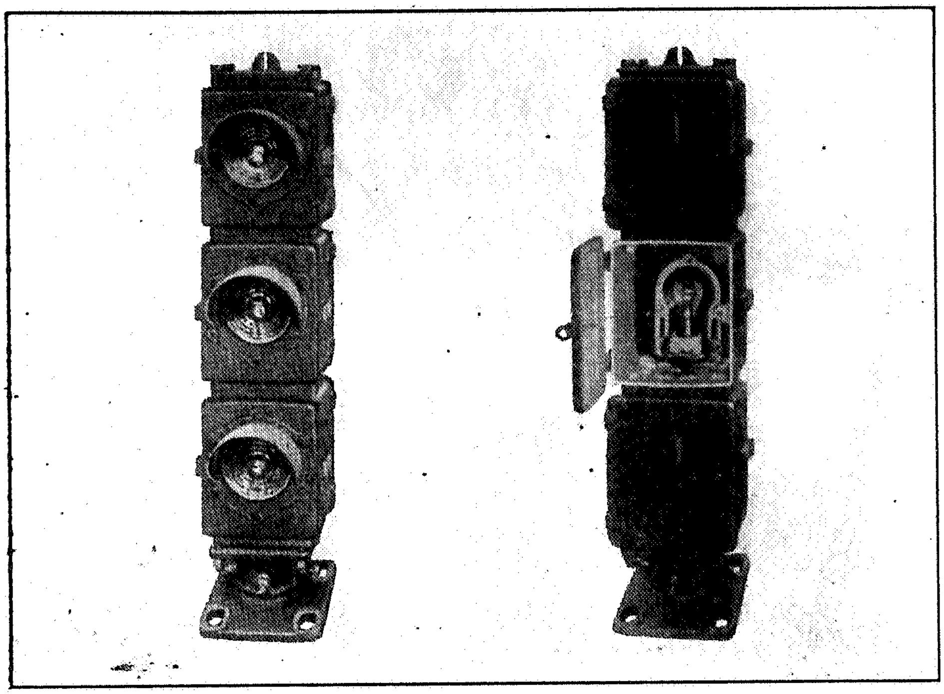


Fig. 8.
Style F, Color Light Signal.

rated at 14 volts and 10 watts. When furnished for daylight use the signal is equipped with 5-inch doublet lenses and concentrated double filament lamps of the medium screw base type rated at 14 volts, 30 watts, or 120 volts, 30 watts. The outer lens is 5 inches in diameter, of clear glass, and the inner lens is 3⅝ inches in diameter, of colored glass. Hoods are provided and if proper side clearances permit, backgrounds may be used. The lamps are not accurately based, but the lamp receptacles are adjustable, so that in replacing lamps the filament may be placed in the focal center of the lens.

Style F.

Figure 8 illustrates a signal similar to Fig. 2, except it is smaller in size, for use where close clearances prevail. This signal is used on electric railways and as a three-indication dwarf signal on steam railways.

While this figure shows the signal as a dwarf, the high signal is similar in all respects except that the base is arranged for application to an iron post instead of directly to a foundation.

This signal has 5-inch doublet lens units, which, except for size, are exactly similar to the 8⅜ inch doublet lens previously described. The outer clear lens is 5 inches in diameter and the colored lens is

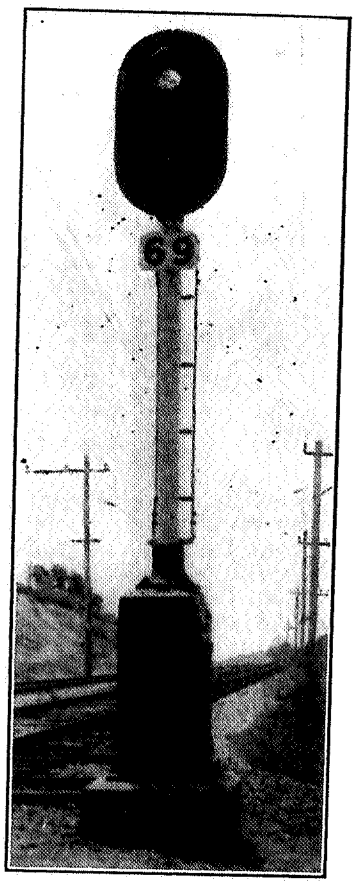


Fig. 9.
Style N, Color Light Signal.

3⅝ inches in diameter. The lens unit employs lamps of the same size and rating as used in the 8⅜ inch doublet lens, which vary, depending on the range desired. A 10-volt, 40-watt lamp is used for a range from 3000 to 3500 feet, an 8-volt, 10-watt lamp is used for a range from 1000 to 1500 feet, and a 120-volt, 30-watt lamp is used for a range from 2000 to 2500 feet.

Style N.

Figure 9 illustrates another type of signal that is used in about the same way as the one shown in Fig. 8.

This signal consists of a cast-iron case with either two or three openings to which have been applied doublet lenses, the outer lens being 6⅜ inches in diameter and the inner colored lens 5½ inches in diameter. This type of signal is generally installed with a separate transformer having a 110-volt primary with a secondary for 30-volt, 36-watt lamps.

The lamp receptacles are mounted on an adjustable bracket so that the man in the field can adjust the lamp filament to insure a satisfactory indication whenever lamps are replaced. Medium screw base lamps are used in this signal.

Fig. 10.
Style N-2, Color Light Signal.

Style N-2.

Figure 10 illustrates a signal similar to Fig. 9, used as a dwarf signal, the difference being in the type of lamp receptacle used and the method of mounting. The signal has a receptacle which is accurately located at the factory and requires a rebased lamp with a bayonet base. Lamp replacements can be made in the field without adjustments, due to the accurately located filament.

A triangular arrangement of lenses can be furnished, these signals being designated as "TN" and "TN-2," to correspond with the vertical designs "N" and "N-2," already described. The purpose of the triangular arrangement is to provide greater vertical clearance where a three-indication signal is used.

These signals, like the high signals, are ordinarily installed with a separate transformer, having a 110-volt primary winding with a secondary for 30-volt, 36-watt, or 10-volt, 18-watt lamps.

Style L.

Figure 11 illustrates still another type used as a high signal from which it will be seen that the design is somewhat similar to those shown by other figures, the principal difference being in the lamp receptacle which allows for two lamps to guard against lamp failure, the forward one being called the main lamp and the rear one the auxiliary or pilot lamp. The main lamp is 6 volts, 29 watts, specially based and in an accurately located socket, the rear lamp being 55 volts, 25 watts with medium screw base not accurately located.

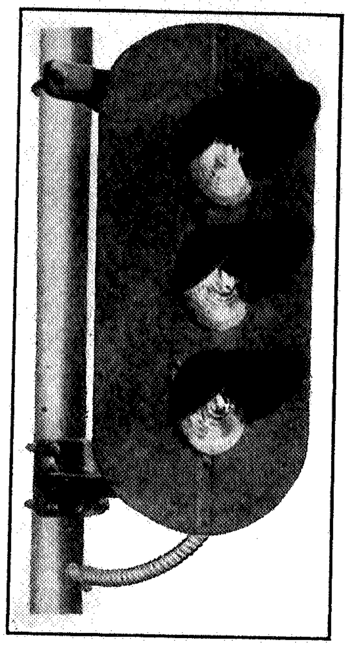


Fig. 11.
Style L, Color Light Signal.

In this signal unit the regular doublet lens combination is used, the outer lens being 8⅜ inches in diameter for long range. Deflecting prism cover glasses are used to give a horizontal or vertical spread. Sufficient space is provided in the case for housing individual lighting transformers. The case is mounted on a standard adjustable bracket which permits both horizontal and vertical adjustment.

Style M.

The Style M color light signal is very similar to the Styles R and L, as illustrated in Figs. 1 and 11, in so far as the case and lenses are concerned. The lamps used are the medium screw base with adjustable receptacles and are 30 volts, 36 watts, or 110 volts, 25 watts.

Searchlight type.

Another type of color light signal used is known as the searchlight signal. It differs from the signals previously described in that all the aspects are given through one lens of clear glass. This is accomplished by a movable member of the unit placing a roundel of desired color in front of the lamp.

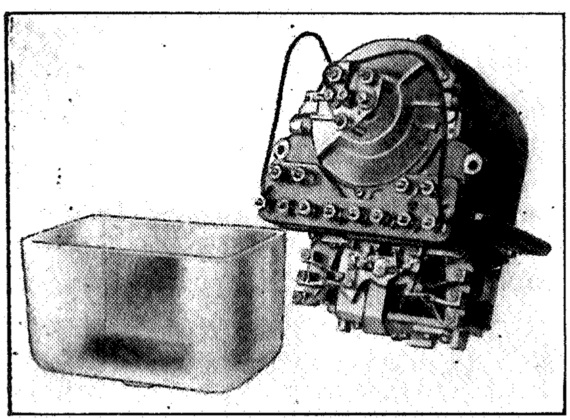
The movable member of the unit mentioned is a standard relay of the three-position type, so arranged that when de-energized it will assume the neutral central position and give a red indication; the relay may be of either the alternating or direct current type.

When operated by alternating current a standard polyphase vane relay mechanism is used, the roundels being directly mounted on the moving vane in such manner that they may be readily changed without interfering with any other part of the relay mechanism.

