Film-Tech

TROUBLE-SHOOTING

PROJECTION ARCS

RECTIFIERS

for Theatre Use

CAMERON PUBLISHING CO

ARC LAMPS

Rectifiers

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RECTIFIERS

The rectifier, briefly, is not a generator of voltages, but rather is a uni-directional valve offering relatively low resistance to a flow of current in one direction as opposed to a high resistance to similar passage in the other. The manifold mechanical forms this electrical principle has assumed in recent years include not only the original purpose of converting alternating to direct current but also a variety of related and extended applications having wide industrial use.

MERCURY-ARC RECTIFIERS

The nature of the cathode spot formed on the mercury pool determines the rectifying action of mercury-arc rectifiers. As the cathode in this device is the only electrode to which current can flow from the ionized space, any inverse currents to the anode are neglected. Subject to variations with temperature and circuit conditions, cathode spots usually require a current of four or five amperes for their maintenance. When this current is no longer sufficient, the spot extinguishes rapidly, a condition causing potential surges in the circuit from energy stored in any inductances that may be in series with the rectifier. To overcome the high-potential gradient in cathode spots, special starting means consist of an electrode dipping in a mercury reservoir connecting with the cathode when the tube is dipped. A conducting path on the tube's exterior and formed with the aid of aqueous colloidal graphite serves the same purpose.

For output voltages less than 100 volts no anode shielding is required. Current ranges cover 10-300 amperes and can be increased somewhat for short periods without failure. The arc-drop for rectifiers having unshielded anodes is about 15 volts, a condition that increases the operating temperature and hence affects the potential handled.

HIGH-VACUUM, HOT-CATHODE UNITS

A positive potential applied to a cold electrode will collect, under conditions of an electrical field and corresponding potential drop, the electrons emitted by a heated pole and thereby cause a non-reversal flow of current. By insuring a highly evacuated space for this transfer a rectifying device can be made to withstand a high inverse voltage. Within the limits governed by

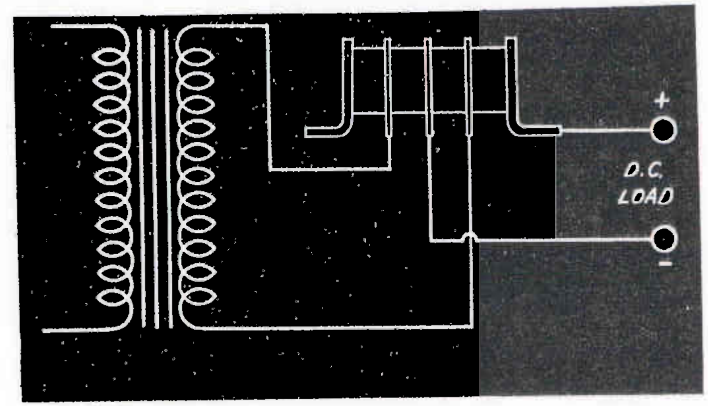
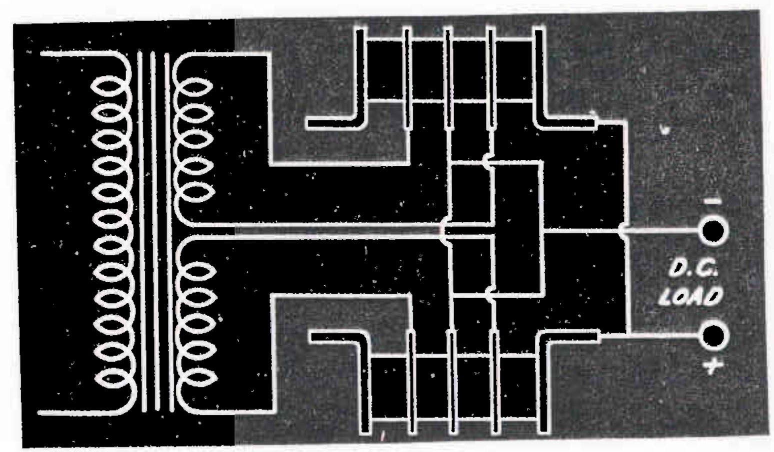


Fig. 104

space-charge effects and resulting power losses, the cathode can be made larger and the currents carried thereby increased.

Somewhat smaller types of hot-cathode valves, more popularly known as high-vacuum half-wave rectifiers



are most efficient in supplying the d-c voltage requirements of cathode-ray tubes. As voltage doublers, two of these types may be operated to deliver approximately twice the voltage obtainable from the half-wave method for the same a-c input voltage.

HOT-CATHODE, GAS AND VAPOR FILLED

When the space between a hot tungsten cathode and a cold graphite anode is filled with argon, the positively charged gas ions neutralize the space charged and permit the passage of current without appreciable loss. The required gas pressure varies from about 0.01 mm to 7 cm, any value in excess of these tending to cause a beakdown accompanied by a reversal of the current's direction.

Liquid or amalgam mercury is used in place of ar-

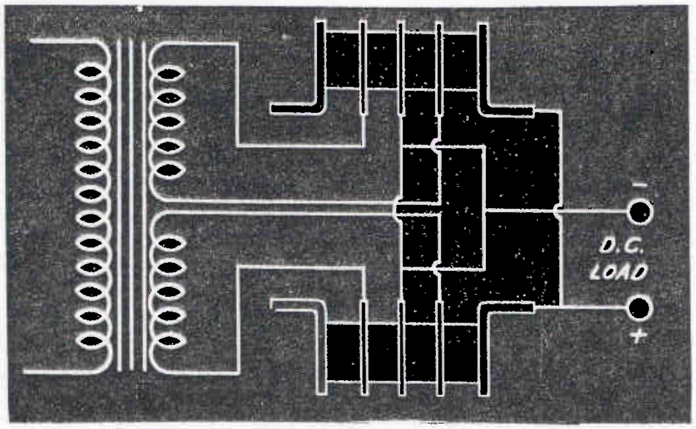


Fig. 106

gon gas to avoid space-charge losses. Unlike the gas filled type whose operating pressure can not be controlled due to internal absorption, the pressure of the mercury vapor can be varied by temperature regulation. Within the limits of pressure and size, these rec-

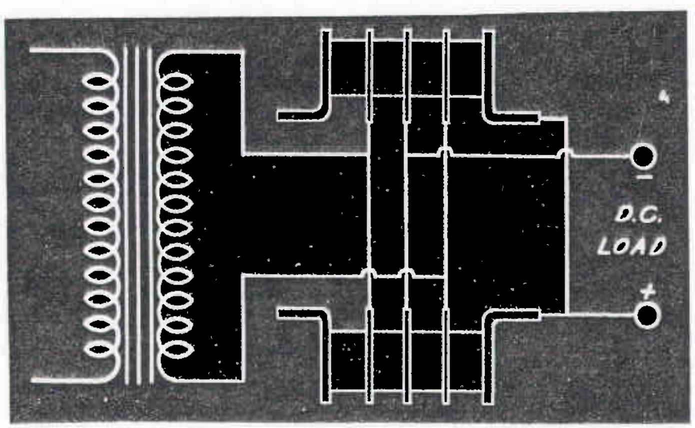


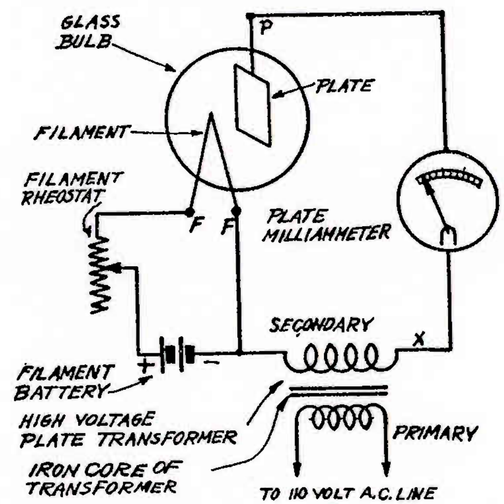
Fig. 107

tifiers have an internal drop of 5-15 volts and a breakdown potential of 400-20,000 volts.

COLD-CATHODE GAS RECTIFIERS

Two electrodes of different area, shape, and substance sealed in helium will discharge with different volt-ampere characteristics in two directions. The difference in electrode dimensions plays the most important part in the operation. With small anodes and larger cathodes the useful rectified current may be twenty times the inverse currents automatically set up in the device before the capacity limit or point of maximum cathode coverage is reached.

The arc-drop is about 100 volts, thus causing efficiencies of less than 50%.



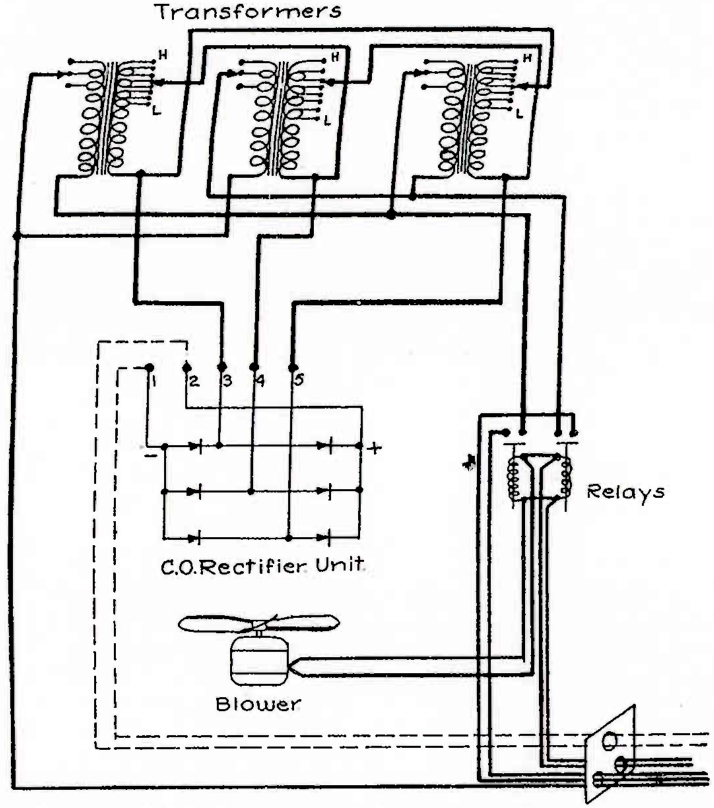
Basic half-wave rectifier circuit

GRID-CONTROLLED VALVES

In the thyratron and grid-glow rectifiers of the gaseous type a grid determines whether an arc is formed while the plate is positive with respect to the filament. If a voltage is applied between the anode and cathode with a sufficient negative grid-bias present, the tube operates like an ordinary vacuum tube, but as the grid is made more positive, at a certain critical voltage, an arc strikes between the anode and the cathode, with an accompanying increase in the anode current. The grid then exercises no further control over the anode current, which must be limited by external resistances so as not to exceed the saturation emissive current of the filament. If the voltage across the tube exceeds the disintregation potential of some twenty to twenty-five volts, the cathode will be disintegrated by positive ion bombardment.

JUNCTION DESIGNS

The junction type of rectifier has grown out of the deficiencies of some of the above discussed rectifiers for all-purpose radio and motion picture work. In an attempt to relate given materials for a non-mechanical



relay, Grondahl first noticed (1920) the asymmetric conductance of a mother copper bearing a cuprous oxide layer. As the voltage is applied to this device a potential hedge, as it were, is instantaneously set up causing a resistance to electric flow in one direction and an assistance to it in the other, thereby effecting the corresponding high and low resistances.

