when desired, the brake valve, that controls the caution indication in the cab.

The figures show how the combination line relay and the polarity-reversing switch are all assembled in one relay instrument. In the same manner the combination engine relay has the stop indication, caution indication, and polarized relays all assembled in one instrument.

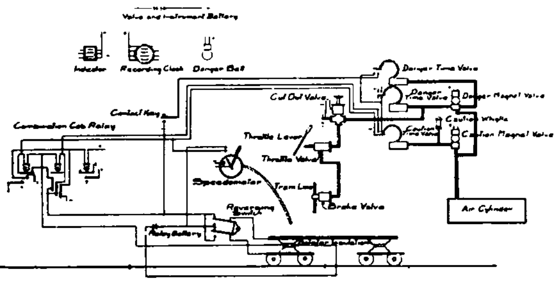


Fig. 15. Instruments, Piping and Primary Circuits in the Cab.

It can be seen that the whole system is operated on a normally closed circuit plan, and that the opening or breaking down of these circuits gives the desired signal indication and brake application. The system is designed to cover all conditions of installations that are likely to be met with, and is absolute but at the same time elastic, so that it can be applied to different conditions of block signal systems, traffic conditions, and local conditions without any other form of block signal system. as desired. It can be made to make only the emergency application of the brake; or a service application to reduce the speed to any required limit; or a light service application at a distant signal location, with an emergency, or speed limit, application at the

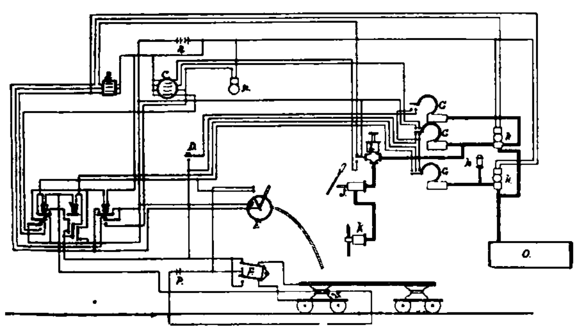


Fig. 16. Complete Cab Wiring Diagram.

home signal. An installation can be made on a railway with any form of automatic block signal system, or simply at interlocking plants, and if desired, on a road with no other block system at all. If it is not desired to embody this in the block signal system, or to install it in its entirety alone, it can be installed on high-speed trains to be operative only at dangerous points.

The system is also applicable to high speed interurban and traction lines. In an installation of this type the track control is accomplished by using A. C. track current where D. C. operating current is used. A small motor-generator takes the place of the primary battery on the engine, and a simple electric cut-out the throttle closing mechanism.

In designing foundations the weight of poles or towers and the weight of the foundation itself can be easily taken care of since they act in a vertical direction. The weight of the wire and of an ice coating have also a horizontal component which must be considered in designing the footings to prevent overturning. The snow or ice load becomes more important as the diameter of the wire decreases. Assuming a coat of ice ½-inch thick, the weight per foot on a No. 3-0 wire, is only 1.5 times as great as that on a No. 10 wire, although the diameter is four times as great.

THE AUTOMATIC SIGNAL AND THE LOCAL CIRCUIT.

BY C. G. STECHER.

This is the second of Mr. Stecher's Lessons on Signaling which deal with types of signal indications and local circuits. The first article of this series was published on page 48 of The Signal Engineer for February, 1912.

THE ENCLOSED DISC SIGNAL.

One of the earliest automatic block signals and one which was quite extensively used in the past, is the enclosed disc signal, the mechanism, or properly speaking, the instrument of which is shown in Fig. 4, M and H M are the electro-magnet coils; P and P^1 are the pole-pieces; A is the circular armature. C is a red cloth disc, the cloth being drawn over a ring made of spring brass wire. R is a disc of red glass enclosed in a light-weight metal frame. This glass is especially prepared for this purpose in order to make it light of weight and at the same time tough and durable. On railroads on which green is the standard color for the clear night indication, another disc of green glass G is added and also a balance rod B to balance this green disc. K is the clamp, by means of which the instrument is fastened into position.

The instrument is so adjusted that it will move from the clear to the danger position by the force of gravity and without the aid of springs, when the circuit is broken and the current ceases flowing through the magnet coils.