Where the direct current relay is used the motor principle of operation is employed. The moving element consists of an armature to which is connected the member containing the desired colored roundels. Figure 12 illustrates relays of this type.

The colored roundels are approximately one inch in diameter, 1/16 inch thick and are made of a specially developed heat-resisting glass accurately ground and polished. As an additional precaution against breakage they are spun into a light aluminum frame.

The signal is furnished with 6⅜, 8⅜ or 10½ inch diameter lens having focal lengths of 3¾, 5 and 6 inches, respectively. Different lens combinations are employed to meet the varying conditions of railroad requirements, such as Spreadlite lens for curves, where it is necessary to have a horizontal spread greater than that provided by the half toric optical lens.



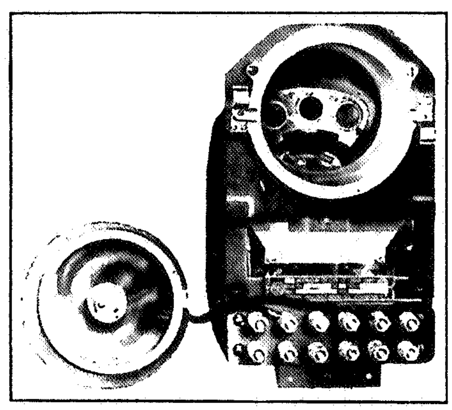


Fig. 12.
Direct Current Mechanisms for Searchlight Type Signals.

With this arrangement of roundels, it can be readily seen that when the relay is de-energized the red roundel will be in front of the lamp giving the Stop indication. When the control circuit is closed poling the vane or roundel carrying member one way, it will move the red roundel giving the Stop indication away from and another colored roundel giving a different indication in front of the lamp, while with the control circuit closed poling the relay in the opposite position, it will move a different colored roundel in front of the lamp and display still another indication. Generally, the three colored roundels used are red, yellow and green, corresponding with the standard aspects displayed by the other types of color light signals. Other colored roundels may be used if desired. A reflector is used to collect a large angle of light from the lamp concentrating the rays so that all will pass through the colored roundels and focus at the focal point of the objective lens.

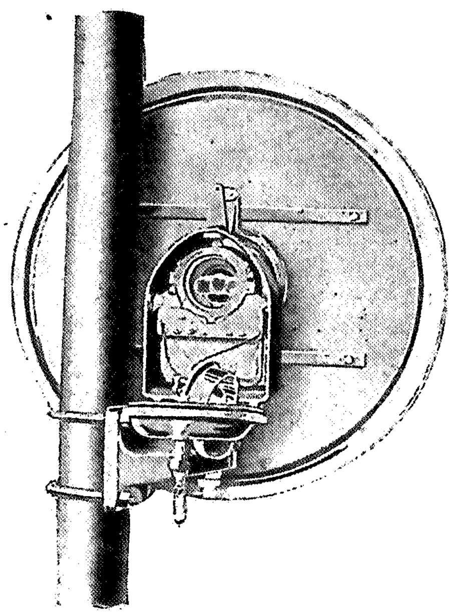


Fig. 13.
Color Light Signal, Searchlight Type.

A background is used and a hood extends forward over the lens to protect it from the direct rays of the sun, being arranged to closely embrace the periphery of the lens, thereby giving the maximum possible effect.

The lamp most generally used with this type of signal is a 12-16 volt, 21 candle power precision lamp with an S-10 or 11 bulb, single contact bayonet base, or a specially based lamp which may be purchased from the signal manufacturer.

Figure 13 illustrates the general arrangement of the unit attached to a signal mast and used as a high signal.

Fundamentally, the signal comprises a concentrated filament lamp with filament located at the focal point of an elliptical reflector, which collects approximately 80 per cent of the light rays emitted from the lamp, and concentrates them at the second focal point of the ellipse. At this point, which is coincident with the focal center

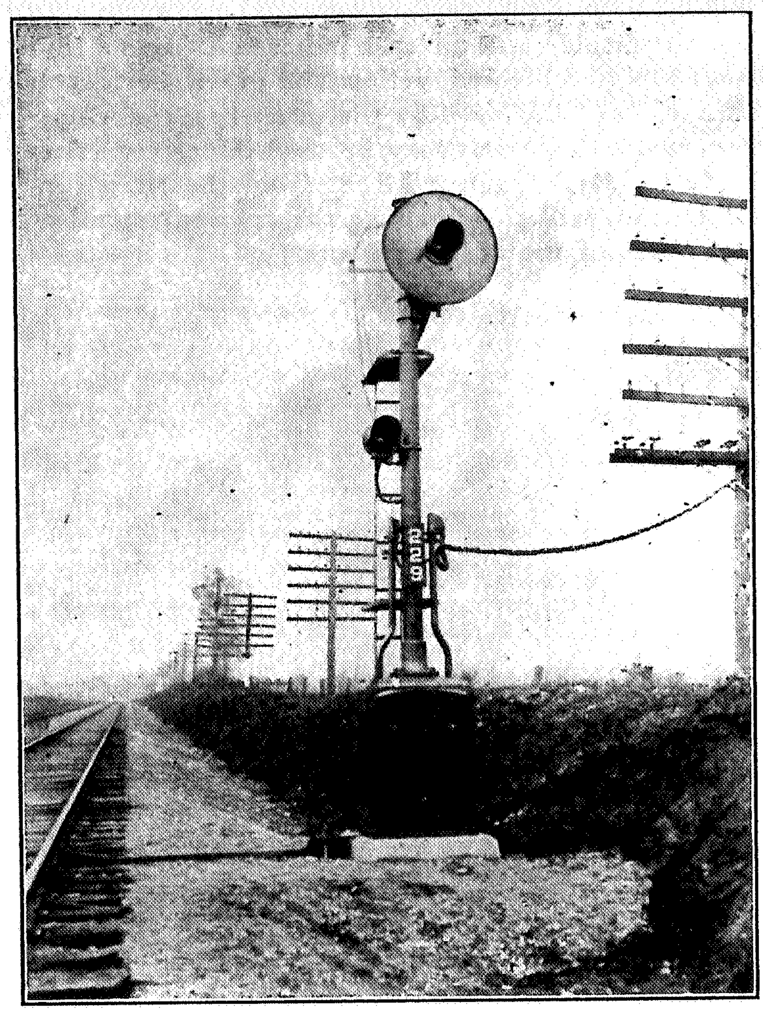


Fig. 14.
Color Light High Signal, Searchlight Type.

of a clear optical lens, the light passes through a miniature colored roundel, enters the lens and emerges in a substantial light beam, as illustrated in Fig. 15.

Figure 14 shows the unit as a high signal, while Fig. 16 shows it as a dwarf signal.

The high signal is supported by an adjustable bracket which provides a separate horizontal and vertical adjustment. These two adjustments, with the hair line peep sight at the top of the signal, provide an easy means of aligning the light beam. The dwarf signal is mounted on an adjustable base permitting horizontal and vertical adjustment of the unit.

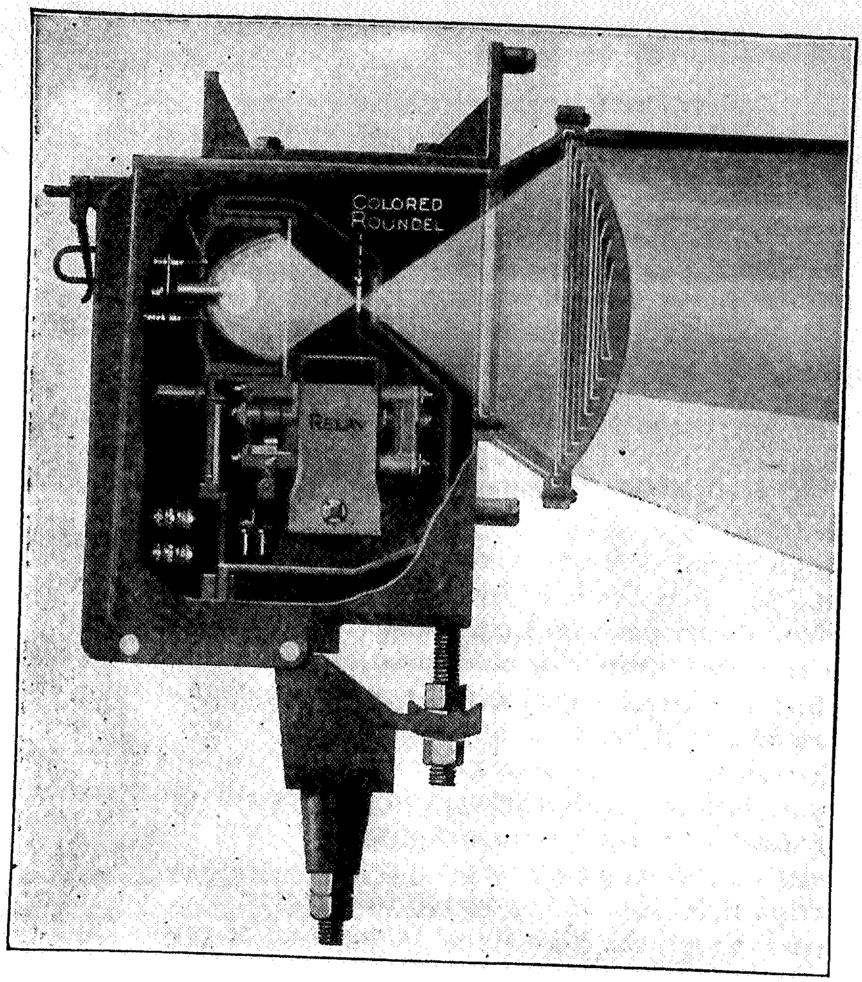


Fig. 15.
Color Light High Signal, Searchlight Type.

