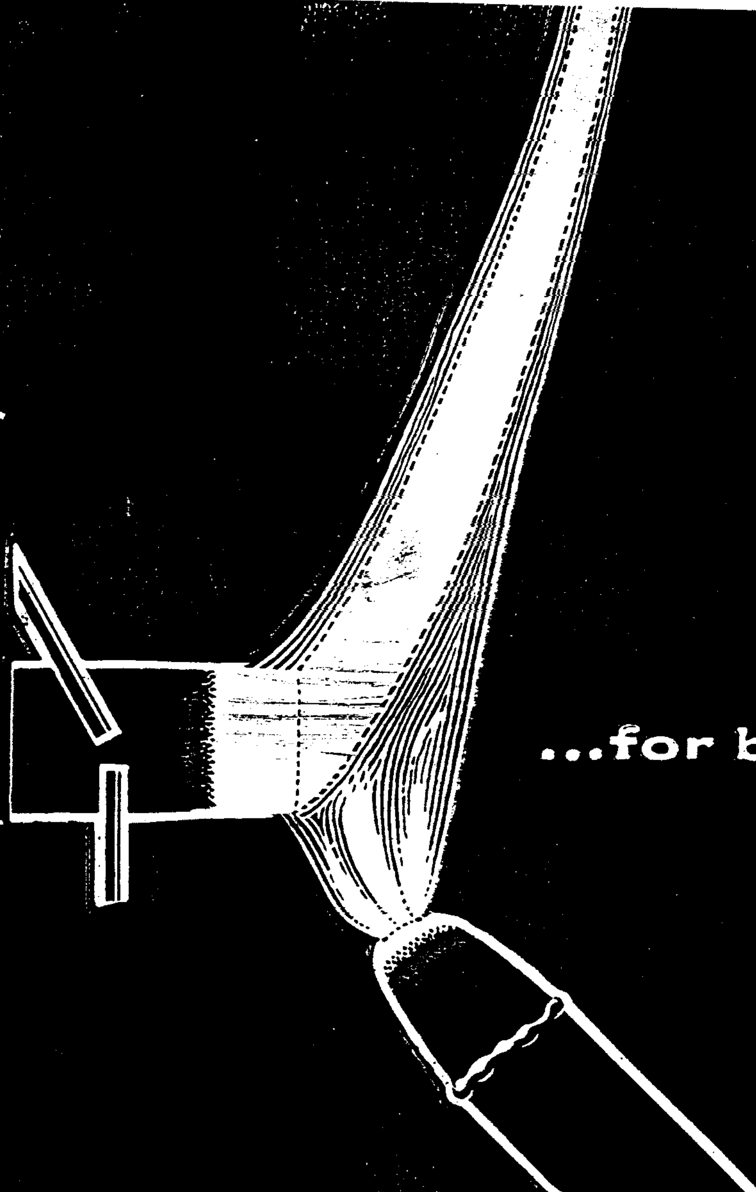
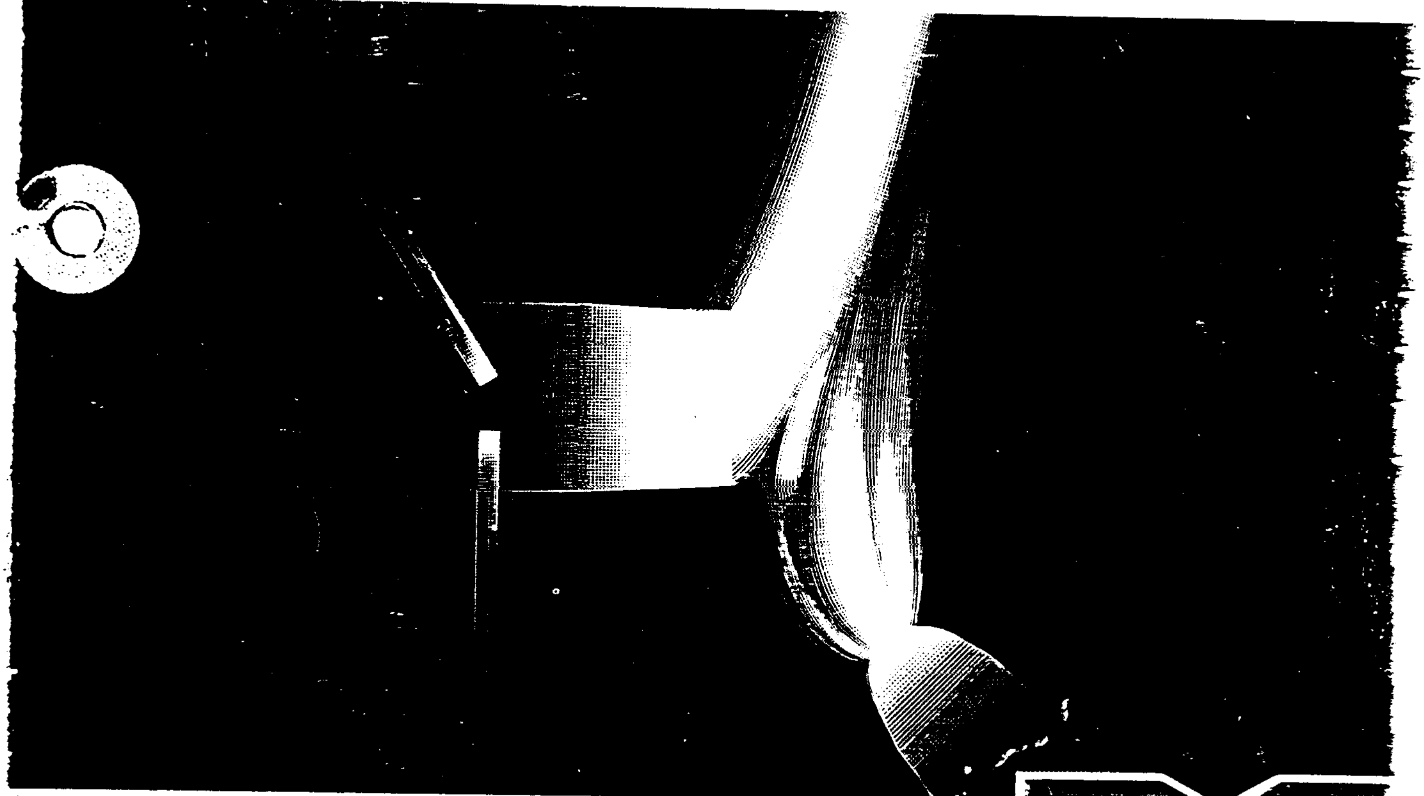
Film-Tech



...for brighter screens

TRADE-MARK

PROJECTOR CARBON BULLETINS



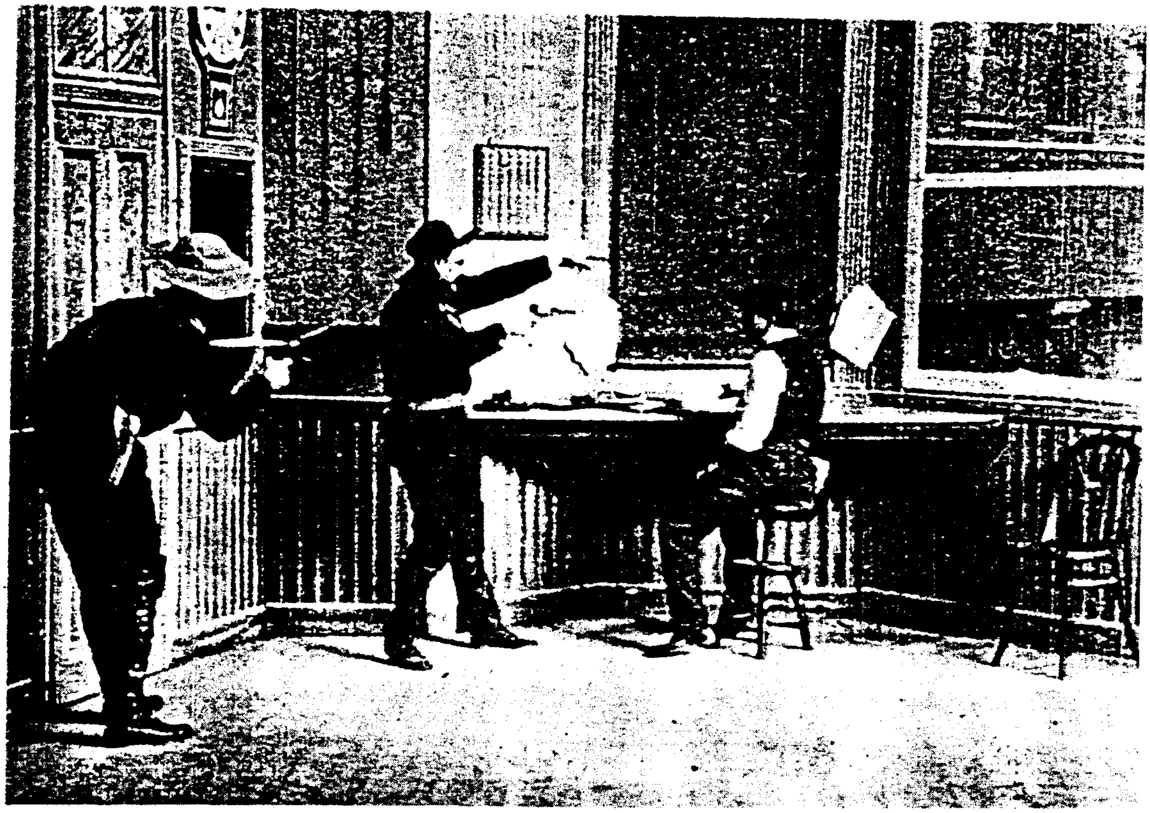
The Carbon Arc

NATIONAL
TRADE MARK
I.
Projector Carbons

This is the first of a series of bulletins prepared to help projectionists get the most efficient operation and the finest screen light obtainable.

Recent developments in the motion picture field—outdoor theatre screens of unprecedented size and distance from the projector, wide-screen systems of photography—increase the demand for maximum projection light. NATIONAL CARBON has new and more powerful carbons to meet these demands.

The fourth edition of the Projector Carbon Handbook, published by National Carbon Company in 1948, contained information on the amount of screen illumination obtainable at that time with the combinations of lamps, optical systems and carbons then available. Although the principles of Projector Carbon operation remain unchanged, there is definite need for the up-to-date information to be contained in this series of bulletins. They are to be issued at periodic intervals. When the complete series has been retained in the binder provided, it will prove an invaluable source of data.



Over 50 years ago, this picture presented the first complete dramatic film story.

It started with "The Great Train Robbery"

Your job . . . and ours

The occupation of motion picture projectionist began when a light source was coupled to a projector for "screen projection for an audience of many people."

The first movies were illuminated by a block of calcite. This method had short life and soon gave way to the carbon arc, which, for over fifty years and until this day, is the most powerful light to "pass through the eye of the needle". . . the projector aperture.

* * *

The years brought these developments:

- Talkies added a sound track.
- Color increased film density.
- Congested cities built the drive-in.
- Television's threat brought the wide screen.