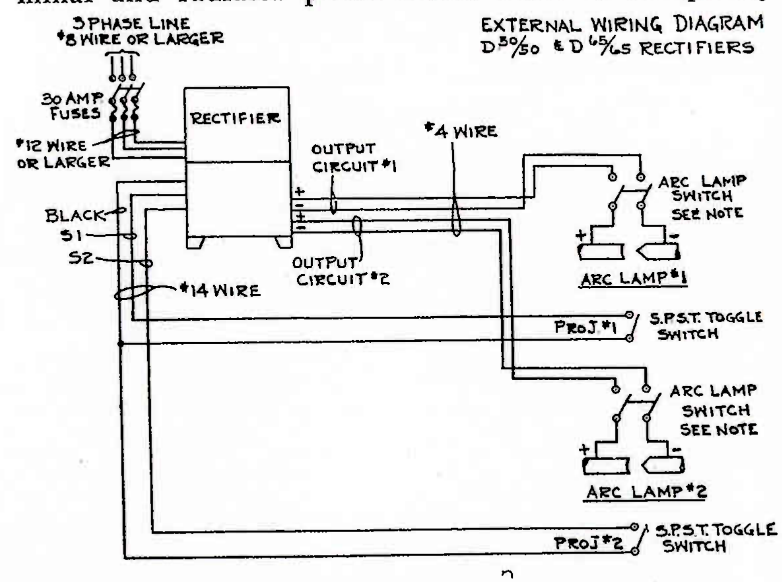
Rectifying efficiencies as high as 70 percent can be obtained in usual practice with these devices. In general, very high frequencies can be rectified, although some capacitance effect is then said to be encountered. Theoretically, a large number of units can be assembled into rectifiers of any desired rating, the maximum space being a cubic foot to every 4 kilowatts and of weight equal to twenty pounds per kilowatt. Of the commercial sizes manufactured at present, trickle chargers have a 13 to 6-watt output (1/2-to-1 ampere at 6 volts), while railway signal rectifiers are constructed that have a 200-watt output. In applications where high currents and small size are essential requirements, the so-called dry disc rectifiers furnish a watt output per cubic inch four to five times that of other types.

The limit to current-carrying capacity depends on the provision for radiating the developed rectifier heat.

MAGNESIUM-CUPRIC SULPHIDE RECTIFIERS

This is a "dry" type rectifier. This unit is to-day being used in the motion picture rectifiers being manufactured by the Forest Manufacturing Company, the unit, however, is manufactured by P. R. Mallory Co.

The magnesium-cupric sulphide rectifier is all metal in construction and contains no liquids, bulbs or moving parts. The rectifier is an assembly of magnesium discs, cupric sulphide discs and a combination of terminal and radiator plates which assist in dissipating



the heat developed in the process of rectification.

FOREST MAGNESIUM-COPPER SULPHIDE RECTIFIER

This is the rectifier constructed especially for motion picture projection work, and employs the Mallory unit, the twin or double type model was originated by Forest. During operation the twin rectifiers work independently of each other, current is completely shut off on that half not in use.

The copper sulphide discs are placed between metallic magnesium discs and metallic non-polarizing discs. These are the important working elements of the rectifier. Heavy radiator plates are placed against the magnesium disc on the one side and the non-polarizing disc on the other side, to assist in heat dissipation. Electric current flows freely in one direction, from the non-polarizing disc through the copper sulphide disc to the magnesium disc. But the flow of current in the opposite direction, that is, from the magnesium disc through the copper sulphide disc to its non-polarizing disc, is greatly impeded. Consequently, the rectifier serves as a uni-directional conductor or valve, changing alternating current into direct current. The rectifying action occurs at the junction interface, and, being electronic in nature, assumes permanence and stability of the rectifying elements.

FOREST TYPE D-50 AND D-65

These types are for simplified high intensity lamps, they are designed for three phase AC current only, with primary transformer taps arranged for connection to a line of the voltage and frequency stamped on the name plates.

The rectifier consists of one separate and complete rectifying bank within one housing and furnishes 42 to 50 amperes for the 50 type with 6x7 carbons, or 56-65 amperes for the 65 type using 7x8 carbons.

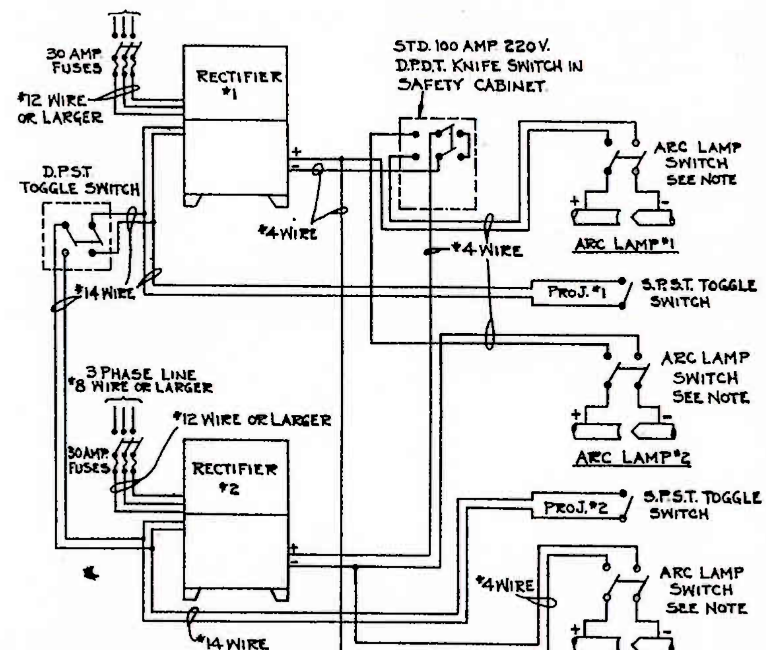
INSTALLATION

The rectifier can be installed in any convenient location in the projection room or in any adjacent room. It is essential however, that the location be well ventilated, preferably in a room with an exhaust fan. The operation of any of the dry type rectifiers in a poorly ventilated room will greatly reduce their efficiency and affect the useful life of the rectifying elements.

Facilities for connection to a three phase current supply should be available, through a suitable fused switch located near the rectifier.

This switch is to be closed to start operation and opened when shutting down, as the primary of the transformer is always connected across the three phase line.

The three phase circuit supplies current for the rectifier bank, the rectifier blower fan and the remote control relay. The rectifier should be connected to the power line and the projector lamp as shown in the diagrams. It is important to observe the rotation of the fan after installation has been completed, to determine if air is being exhausted and not drawn back into the housing. In case air is drawn in at top of rectifier, indicating the fan is running backward, a reversal should be made of any pair of leads in the three phase system.



TITLE EXTERNAL WIRING DIAGRAM D-50 & D 65 RECTIFIERS SUPPLYING 2 SUPREX ARCS & 1 SPOT

REMOTE CONTROL

The rectifier must be operated by remote control, which is accomplished by means of a relay inside the rectifier housing. Operation of the remote control is accomplished by a toggle switch mounted on the side of the housing enclosing the present DC arc switch at the projector, and wired in accordance with the diagram. The present arc switch remains in a closed position and the handle is removed as this switch is no longer used to strike or cut the arc. The remote control toggle switch must be used to control the arc, as in this way, voltage surges are prevented from reaching the rectifier units. This procedure results in increased life of the units and economy in operation.

TRANSFORMER

The rectifier is provided with a three phase transformer, with the secondary wired through a relay and fuses to its bank of rectifying elements. The elements are connected in a full wave three phase bridge circuit.

LINE ADJUSTMENTS

The primary of the transformer is provided with taps to adjust the rectifier to the three phase supply line voltage. These are primary line settings and adjustment is made by moving the terminal strip to the studs nearest the corresponding AC supply voltage.

DC OUTPUT ADJUSTMENTS

Facing the front of the lower compartment of the rectifier panel, the set of six studs on the upper left, is a set of output control studs for the lamphouse. These sets of six studs have an arrow and are the fine adjustments. The sets of three studs marked "LOW" and "HIGH" with an undesignated medium set of terminals, are the coarse adjustments. The three terminal screws at the top of the transformer panel, are connections to the rectifying units. Removing these three wires disconnects the rectifying units from the circuit entirely.

As the rectifier leaves the factory, the connections at the control studs are set at their lowest positions. If the output current is to be increased, first move the fine adjustment connector strip in the direction of the arrow. When it is is in the last position, and the current output is still too low, bring it back to its original position (opposite to the direction shown by arrow), and move the coarse adjustment connector strip to the next position. Then move the fine adjustment in the direction of arrow. By repeating this process the output current rate can be adjusted to practically any desired value within the rating of the rectifier.

SPOT LIGHT OPERATION

Facilities for operation of a spot light or effect projector are provided by the installation of a double pole, double throw switch, and a double pole, single throw toggle switch. This arrangement connects both single rectifiers in series which increases the output DC voltage only while the amperage remains constant. The toggle switch must be operated in order to operate the relay of each rectifier in order to obtain spot light operation after the double pole, double throw, spot light switch has been placed in spot light operation position.

CLEANING AND VENTILATION

It is essential that both the top and the bottom of the rectifier be kept clean to permit unrestricted intake and exhaust of air. The rectifier should be installed as far as possible from walls and adjacent floor space kept free from material which will reduce air circulation. Frequent cleaning of the bottom screen will remove accumulated dirt preventing restriction of air intake.

RELAY CONTACTS

The remote control relay requires no maintainance other than an occasional inspection and cleaning of the contacts. This may be done with a No. 000 sandpaper. Make sure that both contacts of the relay make a positive closure with relay in operated position.

RECTIFIER FUSES

Fuses are located inside the rectifier and are accessible only by removing the upper front panel cover. The rectifier is fused with 80 ampere fuses and under no condition should the size of the fuses be exceeded. The fuses are connected in the low voltage (secondary) AC feed to the rectifier bank for the purpose of protecting the transformer in case of rectifying failure.

EXTERNAL FUSES

The three phase AC supply should be fused with 30 ampere fuses. It is important that no larger size fuses be used as a burn out of the fectifier may result. No fuses are required in the DC circuit between the rectifier and the lamphouse arc, and if fuses are now installed, they should be strapped out or replaced with brass tubing in the fuse clips, unless this is contrary to local regulations.

TROUBLES—LOSS OF AMPERAGE

If there is a flicker on the screen with a considerable loss of amperage, making it difficult to hold the arc, it is an indication of a blown fuse inside the rectifier. Under these conditions both fuses should be removed, tested and blown fuses replaced. If fuses continue to blow, it is an indication of a trouble condition with the rectifier bank. This condition may also be caused by an open contact at the remote control relay, or a poor connection at the fuse block or relay inside the rectifier.

TROUBLES—FLUCTUATING AMEPRAGE

A certain amount of amperage fluctuation can be expected in cases where improper carbon trims are used, but in those cases where fluctuations are evident with the proper trim, the cause can usually be traced to a loose or poorly made connection. Under these conditions, an inspection should be made of all connections, including those inside the rectifier, if necessary. Poor connections in the DC arc circuit usually heat and can be located by feeling with the hand. Loose switches, defective fuses, burnt carbon jaws, etc., can also be responsible for this condition. It is advisable to inspect all connections at regular intervals. Inspection should be made of the lamphouse motor feed control. It should be borne in mind that while making the DC amperage adjustment, the carbon gap should be rigidly held within the proper gap setting, set down by the manufacturer. This carbon setting is approximately 5/16 of an inch.

The ammeter should now be read for the correct current. It is advisable to make frequent calibration checks of the lamphouse meters with a meter of known accuracy to determine if the reading represents the actual amperage.

TROUBLES—FAN FAILURE

Frequent observations should be made to determine if the blower fan is operating at all times while the rectifier is in use, this should be done particularly on starting the rectifier. In case the fan fails to start, the upper front cover should be removed and an attempt made to start rotation with the hand while the power is on. If the fan then fails to rotate or is sluggish, the front cover should be left off and a large fan placed in position to blow directly on the magnesium copper sulphide rectifying units. Operation of the rectifier can then be continued until a replacement for the defective fan can be obtained.

TROUBLES—OPERATION OF BOTH ARCS FROM ONE RECTIFIER

In case of trouble in the rectifier whereby no DC output is available, it is possible to operate both arcs from the adjacent rectifier by "stealing the arc." This is accomplished by disconnecting the arc DC leads from the inoperative rectifier and paralleling them with the DC leads of the good rectifier (positive lead connects to positive lead, negative to negative). If DC fuses and switches are installed, the DC leads may be paralleled at these points, but the fuses of the inoperative rectifier should be removed from their clips, or the switch opened to prevent possibility of a feed-back. The handles of the arc switches should be replaced and the remote control toggle switch of the good rectifier left in the operating position at all times. It must be borne in mind to always extinguish the operating arc before striking the incoming arc. The above emergency operation can be accomplished with no loss of time by the use of an emergency transfer.