A more recent development of this type of signal has eliminated the local source of energy by the substitution of a permanent magnet in place of the field coils. In this same stage of development it was found possible to obtain practically the same indication with a 4-volt, 3-watt lamp as is obtained from a 10-volt, 14-watt lamp. This particular development was brought about by the request for a searchlight type signal which could be used economically in primary battery territory.

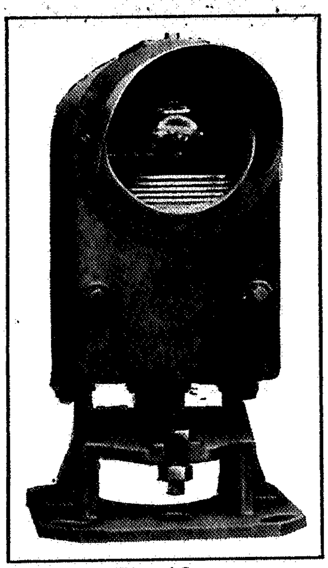


Fig. 16.
Color Light Dwarf Signal, Searchlight Type.

Position Light Signals

For the purpose of eliminating the colored lights for display of the various signal indications and at the same time provide a similar aspect for day and night indications, the position light signal was developed.

The high signal consists of rows of three light units corresponding to the positions occupied by the arms of semaphore signals.

High and dwarf position light signals are available. High signals may be mounted upon a ground mast, signal bridge or cantilever post, while the dwarf signal may be mounted upon a foundation or by means of a wall bracket.

The high signal can be arranged to give indications corresponding to one arm, one arm with marker, two arm, or any other combination desired. Each arm equivalent can give one, two, three or four distinct positions. A complete arrangement of aspects and indications for position light signals is covered in Chapter II.

As stated above, the high signal is made up of rows of light units, each row consisting of three cast-iron lamp cases mounted on 1¼ inch pipe supports extending radially from an iron central hub equipped with a clamp for applying to a 5-inch pipe mast, also an iron terminal box is attached to the mast near the hub. The lamp units are located on an 18-inch radius about a central lamp. The wires leading to each lamp unit pass down through the 1¼ inch pipe supports, through the hub and a short piece of conduit into the terminal box. From the terminal box the wires lead into the signal mast through a flexible connection so that the signal unit may be aligned without disturbing the wiring, all parts of the unit being easily accessible.

A sheet-iron background, attached to the pipe supports by means of substantial brackets, is used for the complete unit. These backgrounds are of two shapes: circular and oblong. The circular one is generally used on the top arm, while the oblong one is used where it is only necessary to bring out one row of lights such as the vertical row on the bottom unit which gives the medium-speed indication.

Figure 17 illustrates a front and rear view of a typical position light signal.

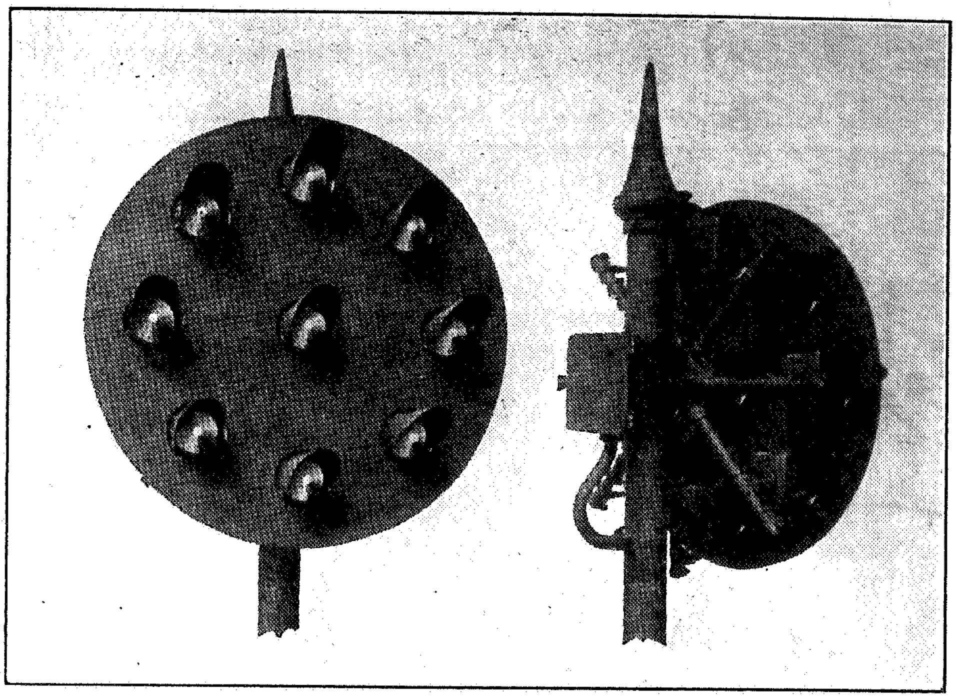


Fig. 17.
Position Light Signal.

A standard signal platform with extended hand rail and standard ladder provides ready access to the units and terminal box when located on ground masts. The lamp units on bridge signals are so located as to make ladders unnecessary.

Lamp.

The lamp unit consists of a cast-iron case with a door on one or both sides, lamp, lamp receptacle, inverted lens, cover glass, mirror, mounting bracket and hood. The lamp has a concentrated filament, single contact bayonet base, without pins, the entire lamp being accurately based similar to certain of the color light signals mentioned above. They are burned under their rated voltage to provide longer life, being rated at 12 volts and 6 candle power. It is desirable to burn them at 11 to 11.5 volts at the lamp terminals. The lamp receptacles are jig-set and cemented in place. This, with the accurately based lamps, permits renewing lamps without affecting the adjustment.

Lens.

The lens is a 5⅜ inch inverted toric lens of clear glass, and has a focal length of 2¼ inches.

Cover glass.

The cover glass is conical in shape, of amber or slight yellowish tinted glass with a frosted tip. The conical shape and frosted tip are to prevent reflections of sunlight or sun-glare and the tinted glass gives a more penetrating beam, especially under foggy weather conditions.

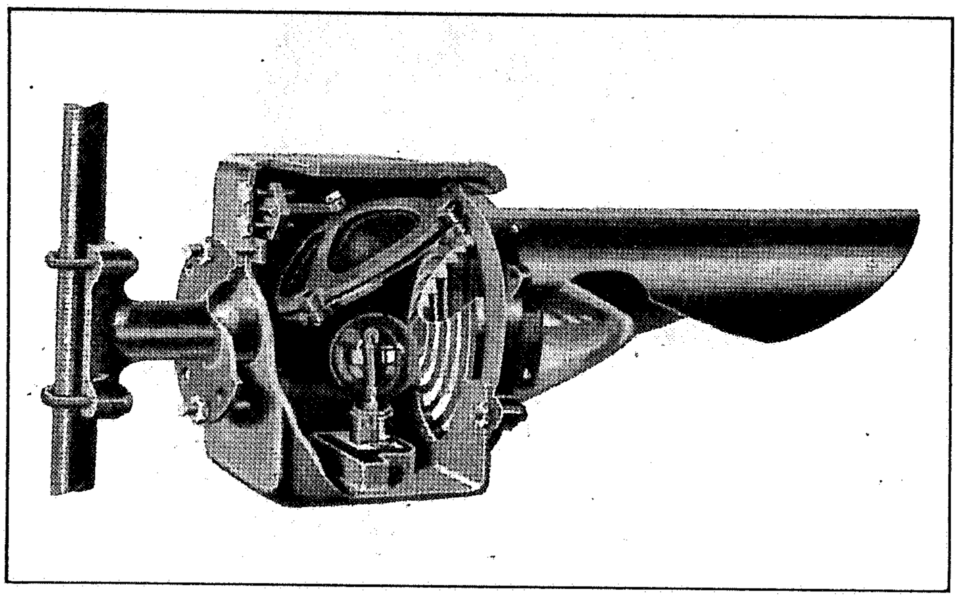


Fig. 18.
Position Light Signal Lamp Unit.

Phantom indications are further prevented by painting a portion of the inside lens surface steps black.

Mirror.

The mirror is adjustably mounted and arranged to deflect some of the rays of light downward to provide a close indication.

Mounting bracket.

The mounting bracket is attached to the lamp case through a ball and socket joint and by four bolts to permit of any adjustment that may be necessary to properly align the lamp. The other end of this bracket is attached to the 1¼ inch pipe post.

Hood.

The hood projects over the cover glass a sufficient distance to prevent the direct sun-rays from striking the cover glass and cutting down the brilliancy of the unit as mentioned under color light signals.

Figure 18 illustrates one of these position light signal lamp units with the various parts exposed.

Only one lamp is used in each lamp unit. Should one lamp in any row burn out, there remain two other units lighted which provide a satisfactory indication.

Dwarf signal.

The position light dwarf signal is for a short range indication and consists of a single cast-iron case with four openings for lenses. A door is provided on either side of the case to provide easy access to wire terminals and lamps. The case is about 15½ inches high, 16 inches wide and 9½ inches deep. The lenses are located on 8-inch center lines, radially from the pivot unit.