Each development was a unique challenge:

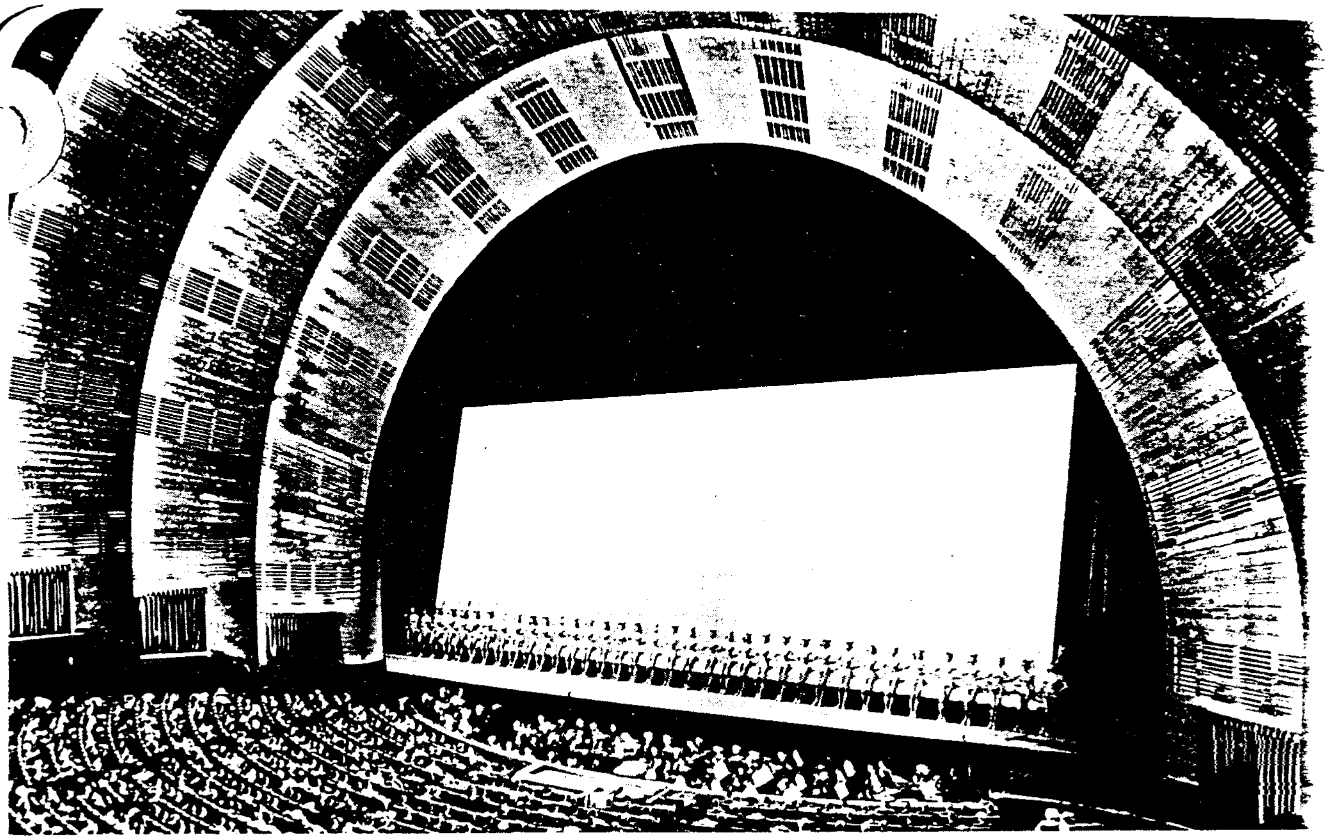
- Eliminate arc noises in studio lamps!
- Light a scene and project the light through color film that has only one-tenth the speed of black-and-white!
- Match the color balance of the sun!
- Illuminate a screen 150 feet wide!
- Throw a beam over 400 feet long!

The carbon arc won handily.

* * *

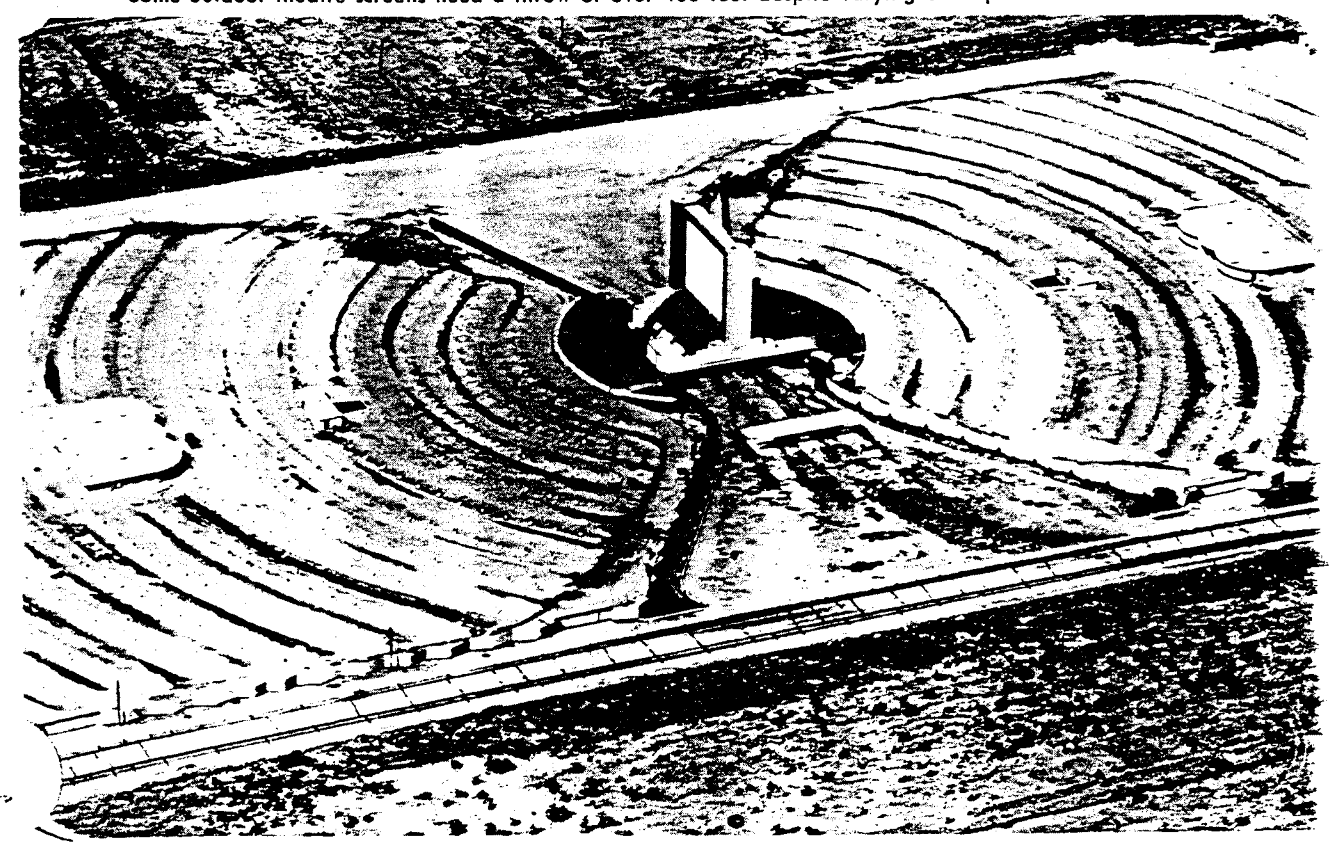
With the range of arcs now available, every theatre, regardless of screen size or projection system, can have light of a very high quality at reasonable cost. Moreover, the light on the screen can be varied in intensity at the will of the projectionist.

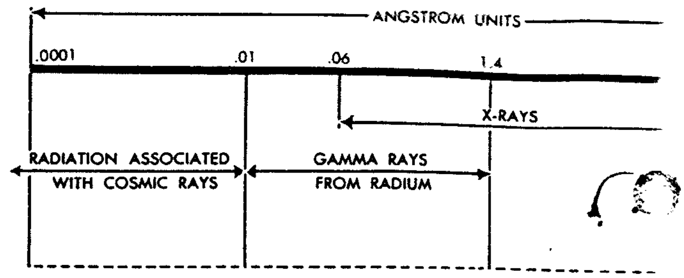
But up-to-date know-how is needed. Who knows when the industry will turn another corner or be asked to take another giant step? If we all keep abreast of today's advancements, it will not be difficult.



The carbon arc meets the challenge of wide-screen illumination at Radio City Music Hall.

Some outdoor theatre screens need a throw of over 400 feet despite varying atmospheric conditions.





Relation of Visual Spectrum to the Radiation Spectrum.

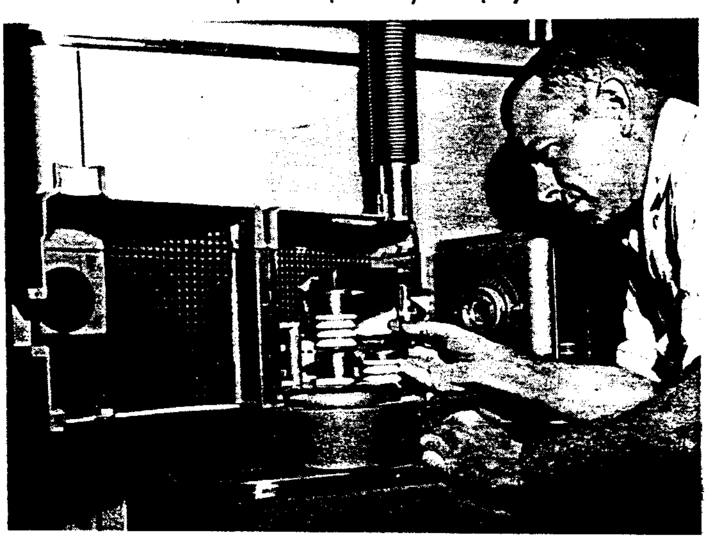
The Carbon Arc

The carbon arc is capable of delivering the highest candlepower per unit area (brightness) of any known artificial light source, surpassing even that of the sun. It also provides a color quality matching that of sunlight. These two characteristics of the arc are largely responsible for its adaptation to motion picture projection, to spot and flood lighting in theatres, and to motion picture studio lighting where the light from the arc can be perfectly matched with film sensitivity.

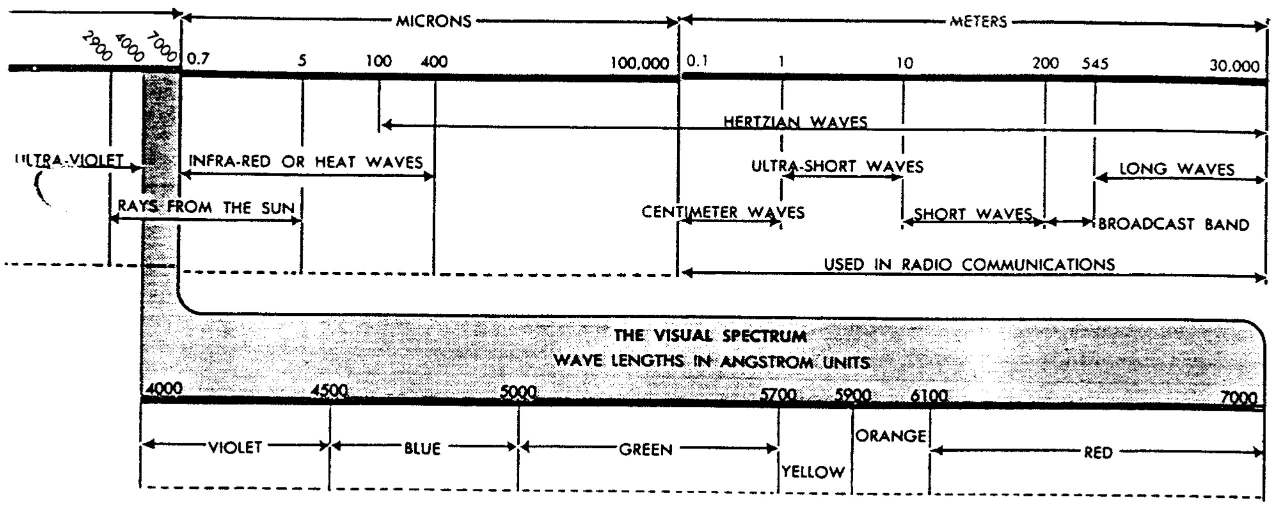
Not only is the carbon arc the most powerful source of artificial light—it is also the most versatile. High intensity arcs, ranging in capacity from less than one kilowatt to as much as 13.5 kilowatts, have been standardized for projection purposes. High intensity studio arcs of 17 kilowatts capacity are common. Experimental arcs of much greater power await only the design of equipment to use them. Such power, concentrated in carbons varying in diameter from only 6mm (¼″) to 16mm (⅝″ plus), generates a light source of extremely high brilliancy that can be easily focused and readily adapted to optical systems requiring a highly concentrated source of radiation. Cored with compounds of rare earths, these carbons produce a snow-white light of daylight quality that is ideal for the projection of color as well as black-and-white film.

The first commercial application of carbon on an extensive scale was in the electric arc lamp. The singular characteristics of carbon make possible a quality and intensity of illumination which can-

Spectroscopic analysis employs the carbon arc.



Hollywood première searchlights use carbon arcs.



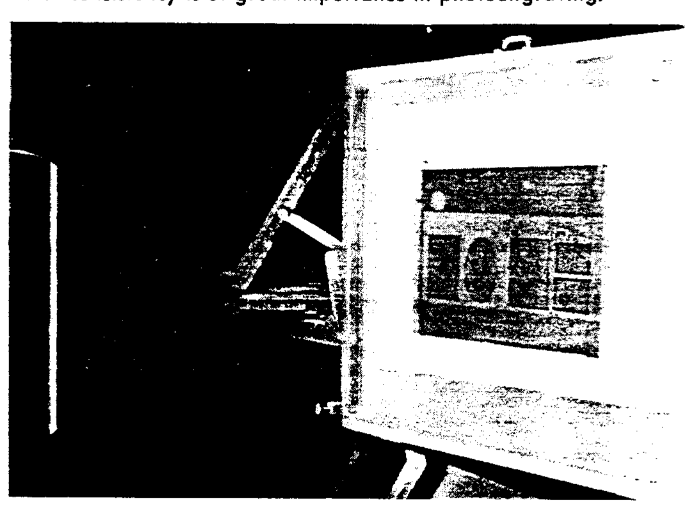
not be obtained in any other way. Carbon has good electrical conductivity; it is non-melting and slow burning at the extreme temperature of the arc; it remains a firm solid at a temperature higher than that attainable by any other substance of suitable electrical conductivity.