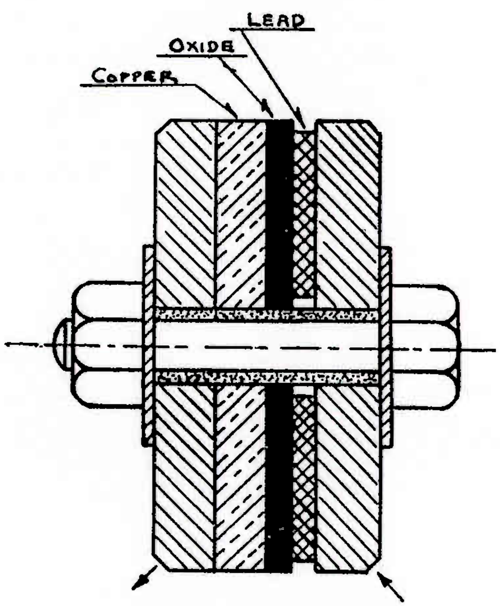
BRENKERT R-6 RECTIFIER

The Brenkert Light Projection Company of Detroit, who have been manufacturing projection equipment for a great number of years, use the Westinghouse Copper-Oxide disc unit, in the production of the Brenkert R-6.

The rectifier is of unit construction, which allows ready removal, for inspection or servicing, or replacement of the transformers, rectifying element, the fan or the relay. These units are contained in a heavily constructed case of welded channel steel frame and heavy steel panels. A panel board on the front of the rectifier contains four sets of binding posts so that proper connection may be made for various incoming line voltages, all connections are made to this panel board, making installation of the rectifier an easy, effective, and positive job.

By means of switching connections to different sets of binding posts, there are ten different sets, it is possible to obtain the exact arc voltage required. Voltage regulations are in one volt steps.

As has already been shown the efficient working of all disc rectifiers depends upon the dissapation of heat generated within the rectifier, and it is all important that the fan be at all times in operation while the rectifier is in use. In the Brenkert Rectifier, they have incorporated an automatic safety device in the shape of a current control switch, which automatically turns the current supply on the rectifier, only when the fan has reached its proper operating speed. Should the fan for any reason become inoperative, this switch will automatically open the rectifier circuit, thus protecting the rectifying units and the transformer from damage. The fan is a ball bearing suction fan, especially designed for this rectifier.



Exaggerated view of single disk unit construction.

The Brenkert R-6 rectifier is made for line voltages of 190-250, three phase, 60 cycle, and gives 40-50 amperes at arc lamp, or if required a three phase, 60 cycle giving 40-65 amperes at arc. The rectifier can also be obtained for two phase circuits, with arc voltages of 40-50 or 40-65 volts. Rectifiers for other line voltages are available,

CARBONS AND THE CARBON ARC

Two carbons set up in a standard lamp house connected cross a line supplying current at a constant voltage without a ballast would not furnish a satisfactory source of light. An electric arc has what is known as negative coefficient of resistance so that the volt-ampere characteristic does not follow Ohm's law. In other words, the voltage of an arc in a circuit without ballast decreases as the current is increased, until the voltage of the arc is not sufficient to sustain the current between the carbons. Then, the arc "snaps" out.

To overcome this, ballast in the form of resistance is connected in the circuit to limit the current and thereby stabilize the arc by maintaining a constant arc voltage. An arc stabilized in this manner provides a steady source of light. The resistance also serves a useful purpose in limiting the amount of current that flows when the arc is struck by shorting the carbons. Without this resistance in the circuit, the current drain from the supply circuit would be excessive. In certain applications, resistance is added, to that necessarily required to stabilize the arc, in order to provide a means of dropping the supply voltage to a value suitable for the arc.

The arc voltage depends on the arc gap, the size and quality of the carbons, the position of the carbons, and the current flowing in the circuit. Due to practical considerations, it is impossible to fix definite values of arc voltage within small limits.

The arc circuits are supplied energy from either the direct current service mains of a company distributing electrical power or, in an AC district, from a convertor, such as a motor generator set or rectifier, which receives alternating current from the service mains and furnishes direct-current for use in the arc circuits.

In all cases, the voltage supplied may be considered as a constant, the value depending on local conditions. The values commonly met in practice, are as follows: 80, 85, 90, 100, and 115 volts. In all cases, the rheostat must be designed for the actual conditions of line voltage, arc voltage, and current range under which it must operate.

The voltage drop in the ballast rheostat equals the difference between the supply voltage and the desired arc voltage. In order to steady the arc, the value of this drop should approximate fifty per cent of the arc voltage.

The manufacturers of motor generators are now advocating a minimum output of 80 volts for low intensity arcs to obtain the proper ballast action from the resistance connected between the generator and the arc. It is their contention that anything less than 80 volts results in an unstable arc which is unsatisfactory for proper projection.

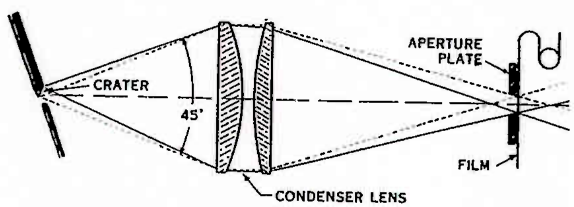


Diagram of Old Type, Low Intensity, D.C. Projection Lamp

For the Hi-Low and Hi-Intensity arc the line voltage must be considerably higher as in these lamps the current is higher. Therefore, the arc voltage goes up and

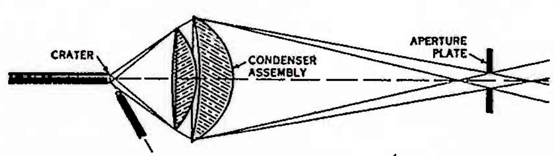


Diagram of High Intensity Arc Lamp — Condenser Type

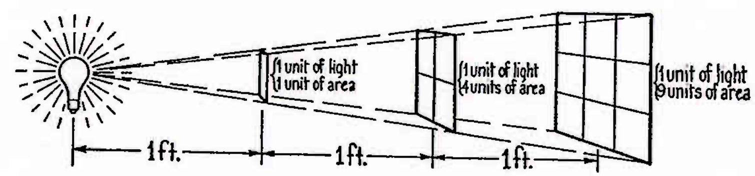
in order to get a steady arc, the line voltage must go up in proportion.

The resistance for use as ballast may be furnished as a fixed resistor or as a rheostat consisting of a number of resistors with means for adjusting the amount of resistance in the circuit. Resistors have been generally used for low current applications and rheostats for both low and high current arc circuits.

The fixed resistors are supplied with a resistance element of nickel-chromium ribbon formed into a U-channel and mounted on a transite bar. This construction makes a light, compact resistance unit and the ribbon presents the maximum surface possible for heat radiation.

The variable rheostats are made up using a suitable combination of resistors to furnish the specified capacity. In order to prove control in 5 ampere steps, wire bar resistors are used for three steps of 5, 10 and 15 amperes. Wire bar resistors are made by winding an alloy resistance wire, having zero temperature coefficient, in the form of a long coil. The coiled wire is wrapped on a narrow transite support, eliminating the sagging of the wire and touching of adjacent coils.

In arc circuits having a maximum current exceeding 110 amperes, it is advisable to reduce the starting current to some value lower than that used for normal opeartion in order to avoid fracturing the carbon due to inrush current, when the arc is struck and to obtain a satisfactory crater in the positive carbon. To provide the reduced current, usually from 1/2 to 2/3 of normal

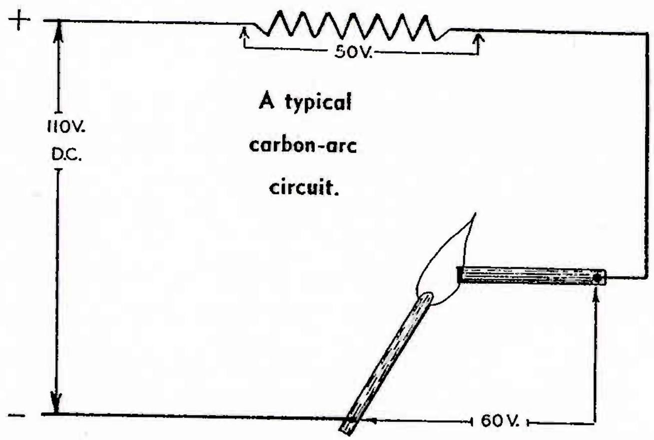


The level of illumination varies inversely as the square of the distance from the light source to the surface

current, an extra terminal is placed on the rheostat. The fixed section of the rheostat is generally connected to this terminal thereby providing a circuit in which the current is limited to the minimum current as specified on the rheostat name plate.

Two wires from the rheostat are carried to the lamphouse and connected to knife switches. The lead from the fixed section of the resistance is connected to one side of the double pole switch and the lead from the variable section to the booster switch. Then the current in the circuit when striking the arc after closing the double pole switch is a minimum. After the carbons are warmed and the crater formed, the normal current is supplied by closing the booster switch.

The use of the booster circuit increases the importance of the minimum current specified for the rheostat. For example, a rheostat having a rating of 60-180 amperes normally operating on 150 amperes would have a warming-up current of 60 amperes. This current is too low to be practical with carbons rated at 150 amperes, but by fixing the minimum current at 90 am-



A typical carbon-arc circuit.

peres, the desired heating and burning would be obtained. However, the boosting current need not limit the specifications of the minimum current because it is always possible to obtain any desired current below this value.

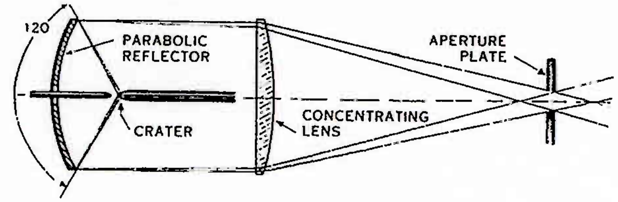
A rheostat rated at 150-210 amperes may be connected so as to furnish a warming-up current of 60 or 90 amperes by supplying an extra terminal. With the increased use of higher amperages in arc circuits the use of booster circuits will become more general.

INSTALLATION

The use of increased current on arc circuits in order to provide suitable light on porous screens results in higher wattages in the ballast rheostats than was the practice before the use of sound in the theater. The present trend in theater design is to provide separate rooms for the rheostat equipment fitted with suitable racks for mounting the rheostats above the floor level and equipped with fans and ventilators for providing continuous air circulation.

Under any circumstances, it is important that sufficient ventilation be provided to carry off the heat given off by the rheostats be so placed as to insure free circulation of air through the resistance elements. The fact that a rheostat becomes heated, when carrying current, is to be expected as its function is to dissipate energy in the form of heat, but it must not be placed in such a position or covered over so that the heat cannot be freely radiated.

In any carbon arc, no matter of what kind, the main considerations are amount of current, voltage across the arc, and length of arc. These are all interdependent, yet if two of the three are fixed, it does not mean that the third will always assume a definite value. This is true largely because, while we have done nothing to change



Low Intensity D.C. Reflector Arc Lamp with Parabolic Mirror

the apparent length, the flow of the arc may have assumed a new path with a different resistance.

This apparent discrepancy seems to bedevil the Suprex arc more than some of the older types. Horizontal operation, together with the very special construction and materials of the carbons, probably explain this. Lengthening the arc increases the voltage across the arc or decreases the amperes, or does a little of each—usually, but not necessarily.

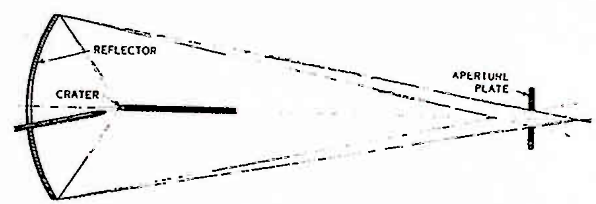
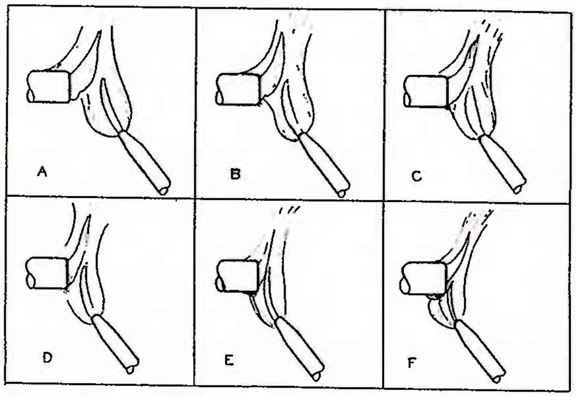


Diagram of High Intensity Reflector Arc Lamp

Quite often when operating an arc on a ballast of fixed resistance and with a supplied voltage so steady that there was no discernable variation, the current is found to vary, sometimes abruptly and sometimes periodically, especially if the current strength is not suited to the size of carbon used. It is this condition that is mystifying and leads to a suspicion as to the infallibility of Ohm's Law.