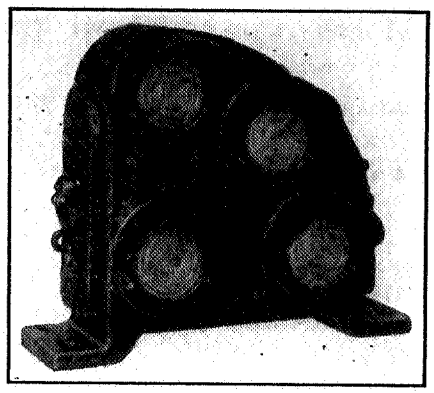


Fig. 19.
Position Light Dwarf Signal.

On account of a short range only being required, no particular attempt is made to secure an accurate location of the lamp with respect to the lens. The lamp receptacle is mounted on a bracket attached to the back of the case, is not jig-set, nor is the lamp rebased. The lamps used are of the concentrated single filament, single contact bayonet candelabra base type rated at 6 to 8 volts, 21 candle power and burned at 4.2 or 4.3 volts, or 12 to 16 volts burned at 11.5 volts.

The lens is 4 inches in diameter, of clear glass, and has its outer surface frosted to provide better diffusion of light and to reduce sun-glare.

This signal is generally mounted at a slight angle, the front of the signal being slightly higher than the back. This throws the main rays from the signal slightly upward so that the engineman will obtain a better view of the given indication from his position which is considerably above the horizontal plane in which the dwarf signal is located.

Figure 19 illustrates the position light dwarf signal.

Color Position Light Signals

This type of signal is practically a combination of the two previous types in that colors as well as positions are utilized, except that two units are used in a row.

The signal consists of a main unit with marker unit above and/or below it to indicate whether the main or restricted route is set up; when the marker unit above the main unit and the main unit are lighted it indicates the main route is to be used; when the marker unit below the main unit and the main unit are lighted it indicates the restricted speed route is to be used. Aspects and indications of this system are fully covered in Chapter II.

There may be two marker units located above and/or below the main unit; the center of the vertical one is located about 4 feet 5 inches above or below the center of the main unit while the center of the other or staggered marker unit is located 2 feet 4 inches from the center to the left of and in a horizontal line from the vertical marker unit.

The main unit consists of the desired number of lamp cases mounted on supports radially from the center, the units in each row being spaced 2 feet 4 inches center to center.

Lamp unit.

Each unit is constructed somewhat along the lines of the lamp unit described under color light signals in that it has the doublet lens arrangement, the outer lens being of clear glass 8⅜ inches in diameter, the inner lens being of the desired color. The marker light is of the same general construction.

The lamp case is of cast aluminum and is bolted to the face plate of the signal.

Lamp.

The lamps used are 13½ volt, 17-watt, C-2 filament, Mazda "C," S-11 gas-filled, equipped with single contact bayonet candelabra base.

A color position light signal is illustrated in Fig. 20.

Fourteen different aspects may be obtained from the color position light signal.

One of the outstanding features with this color system is the fact that when an indication more favorable than Stop is given there are no red lights displayed on the signal.

Each row of units is generally supplied with a transformer with suitable taps to provide close adjustment of the lamp voltage. The standard transformers have a capacity of 40-volt amperes at 60 cycles; one transformer being used for the two lamps, each for the display of the two red, the two yellow, the two green and the two lunar white lights.

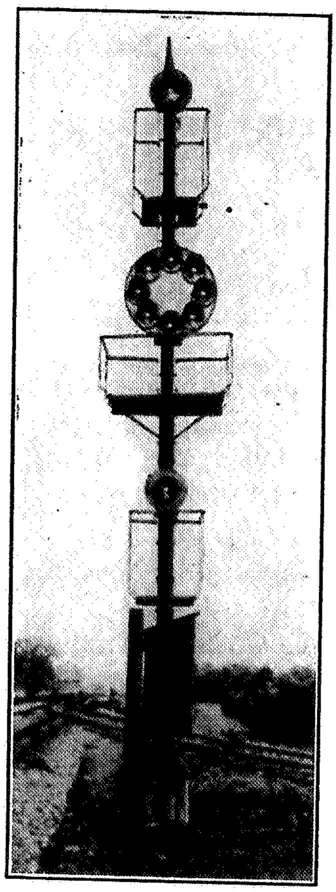


Fig. 20.
Color Position Light Signal.

Dwarf signal.

The dwarf signal is a compact miniature high signal contained in a metal case 2 feet 9½ inches high and 17½ inches wide, resting on a base 24 inches wide and 8 inches deep.

The units in each row are spaced 11½ inch centers. The outer lenses in the dwarf signals are clear glass 3½ inches in diameter, the colored lenses being on the inside similar to the high signals. The lamp is the same as that used in the high signals.

Figure 21 illustrates a color position light dwarf signal, from which it can be seen that it is possible to obtain the same indications as given by the high signals, with the vertical marker units or without marker unit as the case may be. Where the marker unit is used it is spaced 8½ inches above or below the top or bottom vertical unit; no staggered marker unit is necessary. If no marker unit is necessary, the height of the signal is reduced accordingly.

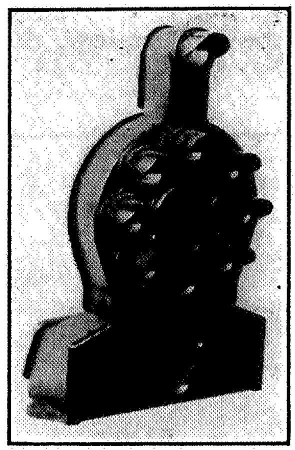


Fig. 21.
Color Position Light Dwarf Signal.

Typical local wiring.

Figures 22, 23, 24 and 25 show typical local wiring for several types of light signals.

Lamps

As the electric lamp plays such an important part in light signals, it is essential that the proper type be used in each signal.

Mention has been made of specially based concentrated filament lamps. These are generally used where long range indications are desired and the illumination of the filament is restricted to a small area at the focal point of the lens system. In other words, the illumination is "concentrated" at the focal point to increase the brilliancy. To further insure the filament being at the focal point, these lamps are accurately based by being placed in a rebasing machine which has adjustments so that the lamp can be held at the focal point and then securely soldered in a brass collar that has two or three pins projecting from the side. The receptacle in the regular lamp unit is arranged so that when the lamp is installed, the pins on the collar fit into slots in the receptacle bringing the filament to the correct focal position.

Figure 26 illustrates a concentrated double filament lamp with the collar soldered to it.

To more nearly insure against illumination failure, a double filament lamp, as illustrated in Fig. 26, is used. This type lamp is furnished in different voltages and wattage, such as 10 volts, 18 watts; 8 volts, 10 watts, etc.

S-11 single contact candelabra bayonet base lamps with special adapters are sometimes used interchangeably with the PS-16 medium based concentrated double filament lamp illustrated in Fig. 26. Both the precision and commercial S-11 lamps have been used. The pre-

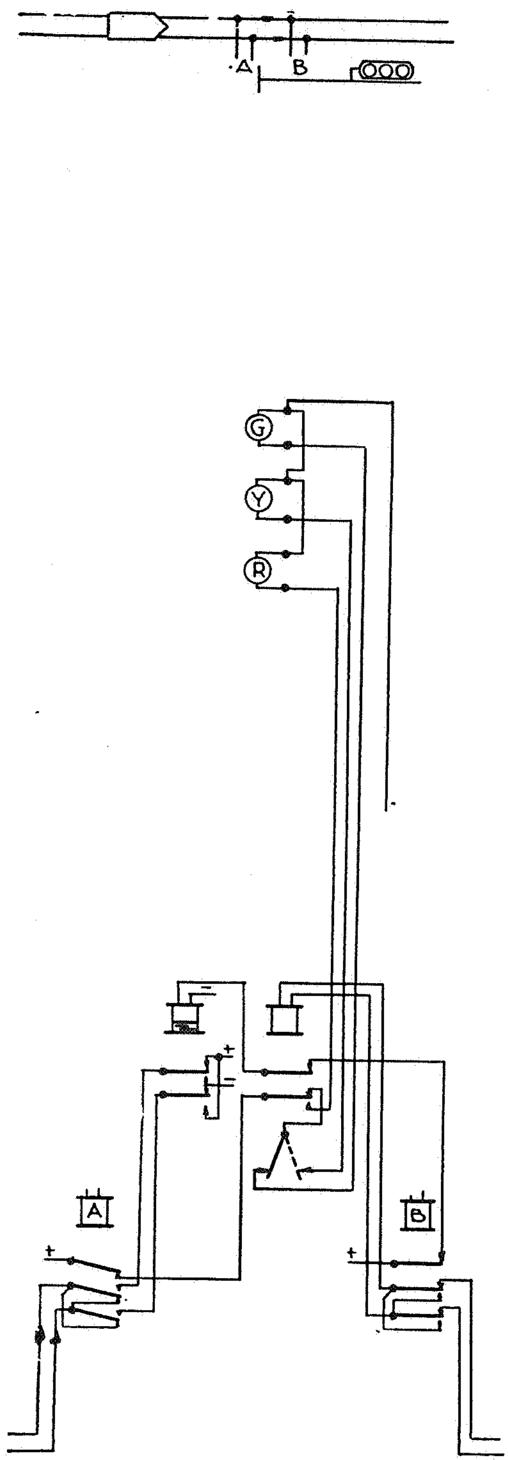


Fig. 22.
Typical Local Wiring—Color Light Signal.