The circular armature is so constructed that when the instrument is in the stop position, only small surfaces of metal are presented to the pole-pieces P and P^1. When the pole-pieces are magnetized they attract the larger surfaces of the armature which are then below the pole-pieces, and the armature is rotated and

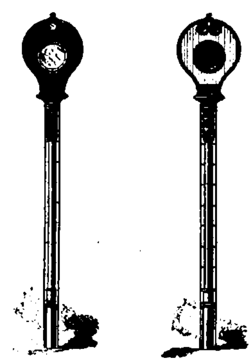


Fig. 1. Standard Disc Signal and C. & N. W. Disc Signal.

with it the several discs, bringing them into their proper positions for the clear indication.

The instrument is enclosed in a wooden case, which must be dust and moisture-proof. Circular openings, into which glasses are set, are provided. Through these the indications are observed. The day stop indication is given by the red cloth disc and when the signal is in the clear position this disc is withdrawn and a white background is presented. The background is formed by a circular pane of glass which has been painted white. This is for the purpose of producing a light interior in order to increase the contrast between the danger and the clear positions of the signal, which would not be obtained if the background were of wood.

For the night indications the signal lamp is supported on an iron bracket on the back of the signal case, and the white light of the lamp is projected through the small openings of the case and the red glass disc when the signal is in the stop position, and through the green glass disc when the signal is in the clear position, where green is standard for the clear indication.

The properties of the electro-magnet were described and explained on pages 151 and 152 in the April, 1911, issue of *The Signal Engineer,* and it is not considered necessary to go into the details in this article.

The magnet coil M is the operating magnet, and is of low resistance,—about 35 ohms. It requires 145 to 175 milli-amperes of current to operate the instrument with a drop of potential across the binding posts of from five to six volts.

This amount of current would be flowing as long as the signal remained in the clear position, so in order to reduce the battery consumption to a minimum, coil H M is added. While the signal is in the stop position and while it is clearing, this coil, which has a resistance of about 485 ohms, is shunted out of the circuit by the spring S. This spring is opened and the contact broken at the end of the movement of the instrument to the clear position by the screw R, leaving H M in the circuit in series. The total resistance of the instrument when in the clear position is, then, as can readily be seen, about 520 ohms, and the flow of current is reduced to from 25 to 30 milli-amperes, with a drop of potential of about 14 volts.

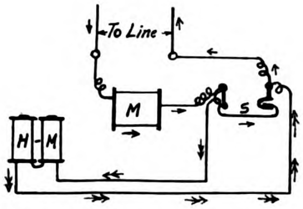


Fig. 2. Wiring of Disc Signal Instrument.

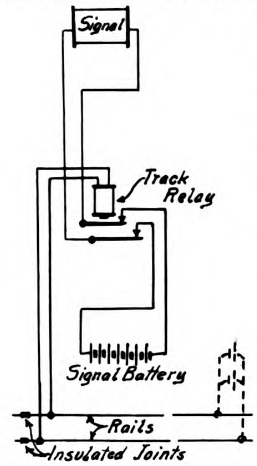


Fig. 3. Wiring Plan for Disc Signal.

On account of the comparatively high resistance of the operating coils of this type of signal, and the small amount of current needed, a control relay is not required when line circuits are employed, but the signal can be controlled direct by the track relays, switch boxes, etc. Gravity batteries, located at the extreme outer end of the circuit, are usually employed. The battery is located at the signal only when the block is the length of one track section or where track circuits are looped ahead through successive track relays.

Fig. 3 shows the local wiring as it would be used under the latter conditions, and it could then be called a local circuit.