The Suprex arc today is operated either off a generating source of constant voltage with a ballast resistance, or off a source having what is known as a drooping characteristic, that is, as the demand for current increases the voltage produced by the generating device decreases. With the drooping characteristic it is possible to operate without the use of ballast, but two arcs cannot be burned simultaneously from the same generating source.

With the other plan, using a constant voltage source, this voltage is held somewhat higher than that required for the arc, the difference being consumed in the ballast. In this manner two or more appliances can be used at one time, and the arc in each will burn independent of all the others. The Suprex arc is particular-



Changes in Arc with Relative Position of Carbons

ly adapted to this sort of operation because the ballast resistance required is small, being on the order of 6 to 10 volts in place of the 25 to 30 usually employed with the higher voltage arcs.

Supposing, then, an arc is burning on a constant voltage source with a ballast in series. The voltmeter, if steady, will show that the generator output is constant. If the voltage should change, the voltmeter would tell how much, just when, and for how long.

The ballast, adjusted with a certain position of the handle or with a certain combination of short-circuiting clips, has a very definite resistance, which means that with a given current in amperes the voltage across the ballast can be only one definite thing. The one thing that cannot be controlled is the *resistance of the arc itself.*

All of which leads us to an important conclusion.

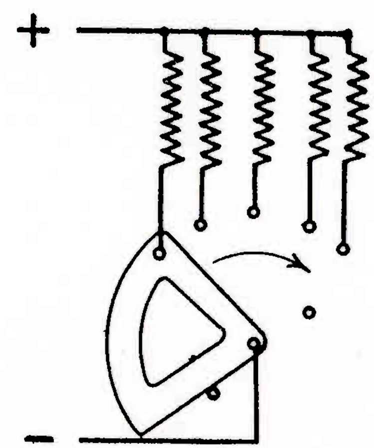
If the voltage remains constant as shown by the meter across the generating source while the current is fluctuating, the current source cannot be blamed for these fluctuations.

Suspicion will fall next on the ballast. Herein is always present a possibility of poor or loose connections, which are really the only cause of rheostat trouble. To detect such trouble is not so easy, since the voltmeter across the rheostat or ballast will keep step with the fluctuations of amperes in the arc because our old friend Ohm's Law is in full force and *if the resistance remains constant, as it should, and the current changes, the voltage drop across the ballast will change up or down in proportion to the current change.*

One way of detecting rheostat trouble is to look for hot spots. The writer has found rheostat installations in which the series ribbon type is used, and where the resistance value is adjusted by the cutting out or in of clips on the front, where the clips had not been tightened and were so hot as to burn the hand.

Another way of checking ballast is to put a voltmeter across its terminals and watch it in conjunction with an ammeter. If at any time a fluctuation of the voltmeter can be detected when the ammeter is steady, the trouble is definitely located in the ballast.

Ballast resistances, of both the series and the multiple



type, are so constructed today that very fine gradations of current values are possible and usually no adjustment of the field regulator is required. These finer gradations are accomplished in both the series and the multiple types by using sections of various resistance values and then arranging that these are inserted *selectively* rather than *progressively.*

To dig into this topic a little deeper: the multiple type of resistance generally consists of wire coils, cast grids or, in some cases, ribbon, the one end of each being attached to one rheostat lead, while the other ends are brought to either a series of contacts which are swept by an arm (Fig. 280) or to independent switches (Fig. 280A) the arm or switch being then connected with the lead of the rheostat.

If the arm is used, the sections of resistance can be cut out or in *progressively only*. There is no choice. If the independent switches be used, the sections can be cut in or out *selectively*, any one being operated at will without disturbing the others.

Similarly with the series type of resistance where all the sections carry the whole current, an arm (Fig. 280B) can be arranged to cut the sections in or out progressively, or clips (Fig. 280C) can be used to "short out" any section selectively.

As an illustration, suppose there are five sections of these which have values of 1, 2, 4, 8, and 16 ohms and all have the same current capacity, the total resistance series-type being 31 ohms. No. 1 may be shorted (Fig. 280C) leaving the resistance 30; No. 2 may be shorted, leaving a balance of 29; Nos. 1 and 2 give 28; No. 4 gives 27; Nos. 1 and 4 give 26; Nos. 2 and 4 give 25, and so on in 1-ohm steps down to a final value of 1 ohm. However, if all of these steps were made of the same

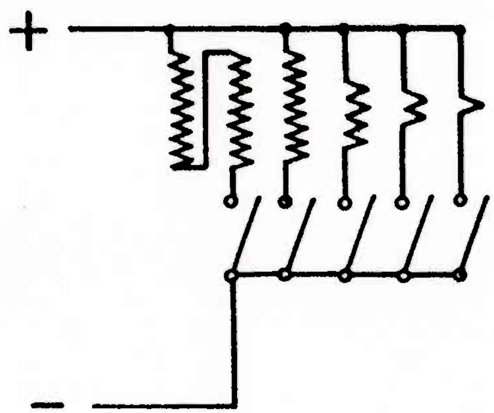


Fig. 280A

value, approximately 6 ohms each, we would be able to get only 30—, 24—, 18—, 12—, and 6-ohm steps.

In the multiple type the same plan brings the same results (Fig. 280A). A shift in the position of the field regulator should no longer be necessary, except possibly in going from an average to a very dense film. The temporary adjustment is possibly more easily accomplished in this way.

It is not unusual to have a steady generator voltage but an unsteady arc due to imperfect contacts in the ballast rheostat or in the wiring. A recent case of this kind was blamed first on the generator, then on the rheostat, but the trouble was finally found in the wiring. The actual fault was hidden in the conduit imbedded in concrete where it could not readily be discovered, and it was located only after all combinations of lamps, wiring and ballast had been tested. The fault always accompanied the combination which included that particular part of the wiring which proved defective. This wiring had to be pulled and repaired.

Frequently it is found that the clips on the series-type ballast now widely used were changed but not

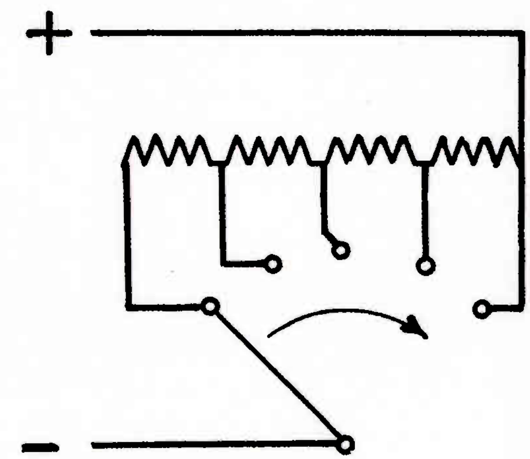


Fig. 280B

tightened. Heating and, in some cases, oxidation ensued with consequent fluctuation of the arc.

Shortly after the introduction of the Suprex arc, where two lamps are burned alternately, and on changeover simultaneously, off the same generator, each lamp with its ballast, complaints were made that on throwing in the second lamp the light of the first lamp would dip. Investigation showed that this statement was true. The voltmeter across the generator showed no drop with the burning of the second lamp; in fact, sometimes an actual slight rise in voltage would ensue indicating overcompounding.

Further investigation showed that in most instances the distance from the projectors to the generator was rather long, and the wire, while in accordance with Underwriters' requirements, had enough resistance drop to account for the trouble. Probably the first thing to occur to most projectionists confronted by this condition would be to increase the size of the wire and its consequent carrying capacity so as to minimize this effect.

A much better solution was worked out. By running two independent lines to the lamps the trouble was entirely eliminated; the amount of copper used was no more than in the original installation. The line drop caused by the current in either lamp was then confined to that lamp, and this drop could then be considered a part of the rheostat drop and had no distorting effect.

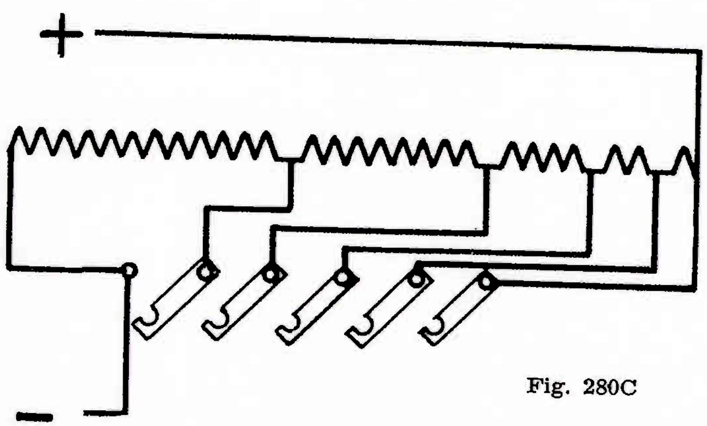


Fig. 280C

The carbon arcs used in the motion picture industry are of three general types — the low-intensity arc, the flame arc, and the high-intensity arc. The low and high intensity arcs have been used in both motion picture photography and in projection, although the former is now obsolete in photography and is steadily being replaced by the more efficient high-intensity type in the projection field as well. The most important use of the flame arc in the motion picture industry is in photography, where it provides a broad beam of suitable color quality for general set illumination. The system of nomenclature that has grown up with the industry is more descriptive of certain types of lamp than of the character of the arc. Names such as "mirror arc," "Hi-Lo," "Simplified High-Intensity," "M. P. Studio," "Baby Spot," and "Sun-Arc" are in common usage, but some of these terms are not descriptive of either the arc itself, the mechanism, the optics, or the service. It is the purpose here to define the arc itself, irrespective of the other factors just mentioned, so that a given trim may be readily classified as to whether it is a low-intensity, a flame, or a high-intensity arc.

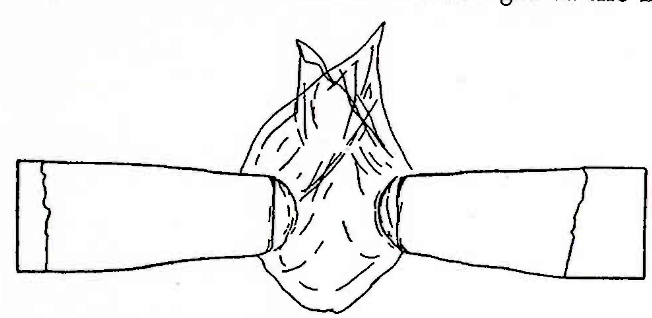
As a basis for classification, the physical nature of the light-source offers the most logical distinction. Therefore the definitions have been phrased from this standpoint, followed in each case by descriptive material in their support.

THE LOW-INTENSITY CARBON ARC

The low-intensity carbon arc is one in which the principal light-source is incandescent solid carbon at or near its sublimation temperature.

In the vast majority of cases, this arc is operated on direct current, although a few carbons are still sold for alternating-current service. The direct-current arc uses neutral cored positive electrodes and either solid or cored negative electrodes. A neutral cored carbon contains a core consisting predominantly of carbon, less dense than the surrounding shell, and incorporating a small percentage of an arc-supporting material The core of these carbons contains flame-supporting material the function of which is to steady the arc, quiet the hum, and whiten the light. In the direct-current arc, the crater face of the positive electrode is used as the light-source for projection, since it operates at a much higher temperature than the negative electrode and so provides about 90 per cent of the total light from the arc. The bright spot on the end of this positive carbon has a rather sharply delineated boundary which is called the anode spot or the positive crater. This crater marks the region within which most of the electric current passes between the anode and the arc stream.

The surface of the crater is heated to its high temperature as the result of the absorption of energy from electrons discharged there, and the absorption of energy from the gaseous region known as the anode layer directly in front of the anode. The arc gas in the major

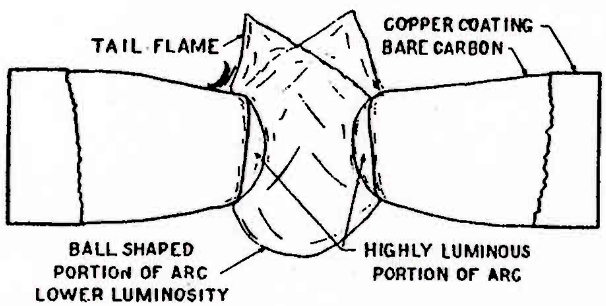


8-mm. a-c. high-intensity carbons, overloaded: 90 amperes, 35 volts.

part of the arc stream is very hot, having a temperature of 6000°C or more, and is therefore highly ionized. In its highly ionized condition, it can carry the current with a fairly low voltage drop per unit length, amounting to about 20 volts per centimeter. In the anode layer, however, the gas is cooled by the proximity of the anode to such an extent that its degree of ionization, and therefore its electrical conductivity, is very low. Because of its low electrical conductivity and because of space-charge effects, a high voltage drop must be concentrated in the region of this anode layer in order to force electrons through it and thus conduct the arc current. This voltage is called the anode drop, and is of the order of magnitude of 35 volts for a low-intensity arc.