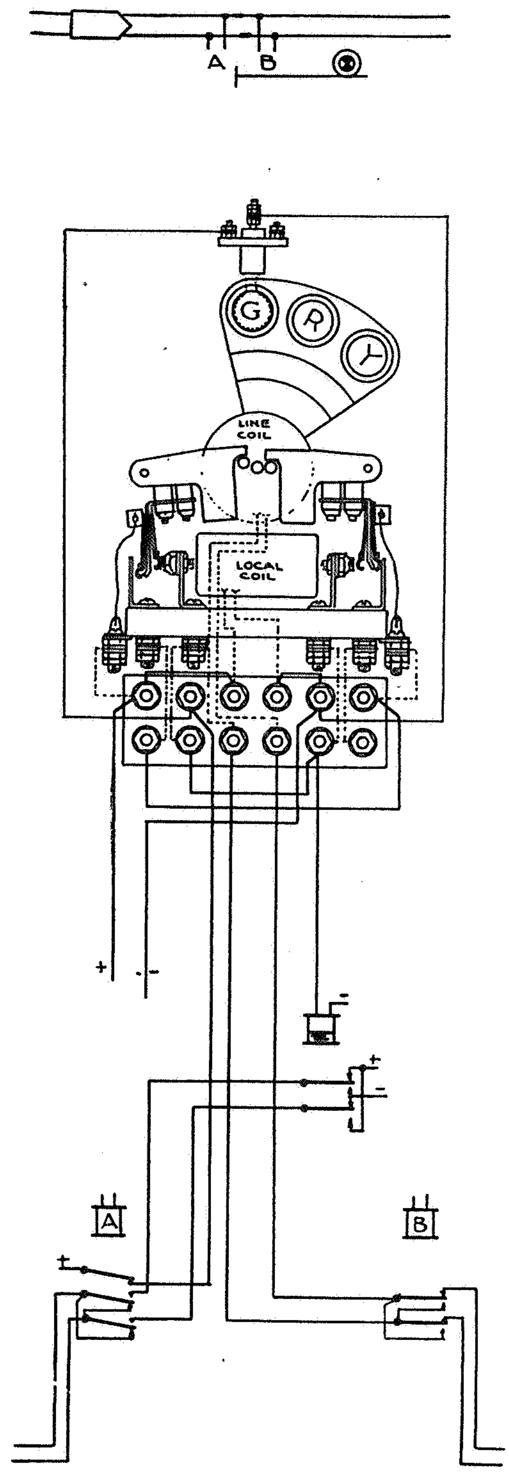


Fig. 23.
Typical Local Wiring—Searchlight Signal.

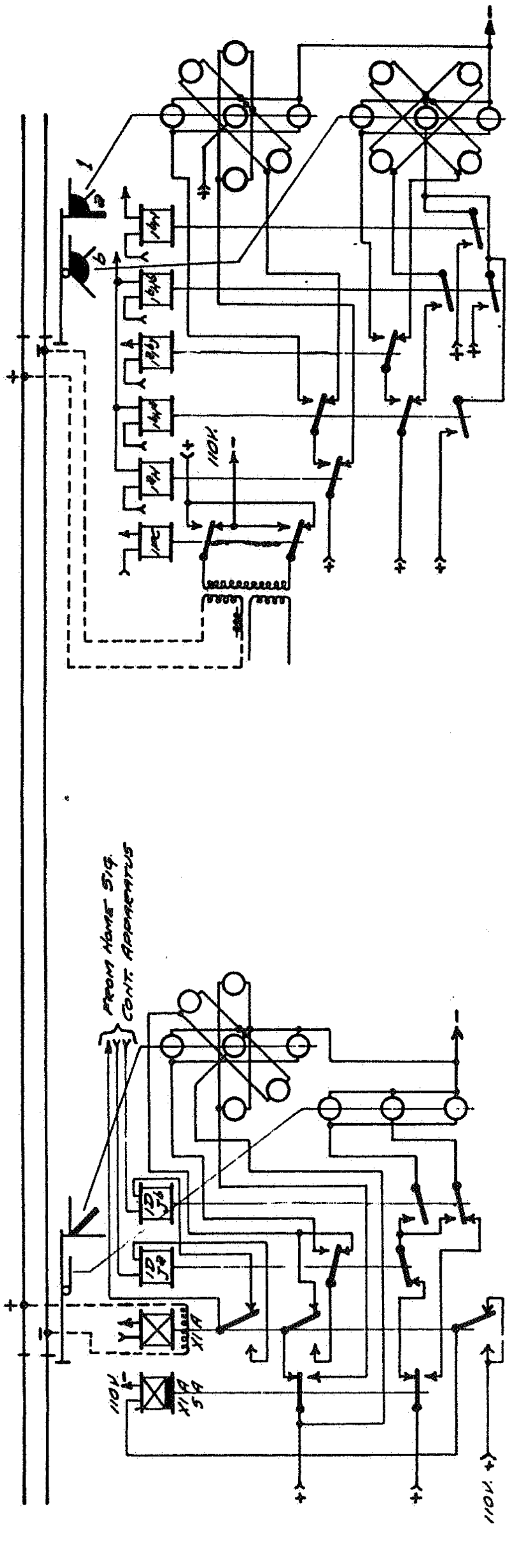


Fig. 24.
Typical Local Wiring—Position Light Signal.

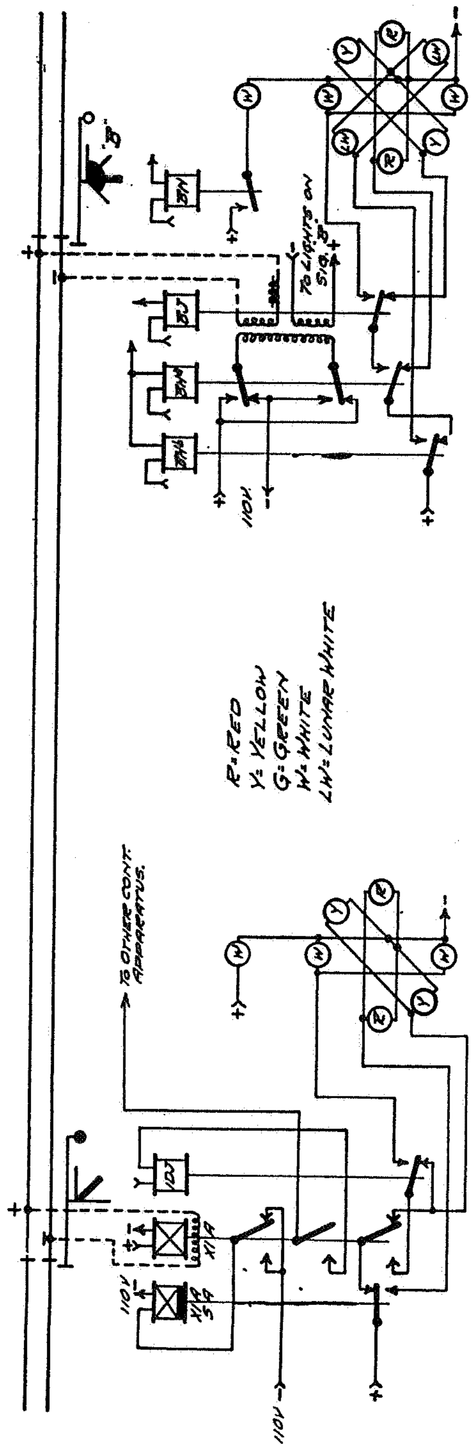


Fig. 25.
Typical Local Wiring—Color Position Light Signal.

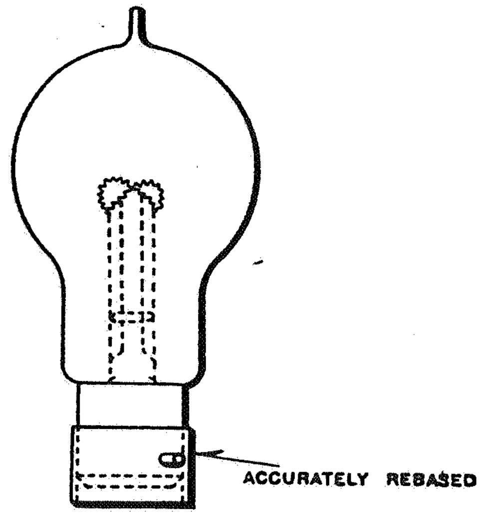


Fig. 26.
Concentrated Double Filament Lamp.

cision lamp is one which has had the brass base accurately located with respect to the filament and cemented in that position. A fixed precision type adapter, as illustrated in Fig. 27, is used with the precision type lamp and with this combination the filament of the S-11 lamp bears the same relation to the pins in the adapter as the filament of the lamp in Fig. 26 bears to the pins in the special collar. The precision S-11 lamp with its special adapters is interchangeable with the accurately based PS-16 lamp.