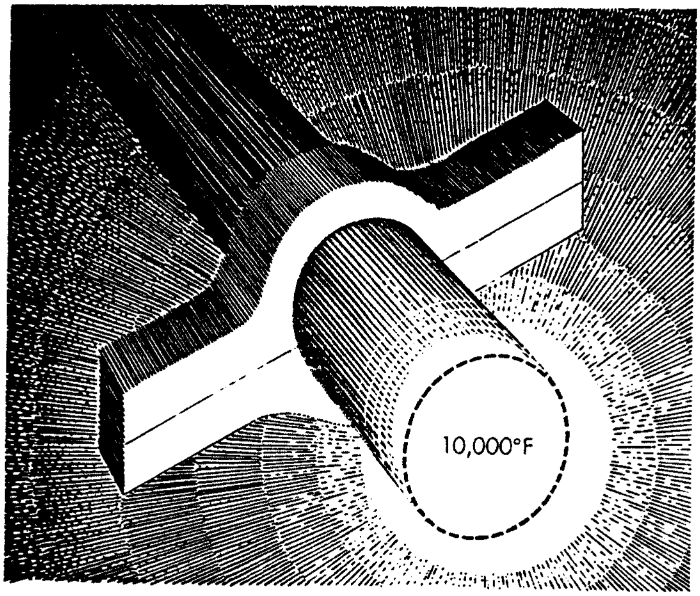
The development of new types of carbon arcs for special applications greatly extended their use in fields where marked superiority over other sources of illumination is shown. For example, carbon and graphite electrodes exceeding even the diamond in purity are used to spark samples for spectroscopic analysis. In hospitals and sanatoria the carbon arc is used to produce artificial sunlight and radiation of specialized character which physicians have found valuable in the prevention and cure of certain physical disorders. The carbon arc is an important tool for processing materials by means of photochemical reactions and for accelerated tests of materials which tend to deteriorate under the action of sunlight. The most powerful searchlights utilize highly developed types of carbon arc lamps with carbons designed for this specific purpose. Thousands of carbon arcs are in daily use in photography, photoengraving, photolithography, blueprinting and other industrial processes.

Motion picture projection would never have reached and could not maintain its present high place without the aid of the carbon arc. The increasingly larger screens, long projection throws and the demands for higher levels of screen illumination in both indoor and drive-in theatres—where screens may be 150 feet wide, or even more—require an intensity in the light source that only the carbon arc can supply. The brightness of the positive carbon crater may be as much as seven million times the brilliancy of the screen.

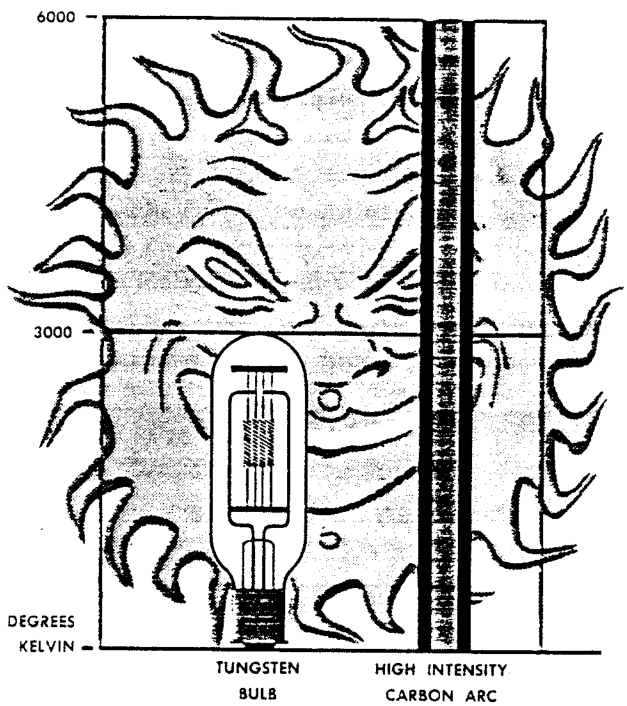
Carbon arc radiation in a dye fading unit.

Color consistency is of great importance in photoengraving.



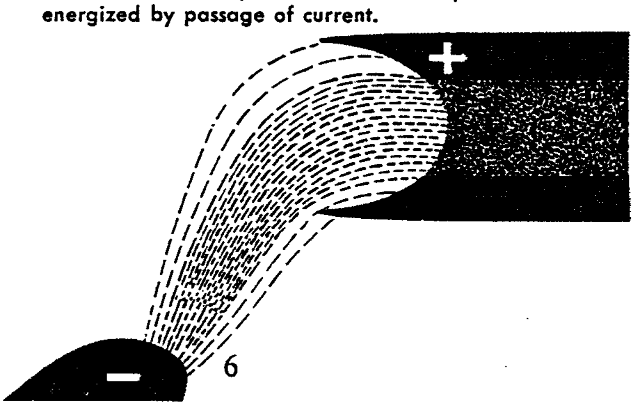


10,000°F at the crater must decrease to 2000°F at the jaws, only a short distance away.



In a comparison of color temperature, the high intensity arc equals the sun in degrees Kelvin.

The rare-earth-compound core of the positive carbon is energized by passage of current.



The demands made upon projector carbons are extremely severe and the present high quality of "National" Projector Carbons has only been attained by painstaking research and years of manufacturing experience. Great care is necessary in selecting raw materials and in maintaining close control over every step in the six to eight weeks required for manufacture.

Projector carbons must conduct electricity at very high current densities, ranging from 140 to 1500 amperes per square inch. They must achieve a very high concentration of energy in the gas ball confined within the positive crater, at the same time supplying volatilized material to maintain this gas ball as an efficient radiator of light. Only carbon can satisfy these requirements—with the cup-shaped crater surrounding a ball of fire at a temperature in excess of 10,000°F and with the carbons gripped only a short distance away by metal jaws, the temperature of which cannot safely exceed 2000°F.

Constant research is necessary to produce new types of carbons and ways of using them which will meet or anticipate the demands created by the steady progress of the motion picture industry.

Physics of the High Intensity Carbon Arc

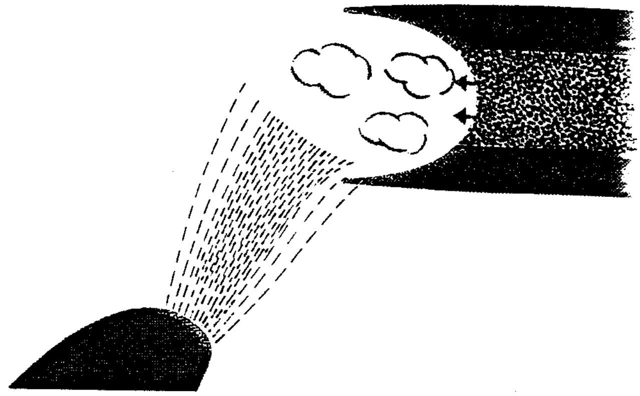
The high intensity carbon arc is such a commonplace and generally useful light source in projection applications that little thought ordinarily is given to the physical processes involved in the operation of such a source. Some of the concepts found useful in the laboratory for the development of new and brighter carbons may be of interest to the users of such carbons.

Incandescent carbon has a volatilization temperature of over 6500°F (3600°C). Since a temperature of only 2600-2900°F (1425-1595°C) is enough to produce "white heat", incandescent carbon is responsible for part of the brightness of the carbon arc crater; for all of it, as a matter of fact, in the low intensity carbon arc.

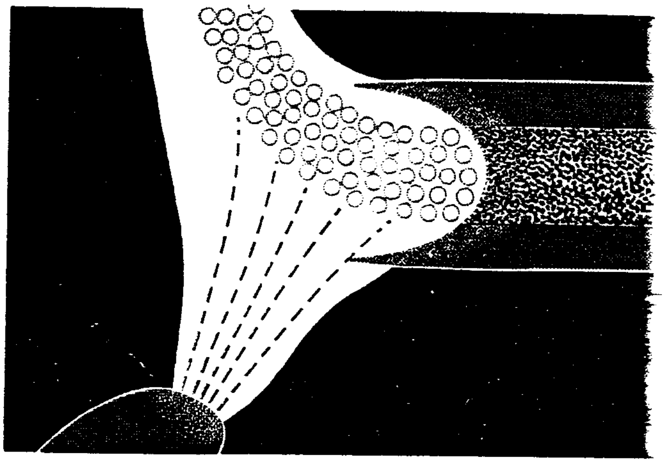
The brightness of the high intensity arc is the result of the combination of a high current density, i.e., a high concentration of electrons in the arc stream, and an atmosphere in the positive crater region rich in "flame materials" volatilized from the special coring of the positive electrode. These flame materials are in most cases compounds of the cerium group of rare-earth metals, combined in a mixture with carbon in the core. As the carbon burns (forming a crater), the core is exposed to the extreme arc temperature and is "vaporized" into the crater enclosure. Part of the core material leaves the crater floor as a gas, while the rest is released in the form of small particles of molten core material.

The rare-earth atoms in the gas are bombarded by electrons to produce very intense light. It is helpful here to picture a maelstrom in the positive crater, with many billions of rare-earth atoms continually colliding with each other and with electrons. As the result of such collisions, a rare-earth atom absorbs energy and is transformed into an "excited" state. In other words, the excited atom possesses energy in excess of the normal stable amount.

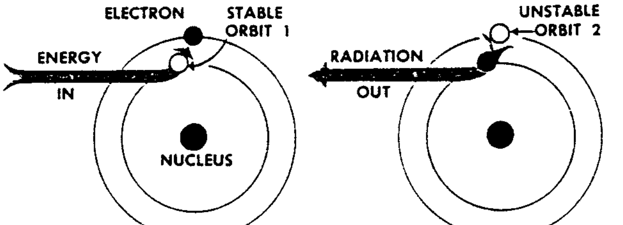
The rare-earth atoms have many electrons (cerium has 58, circulating in 14 different orbits) so that the likelihood of scoring a hit on such a large, well-populated target is correspondingly increased. At the same time, there are a great many excited states possible, so that the likelihood is excellent that a hit will produce excitation. Since the rare-earth atoms are not stable in these excited states, they immediately give up their excess energy. This they do in the form of pulses of radiation, each having a particular wavelength associated with the amount of energy radiated. An excited atom may return to a normal energy level in one or more discrete steps, radiating pulses characteristic



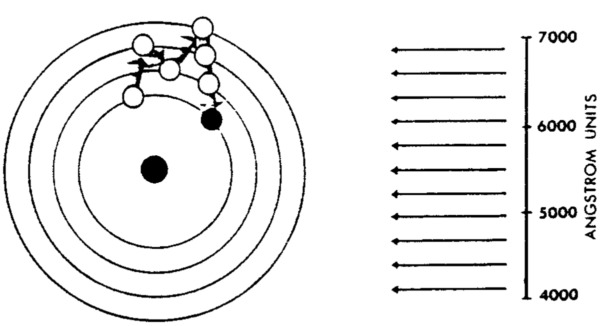
These compounds, rich in flame materials, are volatilized in the crater.



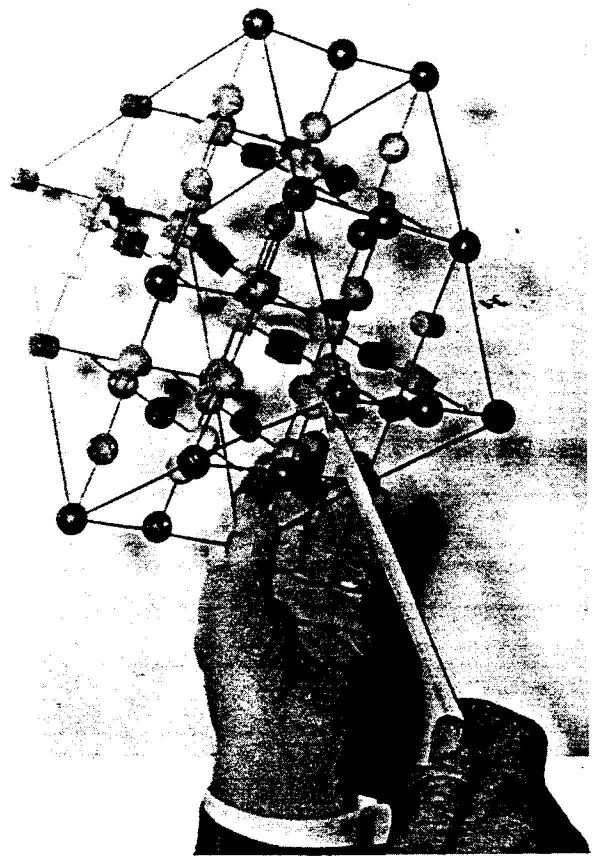
The excited rare-earth atoms emit their unstable energy as visible light of different wavelengths.