This energy dissipated at the anode heats it to incandescence, the maximum temperature obtained being limited by the sublimation temperature of carbon.

This limits the maximum brilliancy of the low-intensity arc to a value of about 175 candles per square-millimeter. The area of the anode spot or crater adjusts itself for a given current so that the heat input is sufficient to bring the crater to a value near this sublimation temperature. An increase in current in the low-intensity arc will, therefore, not increase appreciably the maximum brightness, but will increase the area of the crater surface. Compared to a high-intensity arc, the current-density of a low-intensity arc



80 amperes, 25½ volts; good operating conditions.

is quite low. For the familiar commercial lamps, the current-density in the positive carbon ranges from approximately 50 to 200 amperes per square-inch.

It is interesting to observe that carbon is an ideal material for use as an electrode in such an arc, because it remains a solid at a higher temperature than any other substance of suitable electrical and thermal conductivity, so that a more brilliant light may be produced; while its property of volatilizing directly from a solid to a gaseous state permits convenient disposal of the consumed portion without danger to the associated mechanism.

THE FLAME ARC

A flame arc is one in which the entire arc stream, made luminescent by the addition of flame materials, is used as a light-source.

The flame arc was a natural development from the low-intensity arc, obtained by enlarging the core in the electrodes and replacing part of the carbon there by chemical compounds capable of radiating efficiency in a highly heated gaseous form. Those compounds are vaporized along with the carbon and diffuse throughout the arc flame, rendering it luminescent.

The high concentration of flame materials in the core reduces the area and brilliance of the anode spot so that, at the low current-densities used in flame arcs, the contribution of the electrode incandescence to the total light becomes unimportant. The evaporation of flame materials is low relative to that obtained in a high-intensity arc, and the resulting concentration of flame elements in the arc stream is low so that a high brilliance does not result. Since the whole flame is made luminous, however, the light-source is one of large area and the radiating efficiency is high.

The radiation emitted by the flame arc consists chiefly of the characteristic line spectra of the elements in the flame material, and in the band spectra of the compounds formed. The rare earth metals of the cerium group are used as flame materials where, as in most cases, a white light is desired, while calcium salts are used to give a yellow light and strontium salts red.

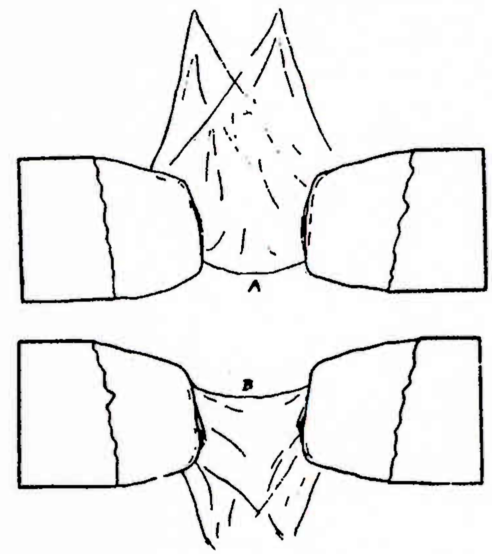
THE HIGH-INTENSITY CARBON ARC

The high-intensity carbon arc as used for projection is one in which, in addition to the light from the incandescent crater surface, there is a significant amount of light originating in the gaseous region immediately in front of the carbons as the result of the combination of a high current-density and an atomsphere rich in flame materials.

To produce a direct-current high-intensity arc, the positive carbon must be cored with chemical compounds similar to those used in flame arc electrodes. The current-density, however, is much lighter, so that the anode spot spreads over the entire tip of the carbon, resulting in the rapid evaporation of flame material as well as carbon from the core. Since flame material is more easily ionized than carbon, its presence in the anode layer results in a lower anode drop at the core area than at the shell of the carbon. This tends to concentrate the current at the core surface, resulting in the hollowing out of a crater as the current is increased. The rapid evaporation of the flame material produces a high concentration of this efficiently radiating gas in the crater and immediately in front of it. This gas, of course, radiates in all directions, even back toward the crater surface, and consequently tends to serve as a blanket preventing the radiative cooling of the crater face. The heat liberated at the crater face must then be dissipated entirely through evaporation of more flame material and through conduction back along the positive carbon. This, of course, tends to increase the evaporation of material within the crater and aids in the tendency for crater formation. Thus in a high-intensity arc there is a close correlation between the crater depth and the brilliancy of the arc gas within and immediately in front of the crater; for a given type of positive carbon, there is a linear relationship between the crater depth and the excess brightness over that of a low-intensity arc.

An increase of current in a high-intensity arc increases the crater area only slightly, but produces a marked increase in brilliancy. The maximum brilliancy of the crater obtained in various types of direct-current high-intensity arcs used in common commercial lamps ranges from 350 to 1200 candles per square-millimeter with current-densities in the positive carbon ranging from 400 to well over 1000 amperes per square-inch. Experimental carbons have been produced with brilliancies in excess of 1500 candles per square-millimeter.

The increased brilliancy of a high-intensity over that of a low-intensity arc is produced by radiation from the high concentration of flame materials within the confines of the crater. The thermal energy supplied by the electrical power input to the arc continually excites the atoms of the flame materials to higher energy states, and the excess energy of these atoms is being continually released in the form of radiation. The high density of radiation results in the production of a strong continuous spectrum in addition to the line spectrum of the flame elements. Since radiation in the visual range of wavelength from 4000 to 7000 Angstroms is required in motion picture services, the most efficient compounds to use as flame materials are those producing the most radiation in this spectral band. Nothing better than the rare earth metals, of which cerium, lanthanum, neodymium, and praesodymium are typical examples, has ever been found for this purpose. With complex atoms having many electrons, countless opportunities for the energy exchanges that give rise to radiation in the visual region are provided, so that no one part of the spectrum is unduly exaggerated, and a while light is naturally produced.



8-mm. a-c. high-intensity carbons, underloaded 60 amperes 24 volts; showing different positions of the arc as it "flops" about

The alternating-current high-intensity arc is also a true high-intensity arc within the meaning of the definition proposed. The high current-density and the high concentration of flame materials combine to produce light both from the incandescent electrode and from the gaseous region immediately adjacent, as they do on direct current.

V RECTIFIERS

Construction, Theory.	The magnesium-cupric sulphide rectifier is all metal in construction and contains no liquids, bulbs or moving parts. The rectifier is an assembly of magnesium discs, cupric sulphide discs and a combination of terminal and radiator plates which assist in dissipating the heat developed in the process of rectification. The Forest rectifier, a magnesium-copper sulphide rectifer made especially for motion picture work is of the twin or double type. The copper sulphide discs are placed between magnesium discs and metallic non-polarizing discs. These are the importand working elements of the rectifier. Heavy radiator plates are placed against the magnesium disc on one side and the non-polarizing disc on the other side, to assist in heat dissipation.
How current is rectified	Electric current flows freely in one direction, from the non-polerizing disc through the copper sulphide disc to the magnesium disc. But the flow of current in the other direction, that is, from the magnesium disc through the copper sulphide disc to its non-polarizing disc, is greatly impeded. Consequently, the rectifier serves as a uni-directional conductor or valve, changing alternating current into direct durrent. The rectifying action occurs at the junction interface and, being electronic in nature, assumes permanence and stability of the rectifying elements.
Installation of Rectifier	The rectifier can be installed in any convenient location in the projection room or in any adjacent room. It is essential however, that the location be well ventilated, preferably in a room with an exhaust fan. The operation of any of the dry type rectifiers in a poorly ventilated room will greatly reduce their working efficiency and affect the useful life of the rectifying elements.
Three Phase Current Supply.	Facilities for connection to a three phase current supply should be available, through a suitable fused switch located near the rectifier. The switch is to be closed to start operation and opened when shutting down, as the primary of the transformer is always connected across the three phase line. The three phase ciruit supplies current for the rectifier bank, the rectifier blower fan and the remote control relay. The rectifier should be connected to the power line and to the projector lamp as shown in the illustration. It is important to observe the rotation of the fan after installation has been completed, to determine if air is being exhausted instead of being drawn into the housing. If so the fan is running backwards and the leads should be reversed.

RECTIFIERS

Remote Control	The rectifier must be operated by remote control, this is accomplished by means of a relay inside the rectifier housing. Operation of the remote control is accomplished by a toggle switch mounted on the side of the housing enclosing the D-C arc switch on the projector, and wired in accordance with the diagram. The usual arc switch on the projector remains closed and the handle is removed as this switch is no longer used to strike or cut the arc. The remote control toggle switch must be used to control the arc, as in this way, voltage surges are prevented from reaching the rectifier units.
Rectifier Transformer	The rectifier is provided with a three phase transformer, with the secondary wired through a relay and fused to its bank of rectifying elements. The elements are connected in a full wave three phase bridge circuit.
Line Adjustments	The primary of the transformer is provided with taps to adjust the rectifier to the three phase supply line voltage. These are primary line settings and adjustment is made by moving the terminal strip to the studs nearest the corresponding A-C supply voltage.
DC Output Adjustments	Facing the front of the lower compartment of the rectifier panel, the set of six studs on the upper left, is a set of output control studs for the lamphouse. These six studs have an arrow and are the fine adjustments. The sets of three studs marked "LOW" and "HIGH" with an undersignated medium set of terminals, are the broad adjustments. The three terminal screws at the top of the transformer panel, are connections to the rectifying units. Removing these three wires disconnects the rectifying units from the circuit entirely. As the rectifier leaves the factory, the connections at the control studs are set at their lowest positions If the output current is to be increased, first move the fine adjustment connector strip in the direction of the arrow. When it is in that position and the current output is still too low, bring it back to its original position and then move the coarse or broad adjustment connector strip to the next position. Then move the fine adjustment in the direction of the arrow. By repeating this process the output current rate can be adjusted to practically any desired value within the range of the rectifier.

RECTIFIERS

Spotlight Operation	Facilities for the op ration of a spot light or effect projector are provided by the installation of a double pole, double throw switch, and a double pole, single throw toggle switch.
	This arrangement connects both single rectifiers in series which increases the output DC voltage only while the amperage remains constant. The toggle switch must be operated in order to operate the relay of each rectifier in order to obtain spot light operation after the double pole, double throw spot light witch has been place in spot light operation position.
Cleaning and Ventilating	It is essential that both the top and the bottom of the rectifier be kept clean to permit unrestricted intake and exhaust of air. The rectifier should be installed as far as possible from walls and adjacent floor space kept free from all material which will reduce air circulation. Frequent cleaning of the bottom screen will remove all accumulated dirt preventing restriction of free air intake.
Relay Contacts	The remote control relay requires no maintenance other than an occasional inspection and cleaning of the contacts. This may be done with #000 sandpaper. Make sure that both contacts of the relay make a positive closure with relay in operating position.
Rectifier Fuses	Fuses are located inside the rectifier and are accessible only by removing the upper front panel cover. The rectifier is fused with 80 ampere fuses and under no condition should the size of these fuses be exceeded The fuses are conneced in the low voltage (secondary) A-C feed to the rectifier bank for the purpose of protecting the transformer in case of any recrifier failure.
External Fuses	The three phase A-C supply should be fused with a 30 ampere fuse. It is important that no higher than a 30 ampere fuse be used as a burn out of the rectifier may be the result. No fuses are required in the D-C circuit between the rectifier and the lamphouse arc, and if fuses are now installed, they should be strapped out or replaced with brass tubing in the fuse clips, unless this is contrary to local regulations. The fuses should be inspected at regular intervals and a close examination of the fuse holders made to see that good electrical contact is being made.