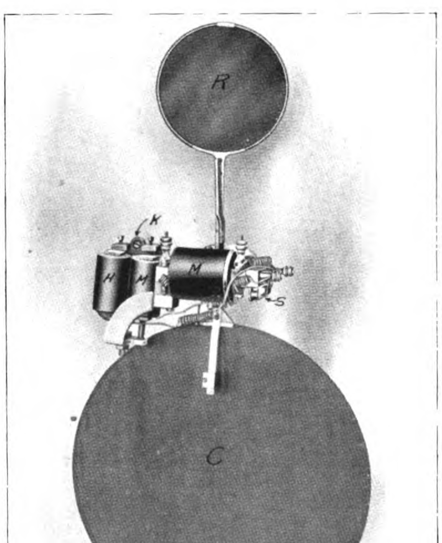
Principally on account of the difficulty experienced by enginemen in observing the indications as given by this signal during the day, especially in foggy or stormy weather, it is being replaced by the semaphore type of signal.

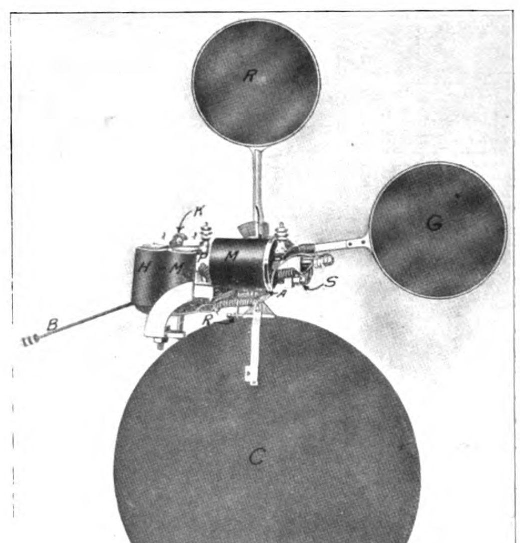
THE ELECTRO-GAS SIGNAL.

One of the early types of semaphore signals used for automatic blocking purposes is the electro-gas signal. The mechanism of this signal is shown in Fig. 6. M is the electro-magnet; A is the armature; C is the controlling valve; R is the reducing valve; G is the pressure guage, one pointer showing the pressure of the main tank and the other that of the auxiliary tank T; P is the cylinder; and K is the clutch arm. The lever L cuts off the supply of gas when the signal is nearly clear.

This signal is operated by the pressure of carbonic acid gas and is controlled or governed by electricity. The gas is compressed in a cylindrical tank to a pressure of about 800 pounds. This tank is placed near the base of the signal, usually in a battery chute, and the gas is carried into the mechanism case through small copper tubing. It then passes through the reducing valve R, which reduces the pressure from that of the main tank to that required to operate the signal, usually about 35 to 40 pounds. This valve is adjustable so that any pressure can be obtained by regulation. From the reducing valve it flows to the auxiliary tank T and then again through small copper tubing to the controlling valve C, which is actuated by the electro-magnet M.

The controlling valve C admits the gas into the cylinder P





Figs. 4 and 5. Disc Signal Instruments with Hold Clear Attachments.

The wiring of the instrument is shown diagramatically in Fig. 2. The single arrows show the path of the current while the instrument is clearing and the double arrows show the path after it has cleared. Fig. 1 shows the disc signal complete—with its mast.

through a port in the piston. The cylinder is the moving part and the piston is stationary. The up-and-down rod, which moves the signal to the clear position, is fastened to the clamp S, which in turn is fastened to a rod which is screwed into the cylinder head.

When the gas is admitted through the port in the stationary piston, the cylinder is forced upward and the signal is moved to the clear piston. It is then held in this position by a projection on the crosshead H, which engages a similar projection on the upper part of the long clutch arm K which is held in position at its lower extremity by the electro-magnet while it is energized.

When the magnet is de-energized, the clutch arm is released and allows the signal to assume the stop position. During this latter movement the cylinder and piston act as a dash-pot and thereby check the signal in its momentum toward the danger position. This checking removes the probability of parts of the mechanism being broken, as without this check the up-and-down rod would deliver a heavy blow to the mechanism on the completion of the downward stroke.