The base on the commercial S-11 lamp bears no fixed relation to the filament, consequently it is necessary to use an adjustable adapter similar to that shown in Fig. 28. The adapter must be adjusted each

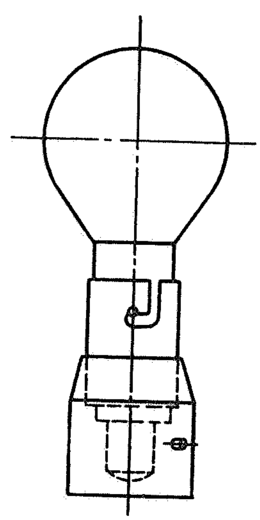


Fig. 27.
Adapter for Precision Lamp.

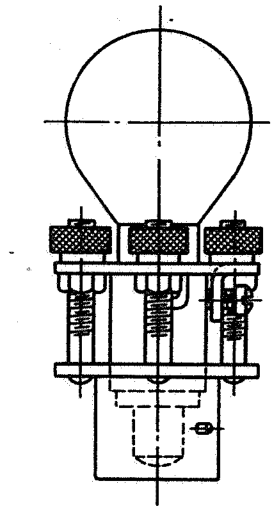


Fig. 28.
Adapter for Commercial Lamp.

time the lamp is replaced. This adjustment is made in a special jig which insures the correct relation between the filament and the pins in the adapter. After the adjustment is made the lamp is locked in that position and the combination lamp and adapter is interchangeable with the standard PS-16 lamp.

Where a particularly long range is not necessary, what is known as a semi-concentrated double filament lamp with screw base, as shown in Fig. 29, is used.

With this type of lamp, accurate location of the filament at the focal point does not obtain.

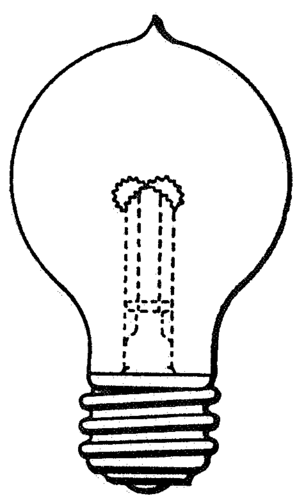


Fig. 29.
Semi-Concentrated Double Filament Lamp, Rebased.

For dwarf and other signals where a wide angle but short range is required, a large single filament wide angle lamp, as illustrated in Fig. 30, is sometimes used.

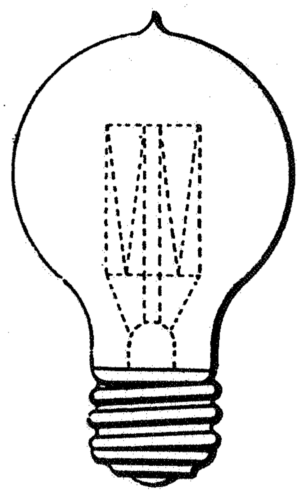


Fig. 30.
Large Single Filament Wide Angle Lamp.

There are various methods used for lighting lamps. In some cases, one transformer with the proper secondary taps is used to light a group of lamps. In other cases an individual transformer is used for each lamp.

*Lamp Replacements Analyzed**

Best results can be obtained from each type of signal only when the proper type lamp is used and when such lamps are operated and maintained in conformance with their peculiar characteristics.

A modern electric lamp consists of a helix of tungsten wire mounted within a sealed glass envelope. This tungsten wire, or filament as it is called, is so designed that it is raised to incandescence by the flow of electric current through it when voltage is impressed across its terminals. The envelope is either evacuated or filled with an atmosphere of a gas which will not combine chemically with the tungsten filament even at the extremely high temperature of incandescence, which, in these lamps, is approximately one-half the temperature of the sun.

* By E. W. Beggs, December 1928 number of *Railway Signaling*.

Depreciation in service.

Although rapid chemical decomposition of the filament is eliminated, the wire wears away gradually as the lamp "burns." This process is called "evaporation," atoms of incandescent tungsten metal being thrown off as vapor which condenses and forms a black deposit on the bulb. The life cycle of a lamp is limited by the time required for this evaporation to reduce the wire at some point so that its effective cross-section is insufficient to carry the current which flows. The wire then fuses at this point and the lamp "burns out."

During this life cycle, the lumen output or candle power of the lamp diminishes, partly on account of attenuation of the metal conductor which reduces the wattage consumed, and partly as a result of the black deposit of tungsten which has evaporated. In common types of lamps used in railroad signal service, the lumen output will have been reduced approximately 15 per cent just before the lamp fails.

The light output of any tungsten filament depends entirely upon the temperature at which it operates, which in turn depends upon the voltage impressed. This relationship is illustrated in curve *A* of Fig. 31. The efficiency of the lamp as a light generating device also varies with the filament temperature and voltage. This is shown graphically by curve *B* of Fig. 31. This curve illustrates the effect of voltage on lumens per watt (a unit candle power light source emits 12.57 lumens).

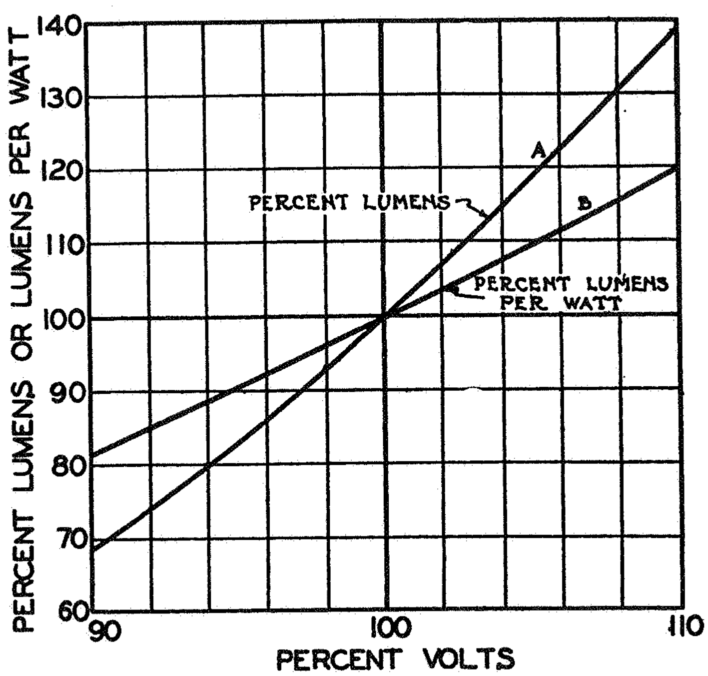


Fig. 31.
Relation Between Light Output, Lamp Efficiency and Impressed Voltage.

Light output and efficiency increase and decrease in proportion to the voltage impressed on the lamp, but the life of a lamp is decreasing as the light output and efficiency increase, that is, it varies inversely with the voltage. This characteristic of a lamp is illustrated by the curve in Fig. 32. It results from the fact that the rate of evaporation is determined by the operating temperature of the tungsten wire. With higher operating temperatures, this rate is greatly increased.

Naturally, very minute variations in effective cross-section of a tungsten filament cause large variations in local temperature. A relatively small rise in temperature causes a great increase in the evaporation rate. For this reason, it is necessary to reduce variations to the absolute minimum. Tungsten filaments of well-made lamps vary so little that it is practically impossible to detect irregularities by measuring devices now available. These variations in small filaments of ordinary commercial lamps are kept within one-millionth of an inch. Uniformity of the tungsten conductor is no more important than purity of the atmosphere in which it operates. There are no devices available today which are capable of detecting the minute quantity of impurities present in an ordinary commercial lamp.

The third most important factor which effects lamp performance is the accuracy with which the filament is formed and mounted within the sealed glass container. The variations which exist in the fila-

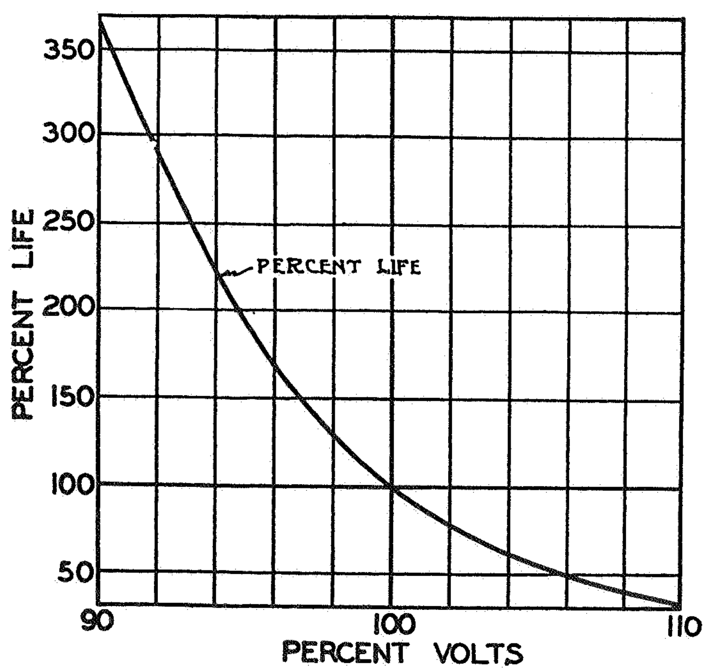


Fig. 32.
Variation in Lamp Life with Impressed Voltage.

ments of individual lamps are measurable but these too are kept to a minimum. They are being constantly reduced by the introduction of new machinery being developed to replace the hand labor which has always been considered necessary in lamp making.