In a simple hydrogen atom: (left) an input of energy causes the electron to revolve in a wider, but unstable orbit. (right) The electron quickly returns to its stable orbit losing its energy as radiated light.

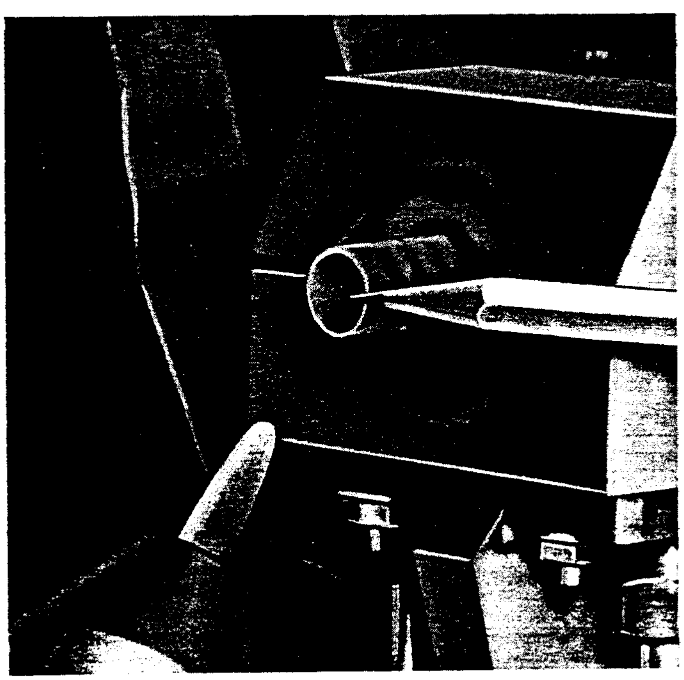


(Left) The atoms are thus constantly absorbing and emitting energy. (right) A rare-earth atom, with many electrons, emits many wavelengths, thus produces a white light.



Laboratory research in the fields of nuclear and solid state physics provides more light on theatre screens.

The crater shape is a function of current flow.



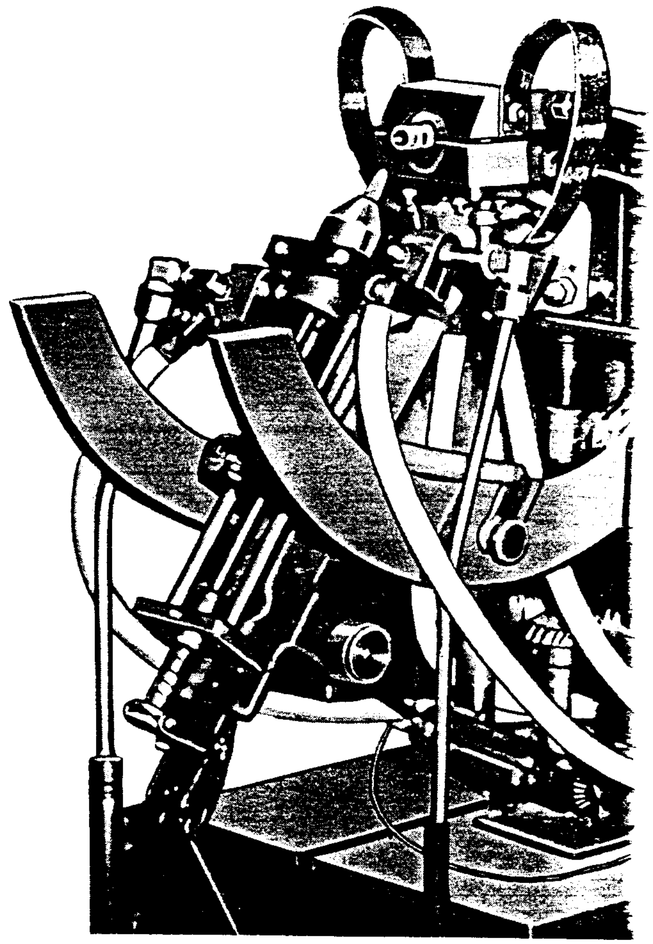
of the energy change in each step. It is a property of the rare-earth atoms that these energy pulses are distributed in great numbers over the range of visual sensitivity, thereby furnishing their share to the brightness of the crater region. The molten particles released into the crater are very hot, perhaps as high as 10,000°F. At such high temperatures these incandescent particles radiate energy at all wavelengths throughout the visible region and also contribute to the high crater brightness. The combination of the atomic and particle radiation processes produces essentially an equal energy spectrum or a "white light". In this way, the brightness of the high intensity carbon arc crater is increased many-fold over that of the plain carbon arc (to more than ten times in the laboratory).

Because the path of least electrical resistance is from the negative carbon to the core, rather than to the shell, of the positive carbon, most of the electrons forming the high current in the arc stream travel to the central core. Here the concentration of energy is so great that the core and the immediately surrounding shell are vaporized faster than the shell at the outside. Thus, a cup or crater is formed on the end of the positive carbon, which is filled with the rich light-producing mixture of rare-earth vapors and electrons. As the current is increased, the depth of this crater likewise increases to a limiting value determined by what is called the "overload" of the carbon. Overload is characterized by the fact that beyond a particular current value the arc no longer burns smoothly and quietly, but becomes unsteady and noisy. Since, for all important uses, the arc must be both stable and quiet, operation is always confined to currents below this overload value.

The maximum current which a given carbon will carry with stable operation is dependent to a significant degree upon the method of burning. For instance, the use of water-cooled positive jaws in combination with specially designed carbons provides better heat dissipation and permits the use of substantially higher currents, and the achievement of correspondingly higher brilliancies. In addition, "blowing" of the arc surrounds the positive crater with a definite directive force for the arc flame, which offers advantages in regard to stabilization and current efficiency of the arc.

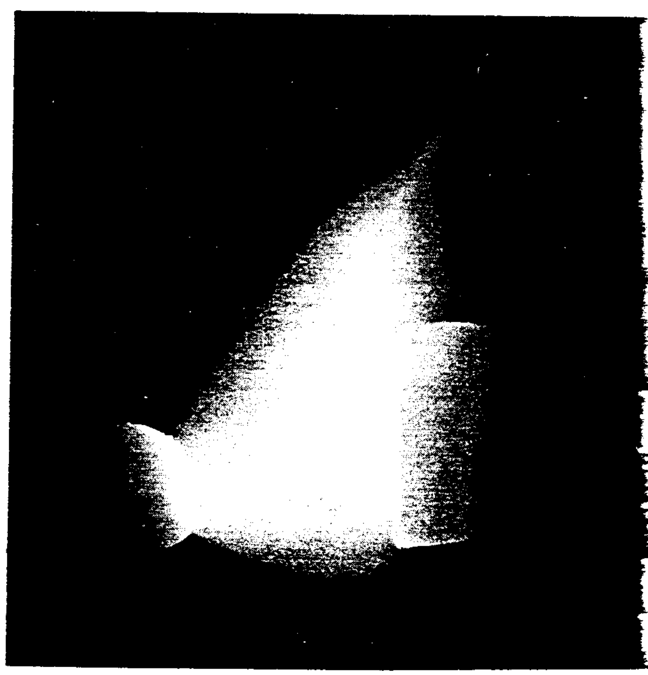
The cover illustration shows a typical high intensity carbon arc, and can now be viewed with a better understanding of what is going on. From the incandescent tip of the negative carbon underneath, countless numbers of electrons are being drawn out into the arc stream and accelerated like bullets toward the positive electrode by the voltage gradient along the arc stream. To make enough electrons available, i.e., 63 followed by 17 zeros (6300000000000000000) electrons per second for each ampere, the negative tip must be heated to a very high temperature; hence, the bright tip and red heat-back of this electrode. These electrons rush across the arc stream, meeting mostly air atoms until they approach the region of the positive carbon, a violet-bluish light resulting from collisions with the air atoms in the arc stream. At the crater region, and particularly inside it, the electron stream encounters the rare-earth atmosphere, with a resultant production of brilliant white light. Under the influence of magnetic field and of convection currents, a bright stream of rare-earth material emerges from the crater and moves upward into the tail flame.

Although the description here is of an angular trim, rotating positive carbon type of high intensity arc, essentially the same phenomena occur in the operation of the co-axial trim, non-rotating, copper-coated positive carbon arc, commonly known as the "Suprex" carbon arc. At right is an illustration of this type of arc.



Research is constantly under way for the improvement of carbon arc light sources.

The co-axial trim, non-rotating, high intensity "Suprex" carbon arc.



NATIONAL Projector Carbons, Types and Sizes

Here is the full list of types and sizes of "National" Projector Carbons. In addition, the proper arc amperages and voltages are given. Since a trim produces maximum light at its top recommended current, it is a good practice to check the amperage and voltage of your trim against those shown in the table.

LAMP TYPES	CATALOG NUMBER	TRIM	ARC AMPS.	ARC VOLTS
"ONE KILOWATT" A.C. LAMPS	L 0503	7mm x 12" "Suprex" (Both holders)......	52 59 66	18 20.5 22
	L 0506	7mm x 14" "Suprex" (Both holders)......	52 59 66	18 20.5 22
"ONE KILOWATT" D.C. LAMPS	L 0503 L 0563	7mm x 12" "Suprex" Pos................ 6mm x 9" "Orotip" C Neg..............	40	27.5
	L 0506 L 0563	7mm x 14" "Suprex" Pos................ 6mm x 9" "Orotip" C Neg..............	40	27.5
SIMPLIFIED HIGH INTENSITY D.C. LAMPS	L 0521 L 0563	7mm x 12" "Suprex" Pos................ 6mm x 9" "Orotip" C Neg..............	42	36
	L 0521 L 0563	7mm x 12" "Suprex" Pos................ 6mm x 9" "Orotip" C Neg..............	45	37
	L 0521 L 0563	7mm x 12" "Suprex" Pos................ 6mm x 9" "Orotip" C Neg..............	50	40
	L 0525 L 0563	7mm x 14" "Suprex" Pos................ 6mm x 9" "Orotip" C Neg..............	42	36
	L 0525 L 0563	7mm x 14" "Suprex" Pos................ 6mm x 9" "Orotip" C Neg..............	45	37
	L 0525 L 0563	7mm x 14" "Suprex" Pos................ 6mm x 9" "Orotip" C Neg..............	50	40
	L 0509 L 0566	8mm x 12" "Suprex" Pos................ 7mm x 9" "Orotip" C Neg..............	60	39
	L 0509 L 0566	8mm x 12" "Suprex" Pos................ 7mm x 9" "Orotip" C Neg..............	70	42
	L 0512 L 0566	8mm x 14" "Suprex" Pos................ 7mm x 9" "Orotip" C Neg..............	60	39
	L 0512 L 0566	8mm x 14" "Suprex" Pos................ 7mm x 9" "Orotip" C Neg..............	65	41
	L 0512 L 0566	8mm x 14" "Suprex" Pos................ 7mm x 9" "Orotip" C Neg..............	70	42
	L 0515 L 0569	9mm x 14" "Suprex" Pos................ 8mm x 9" "Orotip" C Neg..............	65	40
	L 0515 L 0569	9mm x 14" "Suprex" Pos................ 8mm x 9" "Orotip" C Neg..............	75	43
	L 0515 L 0569	9mm x 14" "Suprex" Pos................ 8mm x 9" "Orotip" C Neg..............	80	45

LAMP TYPES	CATALOG NUMBER	TRIM	ARC AMPS.	ARC VOLTS
HIGH INTENSITY REFLECTOR TYPE LAMPS (Rotating)	L 0100	9mm x 17½″ H.I. Projector Pos..........	75	44
	L 0569	8mm x 9″ "Orotip" C Neg..............		
	L 0100	9mm x 17½″ H.I. Projector Pos..........	80	45
	L 0569	8mm x 9″ "Orotip" C Neg..............		
	L 0103	9mm x 20″ H.I. Projector Pos............	75	52
	L 1106	5/16″ x 9″ "Orotip" Cored Neg..........		
	L 0103	9mm x 20″ H.I. Projector Pos............	85	58
	L 1106	5/16″ x 9″ "Orotip" Cored Neg..........		
	L 0106	10mm x 20″ H.I. Projector Pos...........	95	52-57
	L 1115	11/32″ x 9″ "Orotip" Cored Neg.........		
	L 0106	10mm x 20″ H.I. Projector Pos...........	110	60-65
	L 1115	11/32″ x 9″ "Orotip" Cored Neg.........		
	L 0109	11mm x 20″ H.I. Projector Pos...........	110	58-62
	L 1124	3/8″ x 9″ "Orotip" Cored Neg...........		
	L 0109	11mm x 20″ H.I. Projector Pos...........	120	64-68
	L 1124	3/8″ x 9″ "Orotip" Cored Neg...........		
	L 0170	10mm x 20″ "Hitex" Super H.I. Pos......	125	60-64
	L 1130	7/16″ x 9″ "Orotip" Cored Neg..........		
	L 0170	10mm x 20″ "Hitex" Super H.I. Pos......	135	66-70
	L 1139	½″ x 9″ "Orotip" Cored Neg............		
	L 0112	13.6mm x 18″ H.I. Projector Pos.........	135-160	*
	L 1132	7/16″ x 9″ Special "Orotip" Cored Neg...		
	L 0114	13.6mm x 20″ H.I. Projector Pos........	125-135	*
	L 1130	7/16 x 9″ "Orotip" Cored		
	L 0114	13.6mm x 20″ H.I. Projector Pos........	135-160	*
	L 1139	½″ x 9″ "Orotip" Cored or } Neg. ..		
	L 1132	7/16″x9″Special"Orotip"Cored }		