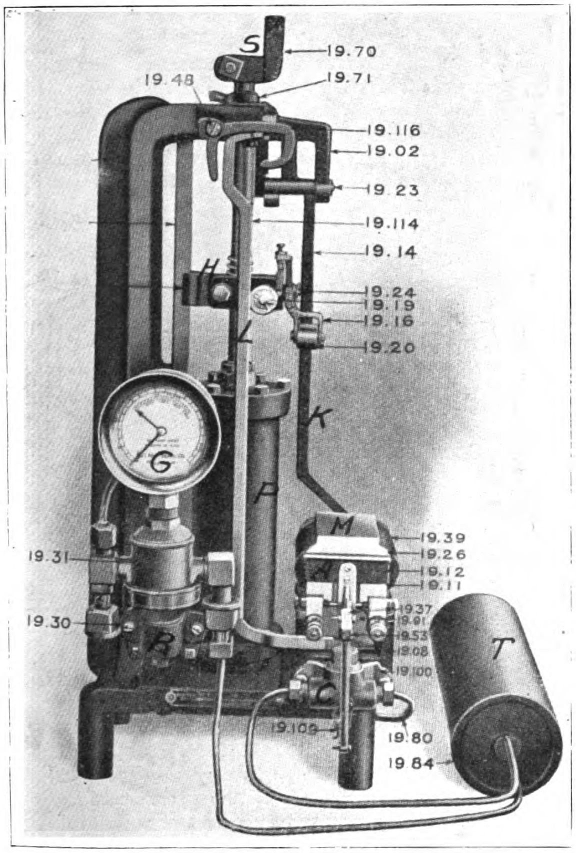


Fig. 6. A Single Gas Mechanism.

The electro-magnet serves a triple purpose. It acts as the control relay, actuates the controlling gas valve, and also holds the clutch arm. It is made in the usual form, being about four inches in length, and is fastened or clamped to the mechanism without any yoke to tie the iron cores together as is usual in electro-magnets. Instead of the ordinary stationary yoke a piece of soft iron is fastened loosely to the lower end of the clutch arm and this lays against the end of the cores and thereby forms the yoke of the magnet as well as the armature for the clutch arm.

The magnet sometimes has two windings, one of low resistance, about 35 ohms, for operating the controlling valve and holding the clutch arm, and the other of high resistance, about 200 ohms, for holding the clutch arm while the signal is in the clear position.

When the signal is nearly clear the high resistance winding is cut into the circuit by means of a circuit-breaker, which is usually fastened directly above the magnet, and which is operated by a rod attached to the crosshead of the cylinder. For the operation of the controlling valve, that is, through the low resistance winding, about 125 amperes of current are required, and about .050 amperes after the high resistance winding has been cut into the circuit.

On account of the comparatively high resistance of the controlling magnet and the small amount of current required to operate it, it is connected directly to the line circuit where such is necessary, consequently a control relay is not required. Either

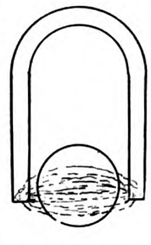


Fig. 7. Coil In Magnetic Field.

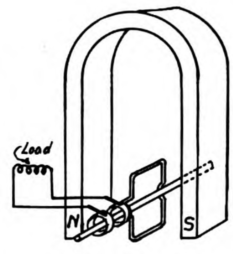


Fig. 8. Simple Dynamo.

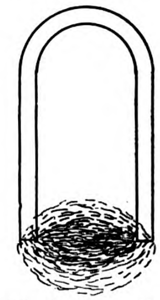


Fig. 9. Magnetic Field.

gravity or caustic soda battery can be used for the control and operation of this signal.

The wiring of this signal is practically the same as that of the enclosed disc signal, which is shown in Fig. 1. This type of signal is now gradually being replaced by motor-operated semaphore signals.

THE ELECTRIC MOTOR AND GENERATOR.

Before describing the different types of motor-operated semaphore signals, a short explanation of the principles and properties of the electric motor will be made. The properties of the ordinary horseshoe magnet are well known. The magnetic lines of force flow from the north pole to the south pole of the magnet, causing a magnetic field between and surrounding the poles. This is shown in Fig. 9.

When a coil composed of one or more turns of wire is revolved or rotated in this magnetic field so that the turns of wire will cut the lines of magnetic force, a current of electricity is generated in the coil. This should be clearly understood. If the coil is revolved as shown in Fig. 7 no current will be generated, becsause the coil is revolving within the magnetic field in such manner that the turn or turns of wire do not cut the lines of force, that is, the coil is revolving constantly in the same number of lines of force and there is no difference in the density of the magnetic field, consequently there is no difference of potential, or in other words, no voltage.