RECTIFIERS--TROUBLES

Loss of Amperage	If there is a flicker on the screen with a considerable loss of amperage, making it difficult to hold the arc, it is an indication of a blown fuse inside the rectifier. Under these conditions both fuses should be removed and tested, the blown fuse being replaced with a new one that is known to be in perfect condition. Replacement fuses for all circuits in and outside of the projection room should always be kept on hand. If fuses continue to blow, it is an indication that the trouble is in the rectifier bank. This condition may also be caused by an open contact at the remote control relay, or a poor connection at the fuse block or relay inside the rectifier.
Fluctuating Voltage	A certain amount of amperage fluctuation can be expected in cases where improper carbon trims are used, but in those cases where fluctuations are evident with the correct trim, the cause can usually be traced to a loose or poorly made connection. Under these conditions, an inspection should be made of all connections, including those inside the rectifier, if necessary. Poor connections in the D-C arc circuits usually heat and can be located by feeling with the hand. Loose switches, defective fuses, burnt carbon jaws, etc can also be responsible for this condition. Periodic checks should be made of the lamphouse feed control, and proper gag setting should be maintained at all times.
Fan Failure	Frequent observations should be made to determine if the blower fan is operating while the rectifier is in use, this should be done particularly on starting the rectifier. In case the fan fails to start, the upper front cover should be removed and an attemp made to start rotation with the hand while the power is on. If the fan fails to rotate or is sluggish, the front cover should be left off and a large fan placed in front of the rectifier to blow directly on the copper discs. Operation can be continued until the fan trouble has been located.
Operation of Both Arcs From One Rectifier.	In case of trouble in the rectifier whereby no D-C output is available, it is possible to operate both arcs from the adjacent rectifier by "stealing the arc". This is axxo plished by disconnecting the arc D-C leads from the inoperative rectifier and paralleling them with the D-C leads of the good rectifier (positive lead connects to positive lead and negative to negative) If D-C fuses and switches are installed, the D-C leads may be paralleled at these points, but the fuses of the inoperative rectifier should be removed from their clips, or the switch opened to prevent possibility of a feed-back. The handles of the arc switches should be replaced and the remote control toggle switch of the good rectifier left in the operating position at all times. It must be borne in mind to always extinguish the operating arc before striking the incoming arc. The above emergency operation can be accomplished with no loss of time by the use of an emergency transfer.

TROUBLE CHARTS----CARBONS.

TROUBLES	PROBABLE CAUSE	REMEDY
SPUTTERING AT THE ARC.	Carbons not properly set or trimmed. Keeping too short an arc. Using damp carbons.	Reset or retrim. Dry carbons throughly before using. This may be done by laying one or two carbons in the lamp house, or on top of the rheostat.
FLICKERING OF THE ARC.	Due to using poor carbons or improper setting. Probably the positive carbon is set too far backward.	Use only a good grade of carbons. Try re-setting the trim.
EXCESSIVE SPINDLING.	Using carbon combination of too small a size. Overloading the carbons. Having a poor contact in carbon holders.	Use the trim suggested by the manufacturer. See that the jaws are throughly cleaned and that the carbon make good electrical contact in them. Keep the jaw contacts as smooth as possible.
LOSING THE ARC.	See trouble chart on arc-lamps	See trouble chart on arc-lamps.
LIP ON UPPER CARBON.	This is caused by setting the negative carbon too far forward.	Re-trim.
LOSS OF LIGHT FROM ARC.	Improper setting of carbons. Setting the negative carbon too far back, so that the light is thrown down, instead of towards the condenser.	Re-trim.
NEGATIVE CARBON BEING FED AT TOO FAST A RATE.	See trouble chart on arc-lamps	See trouble chart on arc-lamps.
INTERMITTENT FEEDING OF CARBONS IN HIGH INTENSITY ARCS.	See trouble chart on arc-lamps.	See trouble chart on arc-lamps.
MUSHROOM POINTS.	Keeping too short an arc, this forms a "button" on the negative carbon.	Increase space between carbons.
BURNED OUT CRATERS.	Too high a current. Too low a current, or using carbons too large in diameter. May be caused by a combination of any of these causes.	Check amperage and size of carbons recommended.
CARBONS DO NOT SEPERATE WHEN STRIKING THE ARC. Automatic feed.	See trouble charts on arc-lamps.	See trouble charts on arc-lamps.
ARC WANDERING.	Caused by using the wrong sized carbons and improper setting.	Use metal coated carbon for negative.
UNEQUAL BURNING OF CARBONS. Automatic feed.	See trouble chart on arc-lamps.	See trouble chart on arc-lamps.

TROUBLE CHART----- ARC-LAMPS.

TROUBLES.	PROBABLE CAUSE.	REMEDY.
LOSING THE ARC.	Excessive drafts, use of too high an amperage, use of generator with too low a voltage supply, improper adjustment of arc control motor, dirty motor ball bearings, bent or dirty slide rods.	Locate trouble by inspection.
INTERMITTENT FEEDING OF CARBONS.	Probably due to slipping of clutch, the motor running without feeding the carbons. May be caused by dirt on the slide rods. An open circuit in the armature. Too much tension on the motor brushes.	Tighten the clutch by means of the tension nut. Clean slide rods. Locate by inspection. Readjust brush tension.
UNEQUAL BURNING OF CARBONS.	Using carbons of wrong size combination. If amperage is to high, negative carbon will burn much faster then the positive. The positive will burn too fast if there are excessive drafts through the lamp-house.	Refer to manufacturers recommended carbon combination. Check amperage.
IMPROPER FOCUSING OF THE LIGHT BEAM ON APERTURE.	Improper setting of reflector, improper setting and spacing of mirror, arc-light, and film. Light beam not properly centered.	Reset position. Check spacing distances. Adjust mirror or reflector.
MOTOR DOES NOT START.	Open circuit, probably fuses in control unit blown or not making contact.	Locate by inspection.
CARBONS DO NOT SEPERATE WHEN STRIKING THE ARC.	Current is too low at time of striking. Remember an excess current is necessary at the time of striking an arc.	Increase striking current.
FREQUENT CONDENSER BREAKAGE.	See chart on Projection.	See chart on Projection.
LIGHT ON SCREEN FADES.	Improper setting of carbons probablypositive carbon is to far forward.	Correct carbon setting.
FLICKERING OF ARC.	Due to poor carbons, or improper setting, probably the positive carbon is set too far backward.	Correct carbon setting.
INSUFFICIENT VOLTAGE AT ARC FOR AMPERAGE USED.	To short an arc gap.	Readjust.
NEGATIVE CARBON FEED ADJUSTMENT FEEDING CARBON AT FASTER RATE THAN BEING CONSUMED.	Too short an arc gap.	Slow down the negative feed, do not try speeding up the arc control motor.
LOSS OF CURRENT.	Copper wire terminals oxidized.	Replace with new terminals.
ARCING ACROSS CONTACT INSERT.	Dirt.	Clean contacting surfaces.
SPUTTERING AT THE ARC.	See trouble chart on Carbons.	See trouble chart on carbons.

TROUBLE CHART --- INSPECTION ROUTINE --- LAMP HOUSE.

LAMP HOUSE.
Check condition of lamp-house for carbon dust and stubs. See that lamphouse is cleaned regularily, and all parts in the lamp-house calling for lubrication are oiled or greased.

CONNECTIONS.
Go over the conn ctions between the table switch and the arc-lamp, especially those leads that are located where ever heat is generated. Examine the condition of the lug terminals, and the insulated bushings through which the leads pass.

ARC FEED MOTOR.
Check for proper feeding speed. Over-heating. See that motor runs without binding.

ARC FEED CONTACTS.
Check for dust and dirt. Check to see if they are "pitted" or corroded.

BR SHES.
Check to see if these need renewing, see that they make proper contact and that tension is correct.

CARBON CONTACTS.
Check for dirt, especially carbon dust. see that they are not worn or "pitted" Keep surfaces as smooth and clean as possible.

ARC FEED MECHANISM.
Check for dirt, see that mechanism is properly lubricated.

CARBON FEED ADJUSTMENT.
Check to see this adjustment is set so that carbons are fed at the correct speed. Check for dirt and carbon dust.

CARBON SIZES.
Check to see that carbons of the proper combination and correct sizes are being used for the amount of amperage used.

CARBONS.
Check to see that these are thoroughly dry before being used. Always store carbons in a dry place. Check to see that you have a sufficient supply of carbons on hand.

CLUTCH ON FEEDING ADJUSTMENT.
See that clutch is acting properly so that carbons are being fed at a steady even and correct speed.

OPTICAL TRAIN.
In the lamp house this train may be considered to be made up of the source of light, the reflector, where one is used, and the condensers. Check to see that these elements are in proper focal alignment.
In making this check-up, it would be as well to consider the complete optical train, to the above, add the gate aperture and the objective lens---all these elements must be correctly set for mazimum screen results.

CONDENSERS.
Check to see that condensers are of correct size and combination. See that they are not mounted in the mounts too tightly. Check to see that surface facing the arc is not excesaively pitted. Check to see that no direct draught of air reaches condensers from fan.

REFLECTOR.
Check surface to see that same is not "pitted" That reflector is correctly set. Clean. Check for focal length.

LIGHT DOWSER.
Check to see that this is in working condition.

PROPER SPACING.
Check to see that the spacing or setting of the arc, the reflector and the condensers are correct. See that both lateral and vertical adjustments are properly set.

ARC VISOR.
See that the visor is correctly positioned so that the arc condition may be seen at all times.

MAZDA EQUIPMENTS.
When the lamp house is equipped with mazda lamps in place of the arc-- check to see that Mazda lamp is properly positioned. Check the position and condition of filament. Remember the average life of one of these lamps is around 100 hours. Check condition of glass bulb, discard if this is badly discolored, as this cuts down the light materially.
Check to see that filament of lamp is in alignment with optical train.
Check distances between lamp and reflector and lamp and condensers.

ARC LAMPS

STRONG UTILITY HIGH INTENSITY

The position of the lamp house should be such that the center of the reflector is not less than 29 inches or more than 32 inches from the film aperture; bearing in mind that the 29 inch distance results in most light concentration at the center of the screen with a tendency to a fall off or discoloration at the corners.

As this distance is increased to 32 inches the light distribution to the corners will be improved at the expense of the center brilliancy. At some definite point, which is approximately 30 inches from the film aperture, a compromise will be found that affords most ideal screen illumination.

The optical alignment of the lamphouse with the film aperture should be checked by using the aligning rod which is supplied with the equipment.

ELECTRICAL CONNECTIONS

The electrical connections are marked for polarity, above where the heavy asbestos arc wires lead through the rear lamp-house casting. The positive arc supply wire is at the right and this wire has a red colored wire lug. The negative is at the left.

No seperate connectors are required for the arc feeding system as this motor is connected permanently to the arc circuit inside the lamphouse, and this lamphouse comes completely wired.

The A.C line to the rectifier, whether single or multi-phase, should be wired through the lamphouse table switch, the switch should be on the power supply line ahead of the rectifier, so that the rectifier tubes are not lighted and the rectifier is dead when the arc is not burning.

TRIMMING THE LAMP

To trim the lamp, clamp the 7 m.m. carbon in the positive holder and the 6 m.m. carbon in the negative holder. There should be a ¼ inch gap between the positive and negative carbon tips and this gap should be directly above the tips of the supplemental magnets. This location of the carbons will assure approximate focus when the arc is first struck.

Before trimming the lamphouse seperate the carbon-carriages to the limit of their travel along the carbon feed screw and then set the focus adjustment to its mid-position.

The knurled focus collor at the rear of the lead screw, should be set at its mid position before trimming the lamp, to assure of ample focus adjustment after the arc has been struck.

Seperate the carriages that carry the carbons, to the full length limit of their travel, by depressing their latches with thumbs of each hand. This downward pressure will disengage the carriages from the carbon feed screw so that the carriage will slide freely along the carbon feed screw and guide rods.

CARBON TRIM

The carbon trim required for this lamp is a 7 m.m. by 12 inch or a 7 m.m. by 14 inch copper coated high intensity Suprex positive, and a 6 m.m. by 9 inch copper coated bored Orotip "C" negative, which carbons burn in a horizontal coactional alignment and without rotation.

A 14 inch postive carbon may be used, but this longer carbon will require resetting once to burn the last two inches of the carbon.

PITTING OF REFLECTORS

The pitting of reflectors is a difficulty encountered with all high intensity arcs. This bombardment of the reflector by the arc continues all the time the arc is burning. The reflector may be cleaned by scraping with a flexible razor blade.

LECTRONIC-CONTROL ARC LAMP OSITIVE FEED

-The positive carbon feeding unit consists of two slide rods which support the carbon carrier, and a worm screw suitably attached to the carbon carrier in such a manner that when the screw is rotated the carrier is fed toward the negative carbon.

The slide rods and the worm screw are supported in the usual manner by end plates or bearings.

The feed screw protrudes through the end of one of these supports and has secured directly to it a ratchet gear. This gear is rotated by a co-acting pawl actuated by a solenoid magnet in such a manner that each time the plunger of the solenoid moves in a forward direction the pawl turns the ratchet gear a predetermined distance.