**Data can be obtained from lamp manufacturer*

LAMP TYPES	CATALOG NUMBER	TRIM	ARC AMPS.	ARC VOLTS
HIGH INTENSITY CONDENSER TYPE LAMPS (Rotating)	L 0115	13.6mm x 22″ H.I. Projector Pos.........	125	68
	L 1130	7/16″ x 9″ "Orotip" Cored Neg..........		
	L 0115	13.6mm x 22″ H.I. Projector Pos.........	150	74
	L 1139	½″ x 9″ "Orotip" Cored Neg............		
	L 0115	13.6mm x 22″ H.I. Projector Pos.........	160	77
	L 1139	½″ x 9″ "Orotip" Cored Neg............		
	L 0175	13.6mm x 22″ "Hitex" Super H.I. Pos....	170	70
	L 1142	½″ x 9″ H.D. "Orotip" Cored Neg.......		
	L 0175	13.6mm x 22″ "Hitex" Super H.I. Pos....	180	74
	L 1142	½″ x 9″ H.D. "Orotip" Cored Neg.......		

LAMP TYPES	CATALOG NUMBER	TRIM	ARC AMPS.	ARC VOLTS
LOW INTENSITY D.C. REFLECTOR TYPE LAMPS	L 0921	10mm x 8″ Cored Pos..................	20	55
	L 0903	7mm x 8″ Solid or } Neg...............		
	L 0906	7mm x 8″ Cored }		

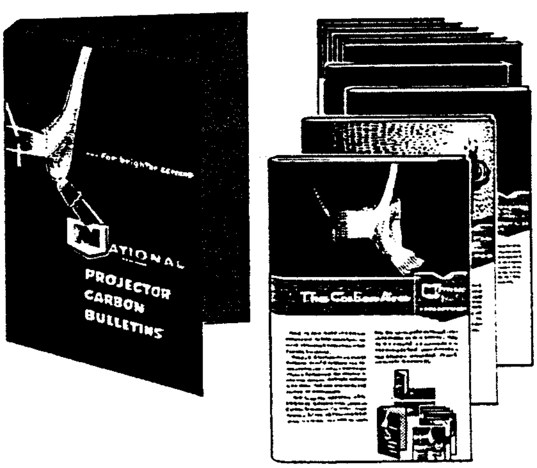
(*continued on page 12*)

LAMP TYPES (*continued*)	CATALOG NUMBER	TRIM	ARC AMPS.	ARC VOLTS
LOW INTENSITY D.C. REFLECTOR TYPE LAMPS	L 0924	12mm x 8″ Cored Pos....................	25	55
	L 0909 L 0912	8mm x 8″ Solid or 8mm x 8″ Cored } Neg................		
	L 0924	12mm x 8″ Cored Pos....................	32	55
	L 0912	8mm x 8″ Cored Neg..................		
	L 0927	13mm x 8″ Cored Pos....................	32	55
	L 0918	9mm x 8″ Cored Neg..................		
	L 0927	13mm x 8″ Cored Pos....................	42	55
	L 0918	9mm x 8″ Cored Neg..................		

An Invitation . . .

The discussions in the "National" Projector Carbon Bulletins will be as comprehensive as possible. If you have an individual problem of carbon arc projection which is not included, please contact the Sales Office of National Carbon Company nearest you.

New York 17, New York.............292 Madison Avenue................MUrray Hill 6-1700
Pittsburgh 22, Pa.............The Oliver Building, Mellon Square..............EXpress 1-3800
Atlanta 3, Georgia..................41 Marietta St., N.W....................MUrray 8-7700
Kansas City, Mo..................910 Baltimore Avenue.................BAltimore 1-2400
Chicago 1, Illinois..................230 N. Michigan Avenue..................FInancial 6-3300
Dallas 1, Texas.....................1511 Bryan Street....................RIverside 1-9176
San Francisco 6, Calif..................22 Battery Street.......................YUkon 2-1360
Los Angeles 58, Calif..................2770 Leonis Blvd.................. LUdlow 3-3061



You will receive . . .

the next Projector Carbon Bulletin three months hence. It will deal with: *Terms—Light Sources and Screen Illumination.*

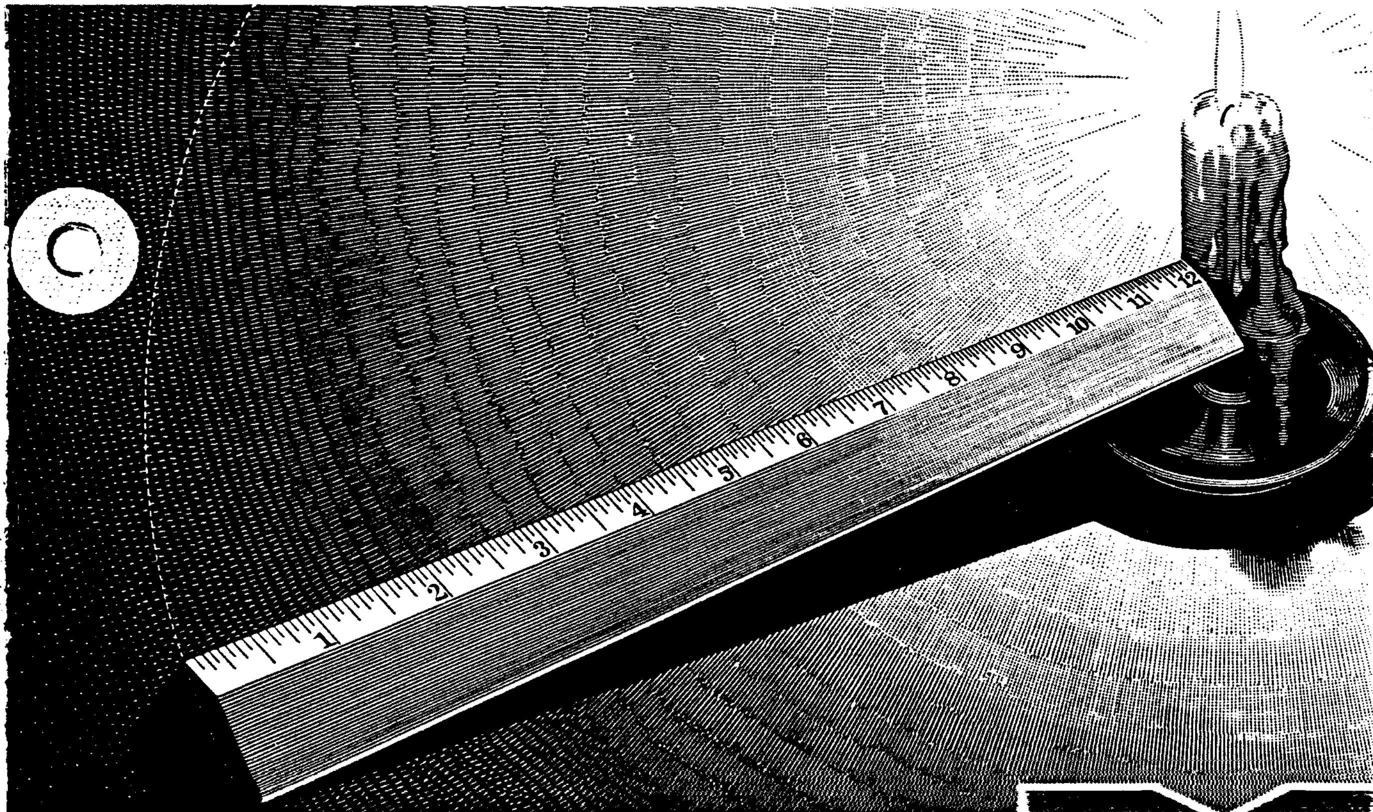
Keep this issue . . .

in the binder sent to you with our compliments. By keeping all the issues, you will have at your finger-tips a concise and highly efficient tool for helping you put more light on your screen at less cost.

UNION CARBIDE

NATIONAL CARBON COMPANY
Division of Union Carbide Corporation
30 East 42nd Street, New York 17, N.Y.

LITHO IN U.S.A.



Terms...Light Sources and Screen Illumination

NATIONAL
TRADE MARK
2.
Projector Carbons

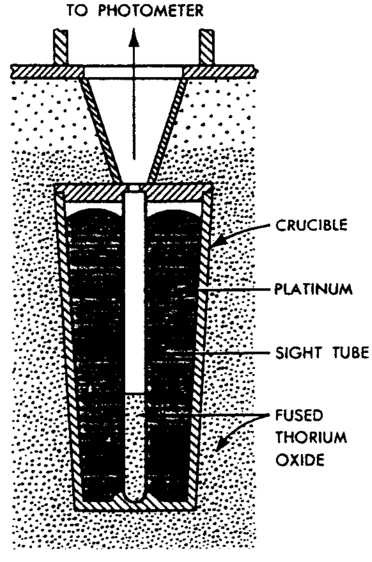
A better understanding of the application and operation of projector carbons with respect to brightness of light source and screen illumination may lie in a comprehension of the way light is measured and some of the terms in general use.

The terms "candle", "candlepower", "lumen", "foot-candle", and "foot-lambert" are conventionally employed as units of measurement of light. The following explanations are based on their application to motion picture projection.

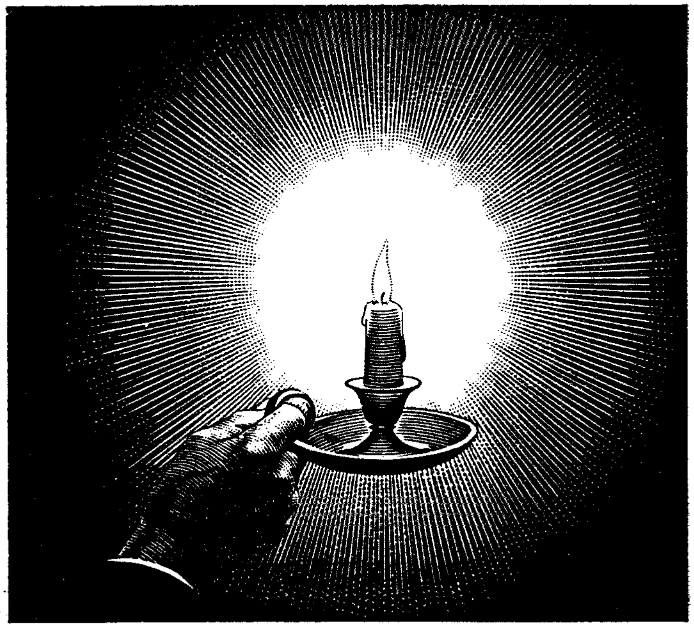
Candle

. . . this is the fundamental unit of light intensity and is a measure of the ability of a source to radiate light. A source is said to have an intensity of *one candle* if it is capable of illuminating an object at a given distance to the same degree as would a standard candle. The standard candle was originally defined in terms of the open flame of a ⅞" sperm candle burning at a specified rate.

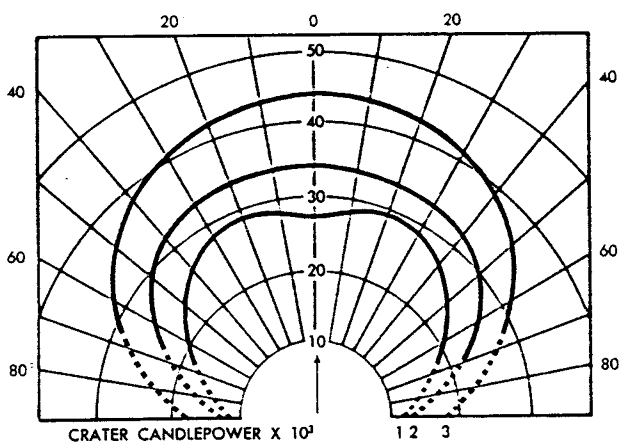
Later, a group of carbon filament lamps were preserved at the National Bureau of Standards. In 1948 these were replaced by a very accurate method based on the solidifying temperature of molten platinum.