If then, the coil is rotated as shown in Fig. 8 the turns of wire are passing through a difference of field density at every half revolution of the coil, the wire is "cutting" the magnetic lines

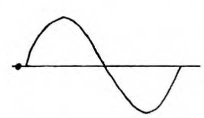


Fig. 10. Alternating Current Wave.

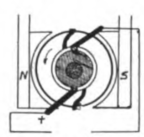


Fig. 11. Single Coil Commutator.

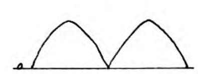


Fig. 12. Pulsating Current Wave.

of force, current is generated within the coil, and a difference of potential at the two terminals is the result.

When the coil is in the position shown in Fig. 8 the voltage is at zero. As the coil is rotated into the magnetic field the voltage increases and attains its maximum when it has reached the maximum density of the magnetic field, or in other words, when it is cutting the largest number of lines of force. It then decreases as it leaves the strongest part of the magnetic field and drops to zero when it reaches the position shown in Fig. 8. This is repeated at every half turn of the coil.

The coil is wound on a slotted soft iron core with a shaft through its center, the ends of the shaft serving for bearings on which to revolve the coil. The two ends of the coil are connected to two insulated copper rings, which are revolved with the coil and from these rings the current is led, or collected and carried, to the external circuit by means of sliding contacts called brushes. The rings are usually called collector-rings.

As has been shown above, the current rises from zero to the maximum and then decreases to zero, increases again to maximum and drops again to zero during every revolution of the coil, or "armature" as it is called. This is termed a complete cycle or two alternations, and the current is called alternating current. The first half of the cycle is considered to be positive or above the zero line, and the second half negative or below the zero line. Fig. 10 shows an alternating current wave of a complete cycle, as it is usually represented on paper. It can readily be seen that there is no apparent positive or negative to this form of current, but that it reverses its direction at every half revolution of the armature.

The simplest form of an alternating current machine is the magneto of a telephone or a test set. This is built on the principles just explained.

The alternating form of current cannot be employed for many purposes, consequently steps must be taken to obtain unidirectional current, that is, current which will at all times flow through the circuit in the same direction. This is accomplished by cutting one of the copper rings into two parts, insulating these parts from each other, and then connecting the two ends of the coil to the two pieces as shown in **Fig. 11. The** two brushes which lead the generated current to the external circuit, press against the split ring at diametrically opposite points, and the brushes are so set that each half of the ring moves out of contact with one brush and into contact with the other at the time when the coil is in such position that it is cutting the least number of lines of force, that is, when the E. M. F. is at zero. The result of this is a rectified, uni-directional, or, as it is usually called, a commutated current.

To explain this more fully, it has already been shown that when the coil is being revolved and is in the position as shown in Fig. 8, the current is at zero, and then increases to maximum and then falls to zero during each one-half revolution of the coil. It is assumed that the direction of the lines of magnetic force between the pole-pieces and the direction of movement of the coil is such that while the coil is moving through the first half of the revolution the current generated in the coil will flow to that segment of the ring on which is then bearing the upper brush, and this would then be the positive (+) brush.

As the coil enters the second half of the revolution the current in the coil reverses its direction and flows towards the other segment, but at the same time or instant at which the current reverses its direction and flows to the other segment, this segment has come into contact with the upper or positive brush and the current again flows over this brush to the external circuit.

The current thus produced, however, is of a pulsating character, as is represented in Fig. 12. In order to obtain a current of an even E. M. F. more coils are added to the armature and the two pieces of the former copper ring are cut so that there will be as many pieces as there are coils. These pieces are then called segments and the whole is called a commutator. The additional coils have the effect that when one coil is leaving the maximum field density another is taking its place, thereby maintaining an even E. M. F.

The horseshoe magnet forms the field of the generator and the coils and the commutator form the armature. In order to make the machine more efficient the field is made in the form of an electro-magnet. The cores are made of iron or cast steel and insulated wire is wound around them. These are then called field coils. There may be one, two, or four, or more field coils, depending on the design and size of the machine and on the purpose for which it was built. Machines with one field coil are usually called single-pole, those with two field coils, bipolar, and those with four or more field coils, multipolar.