On account of these three principal factors and other minor ones, the life and performance of any individual lamp cannot be exactly predicted even under absolutely controlled operating conditions. Only the average life of a group of lamps is within the control of the lamp maker. That life is called the "design life" of the particular type of lamp in question. If all the factors which have a bearing on lamp performance could be absolutely controlled, each lamp in the group would burn exactly the "design life." Although perfect control is still not in sight, nevertheless, the deviation of any individual lamp from the average is relatively small.

Mortality curve.

The results of years of testing have shown that whereas the life of any one lamp is always unknown just as it is with human beings, nevertheless, a life expectancy table may be used with confidence just as it is used by life insurance companies in calculating premiums. The lamp mortality curve shown in Fig. 33 illustrates this fact. This curve represents tests of large quantities of railway signal lamps. It shows that at various points throughout the life of the group, certain definite percentages of the lamps tested will have failed, while the remainder will be still giving service. For instance, if the average life of the group is 1000 hours, over 90 per cent of these lamps will still be functioning after 500 burning hours. At 750 hours, over 70 per cent will have survived. At points near the design life or average life of the group of lamps, the failures occur more rapidly because, of course, the majority of them will burn out near the design life. A few lamps will continue to burn considerably beyond the point of 100 per cent life, compensating for those few which burned out earlier.

The general shape of this curve is entirely dependent upon the laws of chemistry and electricity. It is affected by the ability of the lamp manufacturer to make lamps according to the designs laid down by the engineers. It is also, of course, influenced by the conditions under which the lamps operate.

The effect of voltage variation and vibration which are met in signal service has not been accurately determined. Data available indicate that in signaling service, both of these factors will have relatively little effect on the life expectancy of those lamps which are destined to fail prior to the "design life" of the group. They will probably cut off the life of lamps which on laboratory life tests continue to burn far beyond the 100 per cent point.

The best time to relamp depends upon the operating conditions of the railroad. Where the traffic is relatively heavy, naturally outages are more serious. Also, where the cost of lamp renewals required by unexpected burn-outs is high, these outages should be kept to a minimum and, consequently, renewals should be made earlier in the life of the group of lamps installed. The design of the signaling system also has a large bearing on the ideal time for relamping.

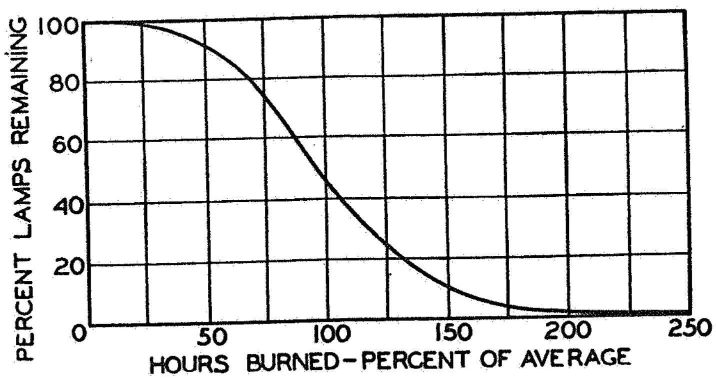


Fig. 33.
Mortality Curve of Lamps Showing Life Expectancy at Any Stage of Average Life.

Where stand-by lamps are used in the signal or where the burn-out of one or more lamps will not cause a signal failure, it is less vital that lamp renewals be made early. These factors must be carefully analyzed.

The peculiar shape of the mortality curve, however, makes it possible to select an approximate renewal point which will apply universally in spite of the various methods of signal operation and the different designs of signals now in use. This curve has a decided "knee" at 50 per cent life. Up to that point, only a few of the lamps will have failed and after that point, failures start to occur at a rapidly increasing rate. It can, therefore, be recommended with confidence that all incandescent lamps for signal service be renewed at or just before this sharp downward bend in the mortality curve. Faithful execution of such a relamping schedule will, over a period of years, reduce the signal failure due to lamp burn-outs to about one-tenth the number which would be obtained if the lamps were left in the signals until they burned out.

Instructions

Light signals should be maintained and tested in accordance with the following instructions:

General.

1. Mast must be vertical and signal aligned to give the best possible indication to approaching trains. Light beam must intersect a point 12 feet above the rail at the location where enginemen observe the indication. After adjustments are made, lock nuts must be securely fastened.

2. Lenses, roundels, glass and lamps must be cleaned as often as necessary to insure a good indication.

3. Reflectors must be kept clean, using a soft cloth free from lint for this purpose. Metal reflectors must be cleaned with a clean dry cloth.

4. Broken or defective reflectors, broken or cracked lenses, roundels or glass must be replaced.

5. Base of ladder must be secured to a suitable support.

6. Door or cover of unit must be in good condition and gaskets in place. Unit must not be opened in stormy weather except when conditions require.

7. Ladders, hand railings and platforms must be kept in good condition and securely fastened.

8. Work that may interfere with the safe movement of trains must not be started until train movements have been fully protected.

9. When double filament lamps are used, lamps must be renewed when one filament fails.

10. Lamps must be replaced in kind.

11. Care must be exercised when applying bayonet base lamps, to see that the pins in the lamp base are turned to the end of the slot in the receptacle and forced into place by the contact spring.

12. Rated voltage of lamps must not be exceeded. If the range required of the signal permits, lamps should be burned from 10 to 20 per cent under rated voltage.

13. Manufacturer's instructions must be followed unless they conflict with general or detailed instructions in which case proper authority must be consulted for correct procedure.

Color light signal—Searchlight type.

14. The relay mechanism must be maintained in accordance with A.R.A. Signal Section Instructions for Inspecting and Testing Relays (covered in Chapter VI—Direct Current Relays and/or Chapter X—Alternating Current Relays), except as to operating requirements which are covered in Instruction 18.

Table of Operating Characteristics of Searchlight, Color Light Signals

3 INDICATION

SHOP REQUIREMENTS											FIELD REQUIREMENTS						
VOLTAGE RANGE CONTACT	NOMINAL RESISTANCE		INITIAL CHARGE		MINIMUM DROPAWAY		MAXIMUM PICK UP AND WORKING		FIELD ENERGY		MINIMUM DROPAWAY		MAXIMUM PICKUP AND WORKING		FIELD ENERGY		
	ARM.	FIELD															
VOLTS	OHMS	OHMS	VOLTS	AMPS	VOLTS	AMPS	VOLTS	AMPS	VOLTS	AMPS	VOLTS	AMPS	VOLTS	AMPS	VOLTS	AMPS	
1ST	250	500	9.0	.036	1.5	.006	5.0	.020	6.0	.012	1.0	.004	6.0	.029	6.0	.012	HALL
1ST	250	500	9.0	.036	2.5	.010	6.5	.026	6.0	.012	2.0	.008	7.5	.030	6.0	.012	U.S.&S.CO. INTER
1ST	250	500	9.0	.036	2.5	.010	6.5	.026	6.0	.012	2.0	.008	7.5	.030	6.0	.012	U.S.&S.CO. UNIV.
1ST	250	300	9.0	.036	1.25	.005	6.0	.024	7.5	.025	1.0	.004	7.0	.028	7.5	.025	G.R.S.CO. S
1ST	250	300	9.0	.036	1.5	.006	6.0	.024	7.5	.025	1.25	.005	7.0	.028	7.5	.025	G.R.S.CO. SA
2 INDICATION (FIELD AND. ARMATURE COILS CONNECTED IN PARALLEL)																	
1ST	250(167)	500	9.0	.054	2.5	.015	6.0	.036			1.84	.011	6.8	.041			HALL
1ST	250(167)	500	9.0	.054	3.34	.020	6.5	.039			2.67	.016	7.2	.043			U.S.&S.CO. INTER
1ST	250(167)	500	9.0	.054	3.34	.020	6.5	.039			2.67	.016	7.2	.043			U.S.&S.CO. UNIV.
1ST	250(136)	300	9.0	.066	2.04	.015	7.2	.053			1.5	.011	7.9	.058			G.R.S.CO. S
1ST	250(136)	300	9.0	.066	2.72	.020	7.2	.053			2.2	.016	7.9	.058			G.R.S.CO. SA

DUE TO THE ALLOWABLE VARIATION OF 10% IN THE RESISTANCE OF THE COILS A 10% VARIATION BETWEEN VOLTAGE AND CURRENT READINGS MAY OCCUR

15. Working voltage must be maintained as closely as practicable to rated voltage. Low current in one element must not be compensated by boosting current in the other element.

16. Relay and reflector units must be securely locked in place.

17. Wires must be arranged so they will not interfere with operating parts of mechanism.

18. Tests must be made and record kept on A.R.A. Signal Section Form 11 or 16 (shown in Chapter VI—Direct Current Relays and Chapter X—Alternating Current Relays) at least once each year and values maintained in accordance with the Table of Operating Characteristics of Searchlight, Color Light Signals.

Color light (other than Searchlight type), position light and color position light signals.

19. Changes in the internal parts of the signal including the lens and lamp receptacles must not be made from their original settings, except that lamp may be changed or reset where provision has been made for proper focusing.

20. Door or cover of lamp unit of color light signal must be kept closed when train is approaching.

21. Necessary action must be taken to guard against phantom indications from reflected external light sources.

22. Where deflecting prisms are used, care must be exercised to see that they are assembled and maintained to spread the light in the proper direction.