Heated by induction, the molten platinum causes the sight tube to glow.



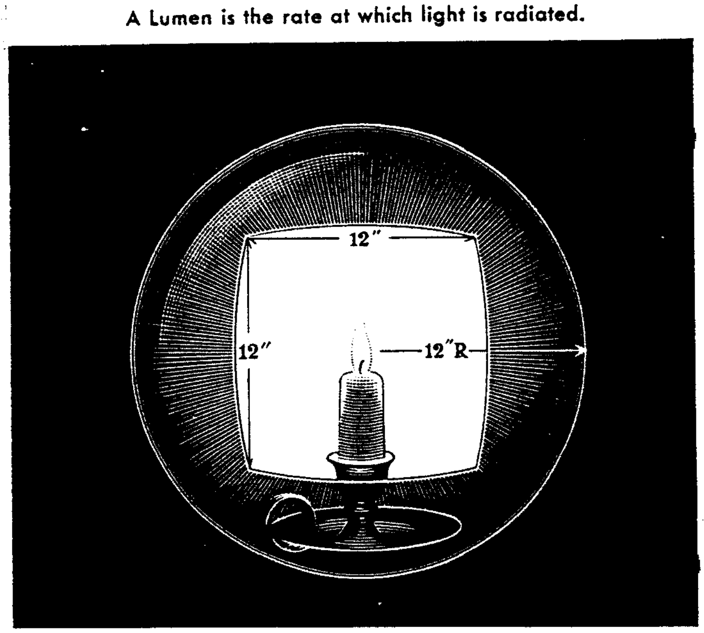
Candlepower is the light intensity of a source.



Light distribution from arc in horizontal plane

1— 9mm x 20" H.I. Projector Positive at 85 amperes
2—10mm x 20" H.I. Projector Positive at 105 amperes
3—11mm x 20" H.I. Projector Positive at 120 amperes

A Lumen is the rate at which light is radiated.



Candlepower

. . . this is the light intensity of a source, expressed in "candles". Thus, it is proper to state that a particular carbon arc has a "candlepower" of 80,000 candles. Particularly with carbon arcs, which emit light in one hemisphere ahead of the crater, the light intensity (or candlepower) varies with the direction of view. It is therefore common to further specify the candlepower with respect to the direction, such as "*horizontal candlepower*", "*axial candlepower*", "*forward candlepower*", etc. Candlepower values can be specified for any direction or angle from which the light source is viewed. Candlepower is the measure of the light-emitting power of a source, without regard to its *area*.

Brightness

. . . is the measure of the light-emitting power of a source in relation to its area. It is expressed in "*candles per unit area*". Obviously, two sources can be of the same candlepower while differing in size. The smaller of the two is then said to be "brighter". The square millimeter (0.00155 sq. in.) has been chosen as the unit area for expressing the brightness values of the carbon arcs described here. *Candlepower* (total light-emitting power of a source) and *brightness* (light-emitting power per unit of area), when measured in all directions, together comprise complete specification of a light source.

Lumen

. . . is the measure of the *rate* at which light pulses are emitted or received. A lumen is the rate at which light is radiated from a source of one candlepower to an area of one square foot, so located that all points of the area are one foot from the source. If a source of one candlepower in all directions is enclosed at the center of a sphere of one foot radius, each square foot area of the sphere will receive light pulses at the rate of one lumen. The lumen is thus a measure of *light flow*, just as, in electrical units, the ampere is a measure of the rate of *current* flow.

Foot-Candle

. . . measures the rate at which light pulses fall on a surface of any area, all points of which are located a distance of one foot from a source of one candlepower. If this surface is one square foot, it receives light pulses at the rate of one lumen. Thus, the illumination in foot-candles, multiplied by the area in square feet of the object, gives the total lumens over that area.

Foot-Lambert

. . . is the unit of "brightness" ordinarily used to define the amount of light per unit area *reflected* from the screen. A perfectly diffusing surface reflecting light at the rate of one lumen per square foot is said to have a brightness of one foot-lambert in all directions.

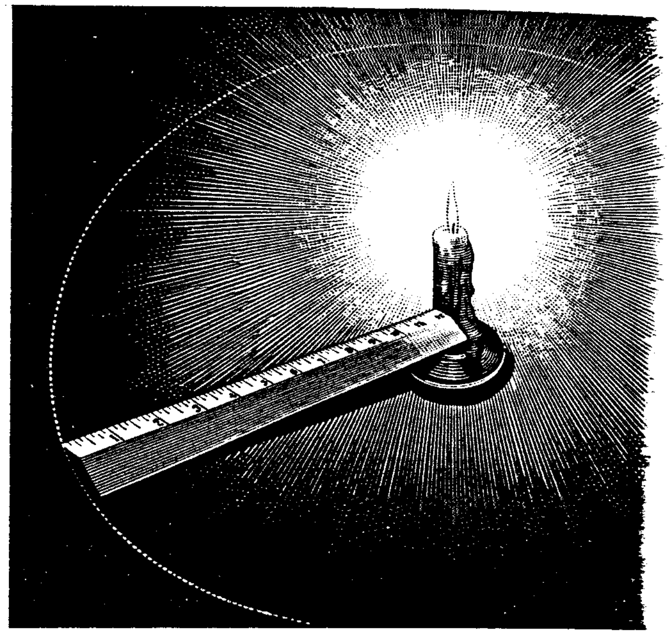
Overall Reflectivity

. . . is the ratio of the total light reflected n *all* directions by the screen to that incident on the screen. This value will always be less than 100%.

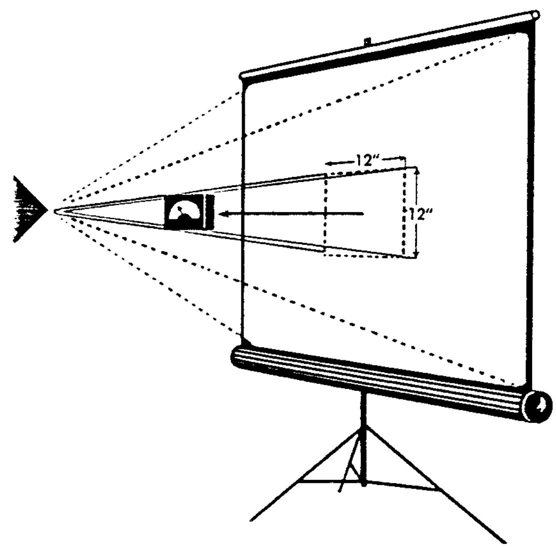
Apparent Reflectivity

. . . is the ratio of the brightness in foot-lamberts to the intensity of the light delivered to the screen in foot-candles. For near-perfect diffusing surfaces (such as flat white screens) this value will approximate that of the overall reflectivity, expressed as a ratio of the same units. Directional screens, which concentrate the incident light within one viewing range, may have an apparent reflectivity of 200% or 300% in one direction and fall far below 100% in others.

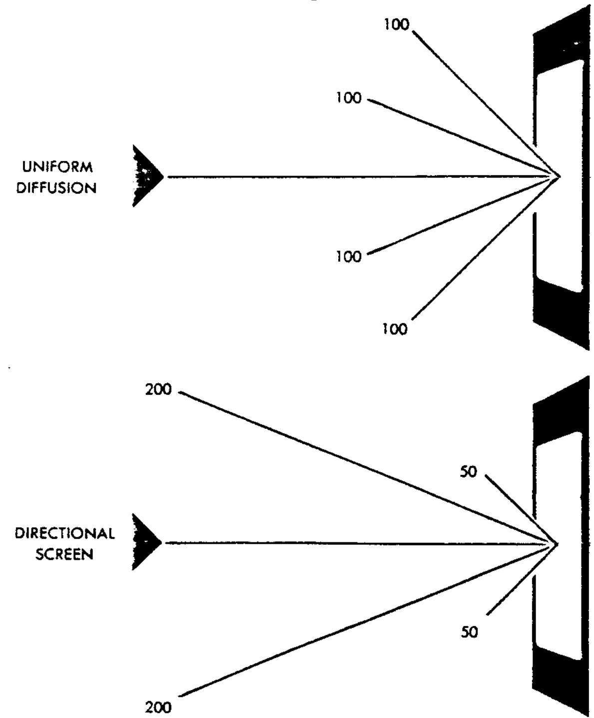
"Foot-candles" and "lumens" are the units commonly used to express values of the projected (incident) light on motion picture screens. Screen light is frequently expressed in *incident lumens*—the total useful light output of the carbon arc lamp and projector mechanism.

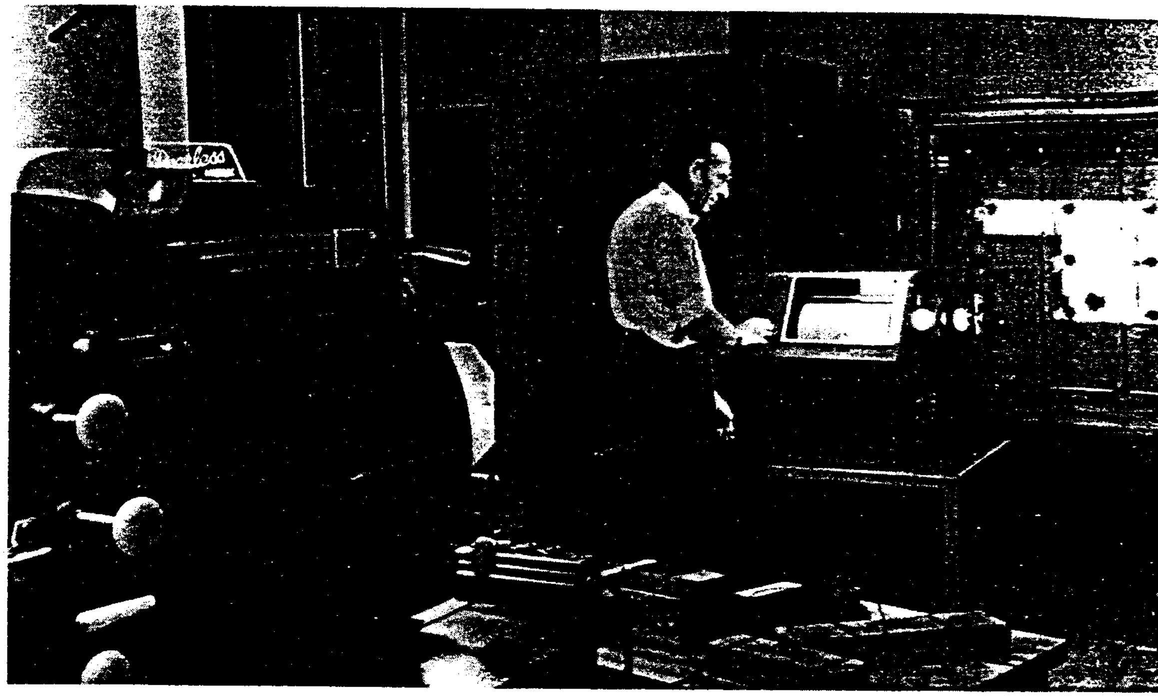


Foot-candle is the rate at which light pulses fall on a surface.



Foot-lambert is the amount of light reflected.