The field winding may be composed of very heavy wires, which are consequently of low resistance, and it is then connected in series with the armature, in what is known as "series machine." If it is composed of fine wire, and consequently has a high resistance, it is connected in parallel with the armature, or in shunt, as it is usually designated, and this is then known as a "shunt machine." Machines are also built which have both methods of winding, series and shunt, and they are known as compound-wound. This last method of winding is usually employed on machines of large capacity and for special purposes.

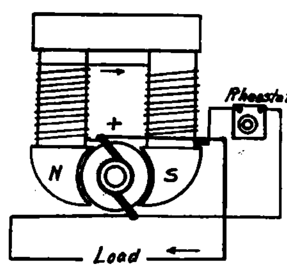


Fig. 13. Shunt Wound Dynamo.

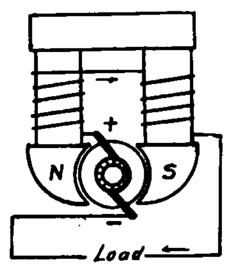


Fig. 14. Series Wound Dynamo.

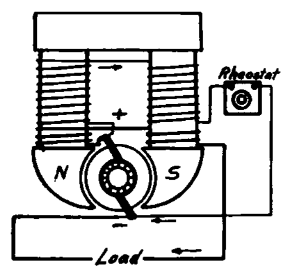


Fig. 15. Compound Wound Dynamo.

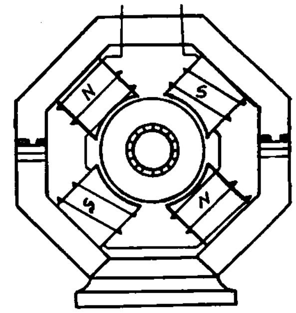


Fig. 16. Multi-polar Field Magnet.

A series-wound machine is shown diagrammatically in Fig. 14; a shunt machine in Fig. 13, and a compound-wound machine in Fig. 15. It will be seen that a rheostat, that is, a variable resistance, is inserted in the shunt winding of the field circuit in the shunt-wound machine. This device is for the purpose of regulating the current flow through the field coils, and thereby regulating the strength of the field magnets.

A pulley or some other driving medium is attached to one end of the shaft of the armature on the end opposite to the commutator, some source of power is applied, and the armature is revolved between the poles of the field magnets. A current is generated in the armature and it is carried off by means of the commutator and the brushes to the external circuit. In the series-wound machine the current output is dependent on, first, the capacity of the machine, and second, on the load, that is, the resistance of the external circuit. With shunt machines the output is regulated by means of the rheostat.

Under the conditions just described, the machine is acting as a generator. If the power which is driving the armature is removed, the armature brushes can be connected to some other source of electricity, such as a generator of larger capacity, and the machine will act as a motor. Current is sent through the armature and the field coils either in series, in shunt, or in series-shunt, depending on the type of machine, as whether it is series, shunt, or compound-wound.

The current flowing through the field coils induces a strong magnetic field between the poles of the field magnets within which the armature is located, and the current flowing through the coils of the armature causes the armature to revolve, on the principle that when a coil carrying current is placed within a strong magnetic field in such position that the current is flowing at right angles to the lines of magnetic force, the coil tends to move to cut the magnetic lines of force, and in this manner the armature of a motor is revolved on its axis or shaft. The pull of an armature is called the "torque," and the strength of the torque is dependent on the ampere-turns in the armature, that is, the number of turns of wire in parallel times the current, and also on the field strength.

On series-wound motors the torque increases with the load, that is, the greater the load, the greater will be the torque. In simple language, it may be stated that the load tends to decrease the speed of the armature of the motor and this allows a heavier flow of current through the motor and consequently an increase in the strength of the torque.