American Railway Signaling Principles and Practices

QUESTIONS ON

CHAPTER XIII

Light Signals

QUESTIONS ON CHAPTER XIII

LIGHT SIGNALS

Historical.

1. What were the objections to the semaphore signal?
2. Along what lines was effort originally made to overcome these?
3. What developments made possible the color light signal?
4. What conditions of service made its development necessary?
5. What indications did the light signal display?
6. Why was more than one lamp necessary?
7. Where were light signals first used, and what was the result?
8. What are the advantages of color light signals over semaphore signals?
9. How extensive has their use become?
10. What three classes of light signals are there?

Color Light Signals

11. How are the indications of color light signals given and to what do they correspond?
12. Name the colors used and explain the meaning of each.
13. Into what two classes may color light signals be grouped?

Long range signals.

14. Where are long range signals used generally and how far can they be seen in daylight?
15. How is the long range vision obtained?
16. How is maximum efficiency secured in the lamps?

Short range signals.

17. Where are short range signals used generally and how far can they be seen?
18. What relation has the distribution of the filament to the spread and range of the signal?
19. What size lenses are generally used in color light signals?

Lamp units.

20. In what are lamp units contained and how are they arranged?
21. How are the cases attached to the masts?
22. When the cases are mounted vertically, in what order are the colors arranged?

Doublet lens.

23. What is a doublet lens?
24. What are its advantages?
25. Describe its assembly.
26. How is the lamp socket supported?

27. What kind of lamps must be used, and are they interchangeable?

28. Give the diameter and focal length of each of the lenses used and describe the action of each when a light is placed at the focal center.

Background and hood.

29. Are backgrounds and hoods used?

30. Explain the purpose of each.

Horizontal units.

31. What are the advantages of horizontal arrangement of units?

32. Are the construction details the same as in the vertical arrangement?

33. Which arrangement requires the greater height where two or more three-indication signal units are used?

Marker lights.

34. When marker light is used, where is it located and of what does it consist?

Triangular units.

35. What are the advantages of the triangular arrangement and where is it used?

36. How does the detail of its construction differ from the other types?

37. What color arrangement may be used?

Style A.

38. For what use was this signal originally designed?

39. Where is it suitable for use?

40. With what size lens and lamp is it equipped for use in tunnels?

41. With what size lens and lamp is it equipped for daylight use?

42. What is the diameter of the two lenses used?

43. Are hoods and backgrounds provided?

44. In replacing lamps, how may the filaments be brought to the focal center?

Style F.

45. Where is the Style F signal used?

46. Can it be used as a high signal?

47. Has it a doublet lens?

48. How does this doublet lens differ from the ones previously described?

49. Give voltage and wattage of lamps that can be used and the range of each.

Style N.

50. Describe the Style N signal.

51. What kind of lamps are used and how may they be properly focused?

Style N-2.

52. Describe the N-2 signal.

53. What kind and type of lamps are used?

54. Are separate transformers ordinarily used?

Style L.

55. How does this signal differ from those previously described?

56. What kind of lamps are used?

57. How is a spread of the light beam secured?

58. How is the case mounted?

Style M.

59. How does this signal differ from the Styles R and L signals?

60. What lamps are used?

Searchlight type.

61. How does this signal differ from those previously described?

62. What is the movable member and how is it arranged?

63. What kind of relay mechanism is used for operation on alternating current?

64. What principle of operation is used when direct current is to be applied?

65. Describe the colored roundels.

66. What different lens combinations can be provided, and why are these found necessary?

67. Describe the operation of the signal.

68. Is a reflector used with this signal?

69. Are background and hood used?

70. What kind of lamp is used?

71. What does the signal comprise?

72. How is the signal supported when used as a high signal; a dwarf signal?

73. What recent developments have broadened the application of this signal and lowered its wattage consumption?

Position Light Signals

74. Why was the position light signal developed?

75. Of what does the high signal consist?

76. Are high and dwarf signals available and how may they be mounted?

77. What indications can high signals be arranged to give?

78. How many positions can be given by each arm equivalent?

79. Describe the assembly of light units which make up a high signal.

80. Describe the backgrounds used and explain how they are applied.

81. What provides access to signals located on ground masts?

Lamp.

82. Describe the lamp unit.

83. What kind of lamp is used?

84. Are lamps burned under rated voltage, and if so, why?

Lens.

85. Describe the lens used.

Cover glass.

86. Describe the cover glass.

87. How are phantom indications further prevented?

Mirror.

88. How is the mirror mounted?

Mounting bracket.

89. How is the mounting bracket attached to lamp and post?

Hood.

90. Why is a hood provided?

91. Is more than one lamp used in each lamp unit?

Dwarf signal.

92. Describe the dwarf signal.

93. Describe the lamp and lamp receptacle used.

94. Describe the lens.

95. Why is the signal mounted at a slight angle?

Color Position Light Signals

96. Of what two types is this signal a combination?

97. Describe the indications of the signal when used in combination with a marker light.

98. If two marker lights are used, how are they located?

99. Of what does the main unit consist?

Lamp unit.

100. Describe the construction of the lamp unit.

Lamp.

101. What kind of lamps are used?

102. How many different aspects may be obtained from the signal?

103. Is a red light displayed when an indication more favorable than Stop is given?

104. Why is a transformer generally supplied for each row of lamps?

Dwarf signal.

105. Describe the dwarf signal.

106. Can the same indications be given by the dwarf as by the high signal?

107. How is the marker light mounted on a dwarf signal?

Typical local wiring.

108. Draw a diagram showing the local wiring for a color light signal.

109. Draw a diagram showing the local wiring for a searchlight signal.

110. Draw a diagram showing the local wiring for a position light signal.

111. Draw a diagram showing the local wiring for a color position light signal.

Lamps

112. Why must the proper type of lamp be used in each signal?

113. What is meant by concentrated filament?

114. What is the purpose of rebasing and how is it accomplished?

115. What is the purpose of double filaments?

116. What is a precision lamp?

117. What is a fixed precision type adapter?

118. How can the precision lamp and precision adapter be used in place of a rebased lamp?

119. Why must an adjustable adapter be used if a commercial lamp is used instead of a precision lamp?

120. How can a commercial lamp and adjustable adapter be used in place of a rebased lamp?

121. Where is the semi-concentrated double screw base lamp used?

122. Is the filament of this lamp accurately located at the focal point?

123. Where a wide angle but short range is required, what lamp is sometimes used?

124. How are lamps lighted?

Lamp Replacements Analyzed

125. Of what does a modern electric lamp consist?

Description in service.

126. What takes place as the lamp burns?

127. What limits the life cycle of a lamp?

128. To what extent is the candle power of a lamp reduced with use, and what is the cause of this reduction?

129. On what does the light output of a tungsten filament depend?

130. On what does the efficiency of a lamp depend?

131. How does light output and efficiency vary with respect to voltage?

132. How does lamp life vary with respect to these factors?

133. Why is it important that the cross-section of a tungsten filament be uniform?

134. Why is it important that the atmosphere in which it operates be pure?

135. Why must the filament be accurately formed and mounted?

136. What is meant by the "design life" of a lamp?

Mortality curve.

137. What does a lamp mortality curve show?

138. Upon what does the shape of this curve depend?

139. What effect has voltage variation and vibration on the life of a lamp?

140. When should lamps in signal service be replaced?

141. How can lamp failures be reduced to a minimum?

Maintaining and Testing Light Signals

General.

142. In what condition must masts be kept?

143. How should signals be aligned?

144. At what location should light beam intersect track, and at what height above rail?

145. After making adjustments, what should be done with respect to lock nuts?

146. How often must lenses, roundels, glass and lamps be cleaned?

147. What must be done to keep reflectors clean?

148. What must be used to clean metal reflectors?

149. What must be done with respect to broken or defective reflectors, broken or cracked lenses, roundels or glass?

150. How must the base of ladder be secured?

151. In what condition must the door or cover of unit be kept, and under what conditions must they not be opened?

152. In what condition must ladders, hand railings and platforms be kept?

153. What precautions must be taken before starting work that may interfere with the safe movement of trains?

154. When must double filament lamps be renewed?

155. What precaution must be taken when replacing lamps?

156. When applying bayonet base lamps, how must the pins in the lamp base be, with respect to the slot, and in what position should the contact spring force them?

157. What precaution must be used in arranging voltage at lamps and at what per cent of the rated voltage of lamps should the voltage be kept if the range of the signal permits?

158. What instructions, if they do not conflict with the detailed or general instructions, must be followed, and in case of conflict, who must be consulted for correct procedure?

Color light signal—Searchlight type.

159. What instructions must be followed in maintaining the Searchlight signal?

160. What requirements in the instructions for inspecting and testing relays are accepted, and where are these covered?

161. How must the working voltage be maintained compared to the rated voltage?

162. What restrictions are there against compensating for low current in one element?

163. How must relay and reflector units be held in place?

164. How must wires in case be arranged?

165. How often must tests be made and records kept and in accordance with what Table must values be maintained?

Color light (other than Searchlight type), position light and color position light signals.

166. How must the internal parts of the signal, including the lens and lamp receptacles, be maintained with respect to their original setting?

167. How must door or cover of lamp unit be kept when trains are approaching?

168. What must be done to guard against phantom indications from external light sources?

169. Where deflecting prisms are used, what precaution must be used when assembling or maintaining them?