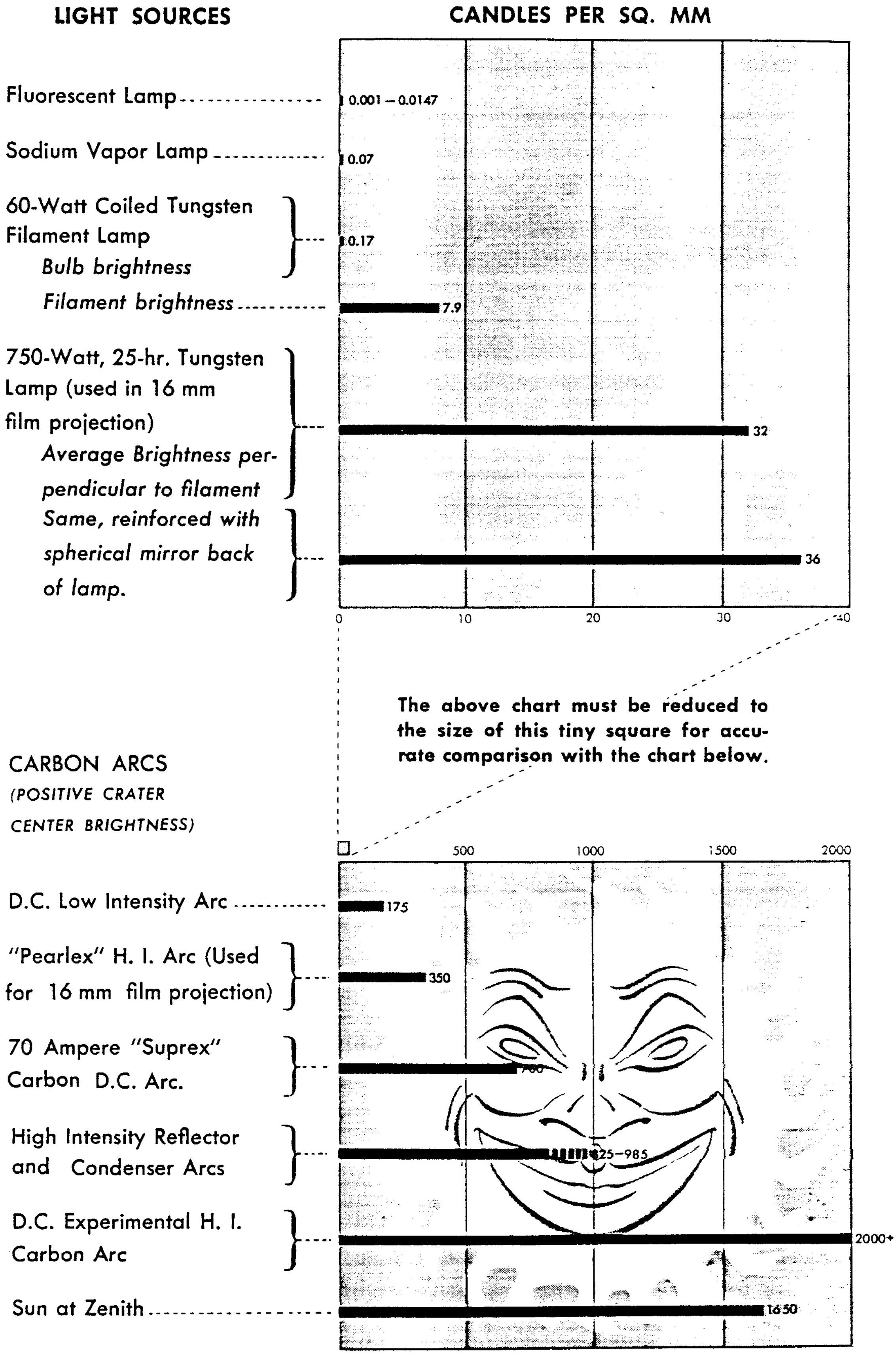
A recording spectroradiometer plots a color output curve in a minute and a half...it previously took half a day.

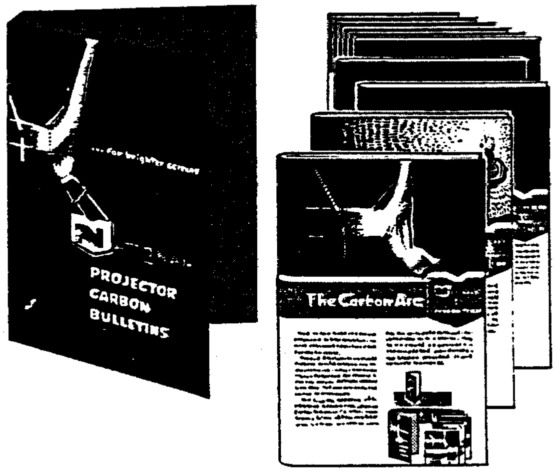
duction of color features is matched by the critical attitude of theatre patrons toward accuracy of color reproduction. The audience sees on the motion picture screen only those colors that are *present in the projection light* and which remain after others are absorbed by the color film. If certain colors are absent from the light, the film cannot put them on the screen; the film can only absorb or transmit the colors that are in the light behind it. Also, any excess of certain colors in the light source distorts the natural hues of color pictures. High intensity carbon arc projection assures an evenly balanced light with all colors present in essentially equal intensity.

From the curves on the preceding page, it can be seen how closely the color distribution of the light from the high intensity carbon arc approaches that of sunlight as compared with the light from the low intensity arc and that of the incandescent filament lamp. This is the quality of projection light for which theatrical color film is processed. It is the only quality of light that gives natural color reproduction with standard 35mm color film. Low intensity lamps give a light of yellowish tint which distorts color values and detracts from the realism and beauty of color pictures. The high intensity arc, emitting essentially equal intensities of all the spectral colors, reproduces all hues and tints with remarkable accuracy.

When it is considered that the record of progress in the production and utilization of carbon arc projection light shows a 10:1 improvement in brightness of the source, a 30:1 improvement in efficiency of screen light production, and a 90:1 improvement in the volume of light on the screen, together with marked improvements in color quality and steadiness, it is not surprising that projection lighting practice has kept fully abreast of progress in all other stages of the industry. Along with this technical advance there has been a 7:1 reduction in operating cost per unit of light on the screen! The expectation of further progress in projection lighting as need arises is fully justified by developments which have not as yet passed beyond the experimental stage.

BRIGHTNESS OF LIGHT SOURCES





THE NEXT ISSUE

. . . of the "National" Projector Carbon Bulletin will be sent to you three months hence. It will deal with: *Screen Light Checking Procedure*.

Keep This Issue

. . . in the binder sent to you with our compliments. By keeping all the issues, you will have at your finger tips a concise and highly efficient tool for helping you put more light on your screen at less cost.

An Invitation

. . . If you have an individual problem of carbon arc projection which is not included, please contact the Sales Office of National Carbon Company nearest you.

New York 17, New York	292 Madison Avenue	MUrray Hill 6-1700
Pittsburgh 22, Pa.	The Oliver Building, Mellon Square	EXpress 1-3800
Atlanta 3, Georgia	41 Marietta St., N.W.	MUrray 8-7700
Kansas City, Mo.	910 Baltimore Avenue	BAltimore 1-2400
Chicago 1, Illinois	230 N. Michigan Avenue	FInancial 6-3300
Dallas 1, Texas	1511 Bryan Street	RIverside 1-9176
San Francisco 6, Calif.	22 Battery Street	YUkon 2-1360
Los Angeles 58, Calif.	2770 Leonis Blvd.	LUdlow 3-3061

UNION CARBIDE

NATIONAL CARBON COMPANY

Division of Union Carbide Corporation

30 East 42nd Street, New York 17, N.Y.

Screen Light Checking Procedure

Part I. Checking Your Light

NATIONAL
TRADE-MARK
3.
Projector Carbons

Wide screen pictures have focused attention on the need for maximum illumination from projection equipment. During the past several years considerable information on the subject of screen light has been published by the Society of Motion Picture and Television Engineers, the Motion Picture Research Council, the International Projectionist Magazine and other trade publications. In the following pages and in Projector Carbon Bulletin No. 4 some of this material is worked into a system which will help you to determine:

(*a*) whether or not your theater screen is receiving enough light;

(*b*) if not, how to locate the trouble.

There are two general reasons why your screen may not be receiving enough light. *First,* one or more parts of your equipment may not be capable of doing the job it should be doing. For example, a lens which is too slow. *Second,* one or more parts of your equipment, even though adequate, may not be properly adjusted. For example, the optical alignment may be off and unless a check is made it may be difficult to determine the source of trouble and make the adjustments.

By carefully working out the instructions step by step in the order in which they are given, the illumination analysis may be made, with a little practice, in about thirty minutes. If light output is found to be below the capacity of your equipment, then a thorough equipment check should be made.

THEATER SCREEN LIGHT CHECKING PROCEDURE

FORM NO. 1—PROJECTION DATA

1. Projection angle	10°
2. Arc lamp type	Non-rotating Positive-Reflector
3. Positive carbon	"Suprex" 8mm X 14"
4. Negative carbon	"Orotip" C 7mm X 9"
5. Arc amperes	64
6. Arc volts	38
7. Projection lens	
(a) Name	Manufacturer and type
(b) f/number	f/2.0
(c) Focal length	5"
(d) Surface coated*	Yes X No
8. Type of projector and model	Manufacturer and type
9. Type of draft glass	None
10. Heat filter type	None
11. Projection port glass	Yes X No
12. Type of power supply	Manufacturer and type
(a) Rating in amperes	70 - 140
(b) Rating in volts	45
(c) Operating voltage	45

*A lens which was originally coated may lose its coating in time. To tell if your lens is coated, remove it and look at it at an angle. If it has a purple cast, it is coated. If in doubt, compare it in this way with a new coated lens.

The suggested method follows:

I. Projection Data

Fill out Form No. 1. (See Sample)
Note: Your meters should be checked for accuracy.

II. Incident Screen Light

Fill out Form No. 2. (See Sample)

Note: There are a number of light meters on the market for the measurement of theater screen light. The one chosen for this work should be equipped with a "Viscor" filter so as to match eye sensitivity and also light output figures published herein which are used for comparisons.

III. Screen Lumens Possible at Top Efficiency

If you have completed the data called for on Forms 1-2 you will have obtained the same type of information as is shown for optimum light output figures for the different optical trains in the Screen

FORM NO. 1—PROJECTION DATA

1. Projection angle - - - - - - - - - ______________________
2. Arc lamp type - - - - - - - - - - ______________________
3. Positive carbon - - - - - - - - - - ______________________
4. Negative carbon - - - - - - - - - ______________________
5. Arc amperes - - - - - - - - - - - ______________________
6. Arc volts - - - - - - - - - - - - - ______________________
7. Projection lens
   - (a) Name - - - - - - - - - - - - ______________________
   - (b) f/number - - - - - - - - - - - ______________________
   - (c) Focal length - - - - - - - - - ______________________
   - (d) Surface coated* - - - - - - - Yes______ No______
8. Type of projector and model - - - ______________________
9. Type of draft glass - - - - - - - ______________________
10. Heat filter type - - - - - - - - - ______________________
11. Projection port glass - - - - - - - Yes______ No______
12. Type of power supply - - - - - - ______________________
    - (a) Rating in amperes - - - - - - ______________________
    - (b) Rating in volts - - - - - - - - ______________________
    - (c) Operating voltage - - - - - - ______________________

*A lens which was originally coated may lose its coating in time. To tell if your lens is coated, remove it and look at it at an angle. If it has a purple cast, it is coated. If in doubt, compare it in this way with a new coated lens.

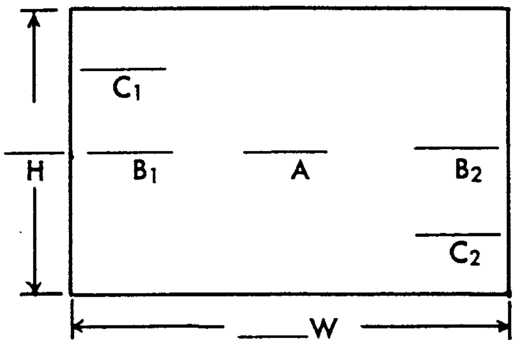
FORM NO. 2—INCIDENT SCREEN LIGHT MEASUREMENT

THEATER______________________________ DATE______________________________

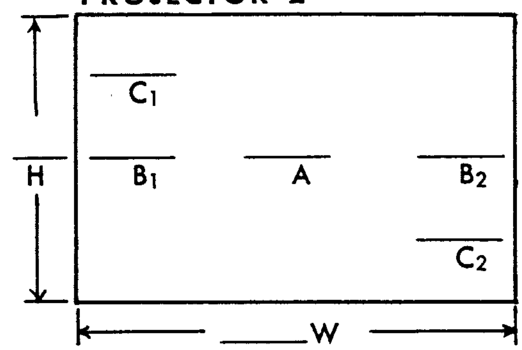
ADDRESS______________________________ REPORTED BY__________________________

____

PROJECTOR 1



PROJECTOR 2



Notes

(a) "C_1" and "C_2" are located approximately 1/20 of H from the top and bottom edges, and 1/20 of W from sides, "B_1" and "B_2" are on the horizontal center and 1/20 of W from sides. "A" is in the exact center.

(b) These measurements were made with a standard aperture in the projector.

(c) On standard screens the ratio of H to W is .73 (H/W - .73). Therefore you may measure the width of your screen (if not known) and to find the height (H) just multiply width (W) by .73. Similar constants can be calculated for other aperture ratios.

(d) Readings are to be taken without any film in the gate.

(e) All readings are made by holding the light meter parallel to and a few inches away from the screen, and facing the beam of light.

Screen Area

Area in square feet = H × W = (1)

Screen Light Intensity and Distribution

Side-to-Center ratio $\frac{B_1 + B_2}{2} \times \frac{1}{A} =$

Corner-to-Center ratio $\frac{C_1 + C_2}{2} \times \frac{1}{A} =$

Screen Lumen Calculation

$A \times 2 =$

$B_1 + B_2 =$

$\frac{C_1 + C_2}{2} =$ ____

Total =

Weighted Avg. = $\frac{\text{Total}}{5} =$ (2)

Screen Lumens = (1) × (2) = (3)

Screen Lumens without shutter = (3) × 2 = (4)

Screen Area

Area in square feet = H × W = (1)

Screen Light Intensity and Distribution

Side-to-Center ratio $\frac{B_1 + B_2}{2} \times \frac{1}{A} =$

Corner-to-Center ratio $\frac{C_1 + C_2}{2} \times \frac{1}{A} =$

Screen Lumen Calculation

$A \times 2 =$

$B_1 + B_2 =$

$\frac{C_1 + C_2}{2} =$ ____

Total =

Weighted Avg. = $\frac{\text{Total}}{5} =$ (2)

Screen Lumens = (1) × (2) = (3)

Screen Lumens without shutter = (3) × 2 = (4)

THEATER SCREEN LIGHT CHECKING PROCEDURE

FORM NO. 2—INCIDENT SCREEN LIGHT MEASUREMENT

THEATER *Bijou* DATE

ADDRESS *Main Street* REPORTED BY *John Doe*

U.S.A.