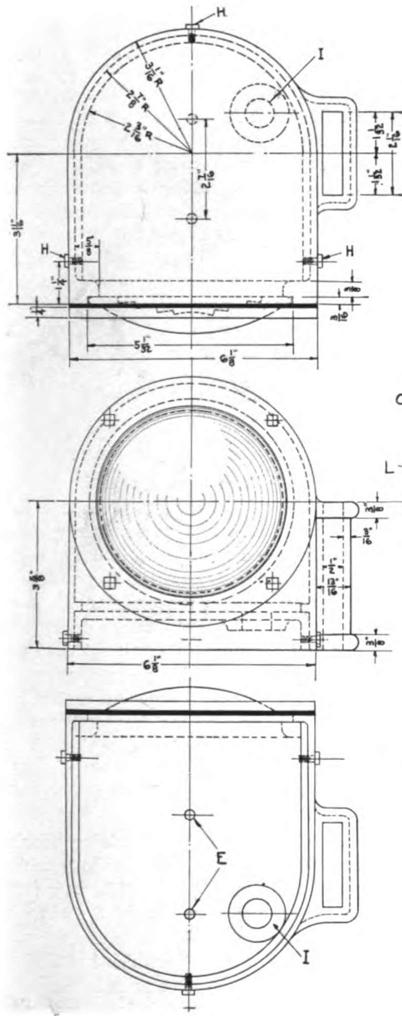
CAST IRON ELECTRIC LAMP.

BY C. P. RHINE.

Electric lamps for signal purposes have usually been considerably larger than required. In most cases they are standard signal lamps with the receptacles inserted.

An electric lamp was recently designed, however, in the office of the signal engineer of a large western railway, that has the excellent qualities of neatness in design and usefulness, and does away with previous objections.

Fig. 1 shows the arrangement of the different parts. "L" is a five-inch clear optical lens and is held in place by the cast-iron clamp ring "C," with the rubber gasket "A" as protection to the lens. "B" is an Edison cleat receptacle (No. 2921 W. E. Co. catalogue). It is bolted to the base "D" with two one-inch No. 8-32 R. H. brass machine screws through the holes "E." The base "D" is designed to fit very snugly into the frame "F" up against the rim "C," and is held in place by three ½ in. No. 10 hex. head cap screws "H." The boss "I" is tapped for ½ in. pipe, and the arrangement of the pipe is clearly shown in Figs. 4 and 5, when the lamp is used on high signals. The socket for the lamp bracket is designed to fit any style of signal without any changes, except on dwarf signals, where the pin is placed through the lamp bracket to hold the lamp at the required height. Figs. 2 and 3 show the lamp on dwarf signals. More than 200 of these cast-iron electric lamps are in use on one division, and they are proving very satisfactory.



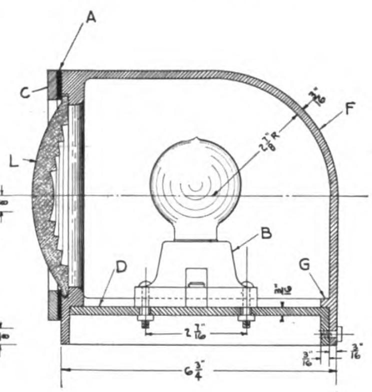


Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

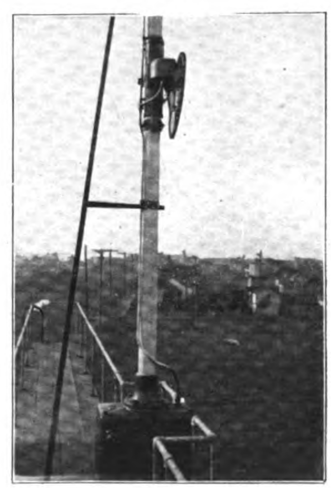


Fig. 5.

While the armature of a motor is revolving, it tends to generate an E. M. F. within itself, which opposes the impressed E. M. F., that is, it opposes the current which is being supplied to the motor and which is driving the armature. This E. M. F. is usually called the counter-E. M. F.

This phenomenon is much more apparent with series motors than with shunt motors. The speed of the series motor is dependent on the load. The lighter the load, the higher will be the speed, and vice versa. While the armature is revolving at high speed the counter-E. M. F. is high, consequently the driving current flow will be low. As the load increases, the speed of the armature decreases, the counter-E. M. F. decreases, the current flow to the motor increases, and consequently the torque increases.