For instance, in the case of a ratchet gear having 30 teeth and a solenoid to rotate it at the rate of one tooth for each solenoid movement, it is apparent that 30 solenoid strokes per minute will revolve the worm screw one revolution per minute. Therefore, if the worm screw has, say, eight threads to the inch, the carbon carrier will be moved forward one-eighth inch. It follows then that 60 solenoid strokes a minute will move the carbon carriage forward $\frac{1}{4}$ inch a minute.

PULSE GENERATOR

An electronic device was designed whereby the regular 110-volt A.C. supply line is converted into impulses which are fed to the solenoid coil. The device, an electronic impulse generator, is extremely simple and compact and has but a single control knob with wich to vary the number of impulses supplied from 20 to 120 a minute—a speed range for the feed mechanism which is much lower and much higher than is ever required.

Production of impulses by the electronic control is regulated as accurately as an electric clock. A graduated dial at the control knob is marked for amperage so that the feeding screw can be at the exact point required by the arc current. As the arc current varies slightly the control may be set to the average condition and will thereafter maintain the arc at the exact focal point.

E NEGATIVE FEED

The negative feed mechanism is exactly the same as the positive mechanism, with a seperate electronic impulse generator controlling the speed of the negative feed.

There being no mechanical or electrical tieup between the positive and negative feeds, each feed may be adjusted wholly independent of the other, and any size or any combination of carbons may be used.

E ELECTRONIC TIMER

The Forest electronic times employs a small thyrathon tube in circuit with condensers and resistors in such a manner that the time current flows through the device and the time that no current flows through the device can be regulated at will by simply increasing or decreasing the amount of resistance in the control circuit.

By simply turning the knob of the variable resistor clockwise or counterclockwise the number of impulses from the timer will be increased or decreased so that the speed of the lamp mechanism can be perfectly and accurately controlled to feed the carbon forward at the exact rate of its consumption.

This electronic timer used with the projection lamp is so designed by use of proper resistors and capacity so that a wide range of adjustments is possible. The lower setting gives a timing too low for feeding any of the present carbon trims and its upper limit gives a timing too fast for feeding present carbons. The internittent steps between the two extremes are fine enough that exact timing for any carbon consumption can be obtained.

CYCLEX ARC LAMP CONNECTING TRANSFORMERS TO PROJECTION SWITCH.

The heavy white leads emerging from the transformers are to be connected to the upper terminals of the projector switch. Be sure that a good electrical contact is made so there will be no heating at this point.

The two lamps should now be set on the projector bases with the edge of the center hole in the mirror 28 inches from the film. This distance should not be varied, as this distance is such as to produce an aperture spot of the correct size. Increasing this distance increases the normal diameter of the spot, causing a distinct loss of light, likewise decreasing this distance will result in too small a spot, creating discolored corner and sides to the screen image.

LINEUP OF LAMP & APERTURE

There are several methods for obtaining the proper line-up, the best of which is undoubtedly by means of a straight steel rod which passes through the rear carbon holder, the front carbon guide and the front clamp extending through the lamphouse front to the aperture. Exact alignment may be obtained in this way.

However if such a rod is not available another but less accurate method is to place carbons in the lamp, lining up the two tips end to end. Remove the carbons without disturbing the position of the carbon holders now sight through the rear carbon holder. A light placed behind the aperture will show wether the carbon jaws are centrally located relative to the aperture.

METHOD OF OBTAINING THE BEST LIGHT UPON SCREEN

Every optical system has two factors in common, focus and working distance. In Cyclex the working distance is 28 inches, that is the distance from the edge of the hole in the center of the mirror to the film.

The exact focus may vary with different reflections and a slight variation in placing the arc out of the correct focus will be immediately reflected upon the screen. The color of light to be selected should be white not blue or yellow. Therefore, by grasping the knobs which control the carbons and rotating them the entire arc (of even arc length) may be moved toward or away from the reflector. The moving of the arc must be done slowly, great care must be taken that the arc length is not altered.

When the arc is too far from the reflector the screen light will be blue, when too close the light will be yellow. In between these extremes will be found one position where a brilliant white light occurs. At this point the aperture spot will be of the correct size to produce a clear field.

When this point is reached the arc image (by means of moving the arc scope swivel) should be set on the lines of the guage card. The process of checking the correct position should be repeated several times with each lamp.

CORRECT CURRENT AND VOLTAGE

There is a definite range of currents within which Cyclex will operate to the best advantage. We advise against any variation from this range as proper results cannot be obtained.

Smaller screens (12to 14 feet) will naturally not require the illumination necessary with the screens 12 to 19 feet in width. Therefore, Cyclex provides for a current range of from 52 to 65 amperes.

Currents below 52 amperes are not recommended for the reason that below this current value the arc is not stable, having a tendency to shift its position, resulting in color change in the projected light.

Currents of the proper value will result in a stable arc of uniform brilliancy.

REASON FOR ALIGNMENT

In a high-intensity carbob arc projection system, utilizing a mirror lamp, all of the brightest portion of the gas ball cannot be focused on the film plane unless the positive carbon is lined up precisely with the mirror. With misalignment, the plane in focus will include either shell light——which is of a lower order of intensity——and yellower, or arc stream light, which is also of lower intensity, and bluer.

The problem is more readily visualized if the gas ball be considered as a flat luminous disc on the end of the tube, with the open face directed toward the mirror.

This mirror has two focal points, both on the central axis passing at right angles through the hole in the mirror. One focal point is about five inches from the base of the mirror; the other something more than thirty inches. The optical properties of the mirror are such that whatever object is placed at one focal point will be imaged at the other.

In projection usage, it is the intent to locate the brightest part of the carbon arc crater (the luminous disc on the end of the tube) at the closest focal point, with the film aperture at the other. With misalignment, some portion of the less brightly illuminated region in the vicinity of the disc will be located at the one focal point. the result will be only a very great loss in light intensity, and a marked variation in the color of the light directed to the other focal point. See Fig 1.

Another critical alignment factor requires that the film aperture be actually located at the second focal point, as just assumed. Finally, the axis of the projection lens must be properly aligned beyond so that, like one of the rifle barrels, it may permit unobstructed passage of the light to the screen.

It is thus evident that unless crater, mirror, aperture and projection lens are all in perfect alignment along a common axis, it will be impossible to bring them into line with the conventional controls. Why? Because these controls can only change working distances along the axis or necessitate tilting of the mirror in various ways.

Mirror Often Blamed when really misalignment is at fault.

The fact often creates the belief that a given mirror is too inaccurate for suitable operation. But before such a mirror is discarded it should be tested under conditions of correct optical train alignment. Sometimes a quick check may be made, if the other lamp seems to give satisfactory service and coverage, by mearly switching mirrors and testing the suspected mirror under conditions of alignment known to be satisfactory.

Basic alignment of all the aforementioned elements is a prerequisite to all successful optical adjustments.

Not only must the mechanism be so aligned as to hold the carbon crater with the gas ball in its proper position with respect to the mirror, but

Continued on next chart.

MISALIGNMENT OF OPTICAL TRAIN.

operation must be maintained so that the crater remains in that position during the burning ofthe trim. If for example, a short grip on the positive carbon causes the crater to raise out of its correct position, then discoloration and loss of light will result, just as though the entire mechanism were out of line. This is also true of a warped or improperly designed carbon-saver, which will either raise the positive carbon in the holder or allow it to tilt in one direction or the other.

BRENKERT Aligning Rods.

The Brenkert kit consists of four rods complete with flanges, and one projector lens-mount adapter.

The Flanges and adapter are made of aluminum, and the rods are made of stainless steel to eliminate any possible chance of rusting, even under conditions of extreme dampness.

It is important that these rods be handled with the same amount of care that would naturally be given to any precision tool. Accurate alignment of an arclamp and projector mechanism depends on each rod being absolutely square with the face of the flange.

Two rods are furnished for lamps using Suprex 7mm and Suprex 8mm positice carbons, and one for the super high-intensity arc lamp using the 13.6-mm carbon. The diameter of the rods in millimeters is stamped on each flange. To check the alignment of the arc lamp with the projector mechanism, proceed as follows----

1.----Remove the projection lens and clamp the lens adapter in the lens mount.

2.----Remove the carbons from the arclamp and move the positive jaw assembly toward the reflector.

3.----Open the arclamp light dowser and lift up the automatic fire shutter; slide the long rod through the lamphouse, through the film trap of the projector mechanism, and through the hole in the lens adaptor.

4.----Move the positive carbon jaw assembly to a position midway between its full-trim position and the carbon guide, and clamp an aligning rod in the carbon jaw with its free end resting on the carbon guide, and its flange adjacent to the flange on the rod through the lens mount.

Use the aligning rod marked 8-mm if an 8-mm or a 9-mm positive carbon is used in the arc lamp, and the 7-mm rod if a 7-mm carbon is used. Use the rod marked 13.6-mm with a super high-intensity lamp by inserting the free end of the aligning rod into the jaws and feed mechanism from the front of the positive head assembly.

5.----Adjust the lamphouse on its base vertically and laterally until the adjacent flanges are flat against each other and flush radially. When this condition has been attained clamp the lamphpuseto the projector base and remove the rods.

PEERLESS Alignment Unit.

Figure 4 illustrates the tools supplied for use with the Peerless lamp.

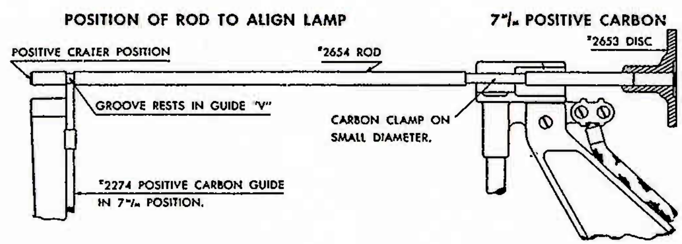


Figure 4A

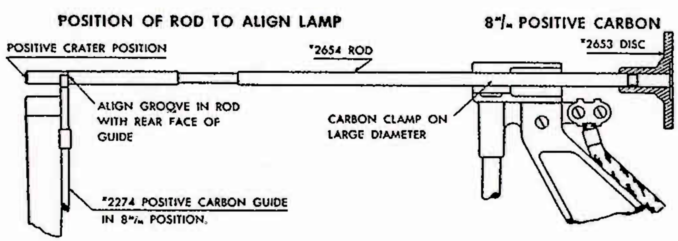


FIGURE 4B

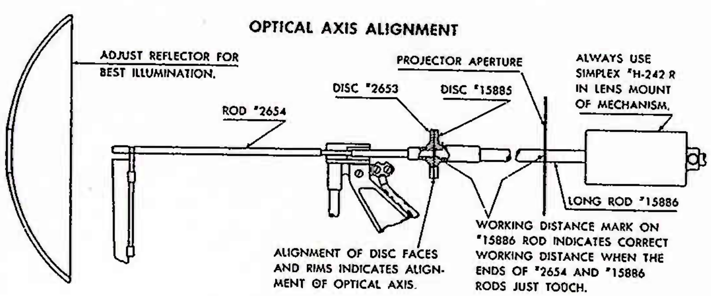


FIGURE 4C

OPTICAL ALIGNMENT CHECK SYSTEMS

PEERLESS Alignment Unit Continued.

These tools provides means for accurately aligning the optical axis of the Peerless Magnarc lamps with the optical axis of the projection lens. Also, to precisely set the correct working distance, between the positive carbon crater and the projector mechanism aperture, which in turn will automatically result in the placement of the reflector vertex at its correct focal position.

Figures 4-A and 4-B illustrate the proper use of rod 2654 in lamps equipped to use either the 6mm or 7mm or 7 x 8mm carbon trims.

TO SET LAMPHOUSE.

To set the lamphouse in its correct position from the projector mechanism aperture: first loosen the screws, which hold the lamphouse to the lamphouse table casting on the pedestal, so that it may be moved forward or backward as needed.

Place all parts of the alignment appliances in the positions as shown in Figure 4-C, and adjust the lamphouse toward or away from the aperture to bring about the condition illustrated in Figure 4-C; then retighten the lamphouse position screws.

To align the lamp axis with the projector lens axis; by means of the adjustment at the top of the projector pedestal, for the lamphouse table casting, centralize the rims and parallel faces of the two discs, after which securely retighten all adjustments to assure a permanent setting of the lamphouse support table.

After completing the foregoing adjustments, strike the arc and, by means of the manual reflector adjustments, adjust the reflector as may be required to obtain the best possible illmination and light distribution.

HY-CANDESCENT UNIT.

This appliance provides means for accurately aligning the optical axis of the lamp with the optical axis of the projection lens, and also to set both the working distance between the condenser system and the projector aperture or film plane, and the focal distance bewteen the face of the positive carbon crater and the plano surface of the rear F 2.0 condenser.

OPERATION 1.

See Figure 6. Before inserting the alignment rods and discs, be certain that the burner is adjusted to its central position inside the lamphouse.

Next install the alignment appliance as in Operation 1, Figure 6, and by means of the adjustments for the lamphouse table casting, at top of the pedestal, centralize the rims and parallel the faces of the two discs as nearly as it is possible.

After this has been done, to make the finer finishing alignment, the burner position should be adjusted inside the lamphouse. All adjustments should be retightened securely.

OPERATION 2.

See Figure 6. Insert the condenser mount, with lenses in its support cradle, and open the inside dowswr. Insert a new positive carbon in the burner, with its

OPERATION 2 Continued.

arcing end protruding the correct burning distance and clamp it in position. Next adjust the condenser mount so that the trimming wrench handle will just fit between the front face of the positive carbon and the rear condenser.

Following this, the final operation is to slide the entire lamphouse back or forward in its tracks and securely clamp it at the point where the indicating ring on the front rod aligns with the faces of the film tracks in the projector mechanism.

STRONG ALIGNING KIT

The Strong lamphouse aligning kit is designed to fill the need for an accurate and reliable method of locating reflector-type projection arc lamps on the projector base, so that the ultimate in optical efficiency and screen illumination is obtained.

As a result of the careful use of this tool, the lamphouse will be aligned so that its optical axis is in line with both the center of the aperture and the center of the lens.

OPERATION.

Prop open the fire shutter, open the change-over dowser and turn projector mechanism by hand so that shutter blades are clear of the projector aperture.

The projector lens should now be removed and the tube with the cord attached, passed through the lens holder and into the lamphouse. The tube should be clamped in the position occupied by the positive carbon in the positive carbon jaw, as shown in Fig 7,

Place the dummy lens in the projector and locate test aperture as shown. The test aperture is held in place by closing the projector film gate.

The lamp shall now be moved sidways, or up and down and also tilted on either plane until the cord comes through the center of the open end of the tube which is clamped in the carbon jaw and passes exactly through the center of the test aperture hole.

MIRROR-TO-FILM PLANE SETTING.

The numbers on the back of the mirror should be checked against manufacturer's data to determine the proper working distance. It is not safe to assume the working distance from mirror diameter alone. As a matter of fact one lamp manufacturer provides mirrors of three different working distances for the same lamp.

The working distance is measured from the inside edge of the mirror centerhole to the film plane. When this distance has been determined from data, the lamphouse should be moved on the base to the prescribed distance, plus or minus one-half inch.

Next the arc-to-mirror distance should be explored, until the best visual results are noted on the screen with shutter running, but without film in the projector. Secure the lamp to the base at the point of best visual results over this range.

During these tests it will be necessary to make use of the lateral and vertical mirror adjustments to arrive at a light-field balance. Here again the best working distance may appear wrong if the optical train is not in true alignment.

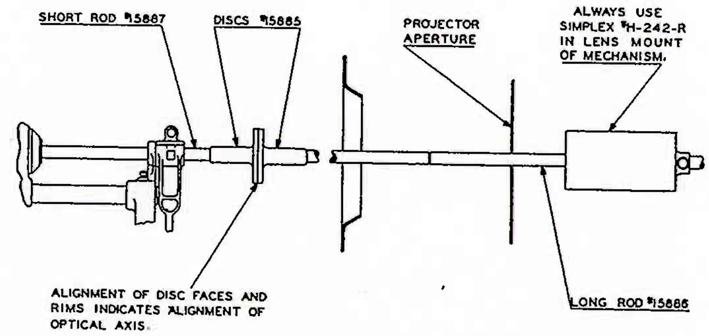


FIGURE 6-Operation 1

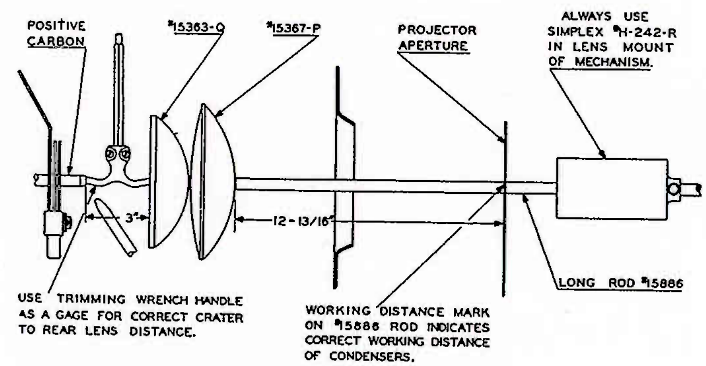


FIGURE 6-Operation 2

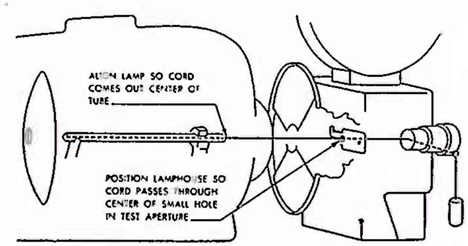


FIGURE 7

CRATER-TO-MIRROR ADJUSTMENT

The gas ball of the carbon arc may be considered as a flat disc with bluish arc stream in front and a yellowish shell to the rear. If the alignment distances, mirror-to-film plane, and mirror-to-arc are correct, the pure white light of the gas ball disc will be focused on the film plane and in turn on the screen by the projection lens.

Within its white-light range, when using a 7 mm positive carbon at 45 amperes, this disc may be considered as having a thickness of roughly 1/8 to 5/32 inch, and, depending upon its area and relationship to the mirror magnification, it is possible to vary total screen light as much as 25% from maximum and still remain within the white-light range by moving the arc toward or away from the mirror. The larger the carbon for a given mirror magnification, the greater this leeway of movement will be.

As the arc is moved towards the mirror, the sopt on the aperture plate becomes larger, the screen light distribution more flat, and the total screen light is reduced.

As the arc is moved away from the mirror, the spot on the aperture becomes smaller, the sides-to-center light distribution ratio becomes greater, and the overall screen light is increased.

A satisfactory method of arriving at the best arc-to-mirror position is to move the arc toward the mirror until the screen light becomes yellowish; then reverse the procedure until the light on the screen begins to turn blue; then move back from the blue zone just sufficiently to obtain a satisfactory side-to-center distribution, bearing in mind that in flatening the field you are reducing the overall screen light.

It is readily seen that if the crater gas ball is not facing the mirror correctly, it may not be possible to clear the light field at anything like the maximum screen light. Therefore, if the plane of the crater is allowed to shift because of a short grip in the holder, or burned carbon-savers, the probable result is that the projectionist, in attempting to operate where the least off-color light is noticed on the screen, has set mirror-to-arc position where the maximum-sized spot is obtained on the aperture plate, and so at minimum light within the white-light range.

CRATER SIZE vs MIRROR MAGNIFICATION

It is obvious that inasmuch as the mirror magnifies an image of the crater on the aperture, the larger the crater the better the coverage. Substitution of a bigger carbon at the current designed for a smaller one, however, cannot be so simply done. It is the crater face diameter and light distribution across the crater face that governs the usable light, and not the overall diameter of the unburned carbon electrode.

A 6-mm positive carbon cannot be satisfactorily used in a standard Suprex lamp designed for larger carbons because, even at maximum current, its crater size is not sufficient to give adequate aperture coverage.

continued on next chart

CRATER SIZE vs MIRROR MAGNIFICATION

If for reasons of lower light requirements the use of a 6-mm positive were indicated, it would be necessary to produce a mirror of greater magnification which would further reduce the light at the film plane.

This same difficulty comes into play when attempting to use a larger-than normal trim at below its rated current. It not only becomes unstable from lack of

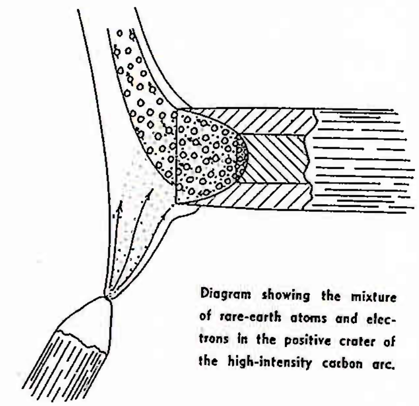


Diagram showing the mixture of rare-earth atoms and electrons in the positive crater of the high-intensity carbon arc.

power, but the overall screen light and color suffers by comparison with a properly burned trim, because the reduction in power input has also reduced the effective size of the crater.

A typical example of the foregoing is the 1-kw lamp where the mirror magnification has been increased to provide coverage with a 7-mm Suprex carbon at 40 amperes and 28.5 arc volts.

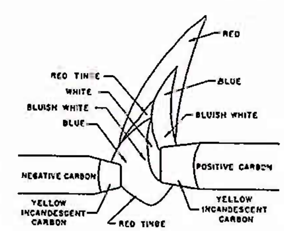


FIGURE 1

Cameron Books May Be Obtained Throughout The World From All Bookstores Carrying Technical Books

HIGHER INDORSEMENTS ARE IMPOSSIBLE—

DEPT. OF COMMERCE, Washington, D. C.:—"These books should be in the possession of every projectionist, theater manager and everyone interested in receiving first hand authentic information regarding the application of sound to motion pictures. Cameron's books are a very worth-while contribution to the motion picture industry."

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TREASURY DEPT., ONTARIO, CANADA, Inspector of Theater's Office:—"Motion Picture Projection is a most excellent work, we have found it of great value."

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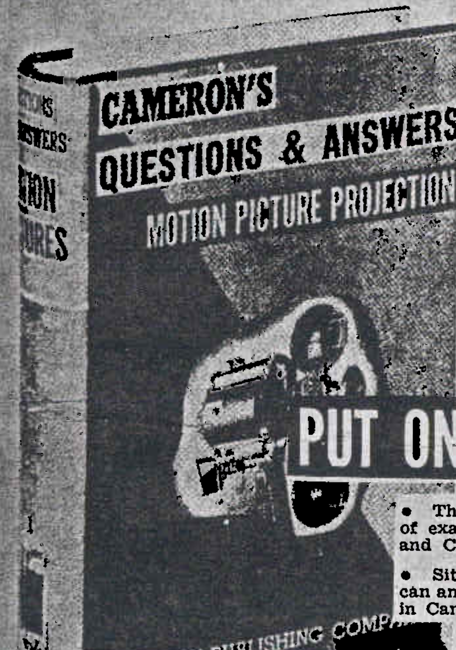

A book containing the questions (with answers) asked by the various examining boards throughout the United States and Canada, when taking the examination for projectionists' operating license.

Price: $5.00

Put on your own Quiz program, see how many of the questions you can answer without turning to the answers given in the book. See for yourself what rating you would get if you were recalled for examination.

PUT ON YOUR OWN QUIZ SHOW

- The questions listed below were taken from the various lists of examination questions used by the 48 States in this Country and Canada, in examining projectionists for operating licenses.
- Sit down with these questions and see just how many you can answer. A list of over 500 questions with answers will be found in Cameron's QUESTIONS AND ANSWERS

1. State what percentage of light is lost between the arc and the screen, through the optical train of the projector. State at what points in the optical train the light is lost and give the percentage of loss at each of these points. Quote figures to show how you arrived at the result.
2. Why is the sparking less in a generator and greater in a motor, when the brushes are rocked forward in direction of rotation?
3. State the theory and operation of a simple vacuum tube.
4. What is the ideal condition as regards drop in wiring up an electrical circuit?
5. How is the speed of a constant current motor governed?
6. Describe a two-phase and a three-phase alternating current.
7. The front shutter and the rear shutter on a projector both run clockwise, yet one cuts off the lower part of the light beam, while the other cuts off the upper part of the light beam. Tell how is possible.
8. What are electrons?
9. How would you go about phasing ...
10. What is intermediate frequ...
11. What is meant by ... all intermittent speeds the s...
12. What makes a shunt ... speed?

- Well, how did you make out in the test? Take the first question for instance—your answer to this should be—Less than 5% of the original 100% of the light reaches the screen. Seems astounding, yet this is quite true. Do you know where the other 95% of the light was lost . . .