PROJECTOR 1

H = 15′4″, W = 21′

10 (C_1)		
11 (B_1)	14 (A)	13 (B_2)
		10 (C_2)

PROJECTOR 2

H = 15′4″, W = 21′

13 (C_1)		
14 (B_1)	17 (A)	15 (B_2)
		14 (C_2)

Notes

(a) "C_1" and "C_2" are located approximately 1/20 of H from the top and bottom edges and 1/20 of W from sides. "B_1" and "B_2" are on the horizontal center and 1/20 of W from sides. "A" is in the exact center.

(b) These measurements were made with a standard aperture in the projector.

(c) On standard screens the ratio of H to W is .73 (H/W = .73). Therefore you may measure the width of your screen (if not known) and to find the height (H) just multiply width (W) by .73. Similar constants can be calculated for other aperture ratios.

(d) Readings are to be taken without any film in the gate.

All readings are made by holding the light meter parallel to and a few inches away from the screen, and facing the beam of light.

Projector 1

Screen Area

Area in square feet = H × W = *322* (1)

Screen Light Intensity and Distribution

Side-to-Center ratio $\frac{B_1 + B_2}{2} \times \frac{1}{A}$ = *86%*

Corner-to-Center ratio $\frac{C_1 + C_2}{2} \times \frac{1}{A}$ = *71%*

Screen Lumen Calculation

A × 2 = *28*

$B_1 + B_2$ = *24*

$\frac{C_1 + C_2}{2}$ = *10*

Total = *62.0*

Weighted Avg. = $\frac{\text{Total}}{5}$ = *12.4* (2)

Screen Lumens = (1) × (2) = *4000* (3)

Screen Lumens without shutter = (3) × 2 = *8000* (4)

Projector 2

Screen Area

Area in square feet = H × W = *322* (1)

Screen Light Intensity and Distribution

Side-to-Center ratio $\frac{B_1 + B_2}{2} \times \frac{1}{A}$ = *85%*

Corner-to-Center ratio $\frac{C_1 + C_2}{2} \times \frac{1}{A}$ = *79%*

Screen Lumen Calculation

A × 2 = *34*

$B_1 + B_2$ = *29*

$\frac{C_1 + C_2}{2}$ = *13.5*

Total = *76.5*

Weighted Avg. = $\frac{\text{Total}}{5}$ = *15.3* (2)

Screen Lumens = (1) × (2) = *4950* (3)

Screen Lumens without shutter = (3) × 2 = *9900* (4)

Illumination Tables (pages 4, 5, 6 and 7). You may, therefore, after first correcting for the percentage loss for port glass and heat filter, match the figures from your own check with those of the tables in this bulletin to determine how close you are to the optimum.

Q. Suppose the amperage I am drawing is in between the amp figures shown. Which lumen figure should I read?

(Continued on page 7)

SCREEN ILLUMINATION with Carbon-Arc

ITEM	POSITIVE DESCRIPTION	POSITIVE CATALOG NO.	NEGATIVE DESCRIPTION	NEGATIVE CATALOG NO.	ARC AMP	ARC VOLTS
NON-ROTATING, REFLECTOR TYPE LAMPS—"ONE KILOWATT" D.C. TRIM						
1	7mm x 12 or 14 in. "Suprex"	L0503 or L0506	6mm x 9 in. "Orotip" C	L0563	40	27.5
NON-ROTATING, HIGH INTENSITY TRIMS						
2	7mm x 12 or 14 in. "Suprex"	L0521 or L0525	6mm x 9 in. "Orotip" C	L0563	42	36
3	7mm x 12 or 14 in. "Suprex"	L0521 or L0525	6mm x 9 in. "Orotip" C	L0563	46	38
4	7mm x 12 or 14 in. "Suprex"	L0521 or L0525	6mm x 9 in. "Orotip" C	L0563	50	40
5	8mm x 12 or 14 in. "Suprex"	L0509 or L0512	7mm x 9 in. "Orotip" C	L0566	60	37
6	8mm x 12 or 14 in. "Suprex"	L0509 or L0512	7mm x 9 in. "Orotip" C	L0566	65	39
7	8mm x 12 or 14 in. "Suprex"	L0509 or L0512	7mm x 9 in. "Orotip" C	L0566	70	40
8	9mm x 14 in. New "Suprex"	L0515	8mm x 9 in. "Orotip" C	L0569	65	40
9	9mm x 14 in. New "Suprex"	L0515	8mm x 9 in. "Orotip" C	L0569	75	43
10	9mm x 14 in. New "Suprex"	L0515	8mm x 9 in. "Orotip" C	L0569	80	45
ROTATING, REFLECTOR TYPE LAMPS						
11	9mm x 20 in. High Intensity	L0103	5/16 x 9 in. "Orotip"	L1106	75	52-57
12	9mm x 20 in. High Intensity	L0103	5/16 x 9 in. "Orotip"	L1106	85	55-60
13	10mm x 20 in. High Intensity	L0106	11/32 x 9 in. "Orotip"	L1115	95	51-57
14	10mm x 20 in. High Intensity	L0106	11/32 x 9 in. "Orotip"	L1115	100	54-59
15	10mm x 20 in. High Intensity	L0106	11/32 x 9 in. "Orotip"	L1115	110	59-65
16	10mm x 20 in. High Intensity	L0106	11/32 x 9 in. "Orotip"	L1115	95	51-57
17	10mm x 20 in. High Intensity	L0106	11/32 x 9 in. "Orotip"	L1115	100	54-59
18	10mm x 20 in. High Intensity	L0106	11/32 x 9 in. "Orotip"	L1115	110	59-65
19	11mm x 20 in. High Intensity	L0109	3/8 x 9 in. "Orotip"	L1124	110	57-62
20	11mm x 20 in. High Intensity	L0109	3/8 x 9 in. "Orotip"	L1124	115	58-64
21	11mm x 20 in. High Intensity	L0109	3/8 x 9 in. "Orotip"	L1124	120	59-68
22	11mm x 20 in. High Intensity	L0109	3/8 x 9 in. "Orotip"	L1124	110	57-62
23	11mm x 20 in. High Intensity	L0109	3/8 x 9 in. "Orotip"	L1124	115	58-6[illegible]
24	11mm x 20 in. High Intensity	L0109	3/8 x 9 in. "Orotip"	L1124	120	59-68

	.MP OPTICAL SYSTEM		RADIANT-ENERGY FLUX AT CENTER OF FILM APERTURE[4]	MAXIMUM LIGHT[3]						APPROX. CARBON CONSUMPTION RATE IN./HR.	
				STANDARD APERTURE 0.825" x .600"		0.839" x 0.715" APERTURE		0.825" x 0.446" APERTURE			
	MIRROR DIAM. (IN.)	MIRROR SPEED	W/SQ. MM	SCREEN LUMENS[1]	% DIST.[2]	SCREEN LUMENS[1]	% DIST.[2]	SCREEN LUMENS[1]	% DIST.[2]	POS.	NEG.
....	11⅜	f/2.5		6,500	65	7,800	65	(4,850)	(65)	5.8	3.4
.....	14	f/2.3		8,650	60	10,400	60	(6,450)	(60)	7.6	3.8
.....	14	f/2.3		10,000	60	12,000	60	(7,450)	(60)	9.3	4.0
....	14	f/2.3	.55	11,700	60	14,000	60	(8,700)	(60)	11.6	4.3
....	14	f/2.3	.60	13,100	60	15,700	60	(9,750)	(60)	9.0	3.8
.....	14	f/2.3	.65	14,400	60	17,200	60	(10,700)	(60)	10.4	4.0
.....	14	f/2.3	.69	15,700	60	18,800	60	(11,700)	(60)	13.6	4.3
....	14	f/2.3	.59	13,000	65	15,500	65	(9,600)	(65)	7.6	3.3
.....	14	f/2.3	.70	15,000	65	17,800	65	(11,100)	(65)	10.8	3.8
	4	f/2.3	.74	16,600	65	19,900	65	(12,300)	(65)	13.8	4.0
.....	16-16½	f/1.9		16,000	55	19,200	55	(11,900)	(55)	14.0	3.3
.....	16-16½	f/1.9	.88[5]	19,500	55	23,000	55	(14,500)	(55)	22.0	3.5
.....	16-16½	f/1.9	.81[5]	18,500	60	22,200	60	(13,700)	(60)	15.0	2.3
.....	16-16½	f/1.9	.89[5]	20,700	60	24,900	60	(15,400)	(60)	16.5	2.5
.....	16-16½	f/1.9	.94[5]	22,000	60	26,500	60	(16,300)	(60)	24.5	3.1
....	18	f/1.7	.85[5]	21,700	60	27,100	60	(16,100)	(60)	15.0	2.3
.....	18	f/1.7	.91[5]	23,700	60	29,100	60	(17,600)	(60)	16.5	2.5
.....	18	f/1.7	.97[5]	25,200	60	31,600	60	(18,700)	(60)	24.5	3.1
.....	16-16½	f/1.9	.85[5]	21,700	60	27,100	60	(16,100)	(60)	12.5	2.7
.....	16-16½	f/1.9	.89[5]	23,100	60	28,800	60	(17,200)	(60)	16.0	2.8
.....	16-16½	f/1.9	.92[5]	24,100	60	30,100	60	(17,900)	(60)	20.5	2.9
..	18	f/1.7	.93[5]	24,800	60	31,200	60	(18,400)	(60)	12.5	2.7
.	3	f/1.7	.95[5]	26,500	60	33,200	60	(19,700)	(60)	16.0	2.8
.....	18	f/1.7	1.00[5]	27,600	60	34,700	60	(20,500)	(60)	20.5	2.9

SCREEN ILLUMINATION (*Continued*)

ITEM	POSITIVE DESCRIPTION	POSITIVE CATALOG NO.	NEGATIVE DESCRIPTION	NEGATIVE CATALOG NO.	AMP	ARC VOLTS
ROTATING, REFLECTOR TYPE LAMPS (*Continued*)						
25	13.6mm x 18 in. High Intensity	L0112	7/16 x 9 in. "Orotip" Special	L1132	135-160	*
26	13.6mm x 20 in. High Intensity	L0114	7/16 x 9 in. "Orotip"	L1130	125-135	*
27	13.6mm x 20 in. High Intensity	L0114	½ x 9 in. "Orotip" or 7/16 x 9 in. "Orotip" Special	L1139 L1132	135-160	*
28	10mm x 20 in. "Hitex"	L0170	7/16 x 9 in. "Orotip"	L1130	125	60-64
29	10mm x 20 in. "Hitex"	L0170	7/16 x 9 in. "Orotip"	L1130	130	62-66
30	10mm x 20 in. "Hitex"	L0170	½ x 9 in. "Orotip"	L1139	135	66-70
31	10mm x 20 in. "Hitex"	L0170	7/16 x 9 in. "Orotip"	L1130	125	60-64
32	10mm x 20 in. "Hitex"	L0170	7/16 x 9 in. "Orotip"	L1130	130	62-66
33	10mm x 20 in. "Hitex"	L0170	½ x 9 in. "Orotip"	L1139	135	66-70
34	10mm "Ultrex"[6]	Exper.	Exper.		165	80
35	11mm "Ultrex"[6]	Exper.	Exper.		195	80
ROTATING, CONDENSER TYPE LAMPS						
36	13.6mm x 22 in. High Intensity	L0115	7/16 x 9 in. "Orotip"	L1130	125	68
37	13.6mm x 22 in. High Intensity	L0115	½ x 9 in. "Orotip"	L1139	150	74
38	13.6mm x 22 in. High Intensity	L0115	½ x 9 in. "Orotip"	L1139	160	77
39	13.6mm x 22 in. "Hitex"	L0175	½ x 9 in. "Orotip" Heavy Duty	L1142	170	70
40	13.6mm x 22 in. "Hitex"	L0175	½ x 9 in. "Orotip" Heavy Duty	L1142	180	74
41	13.6mm x 22 in. "Ultrex"[6]	Exper.	Exper.		265	
42	13.6mm x 22 in. "Ultrex"[6]	Exper.	Exper.		290	80

NOTE: Where differences in results were obtained with different lamps or optics, average performance data are shown. For each burning condition shown above, a projection lens was chosen to match as nearly as possible the condenser or mirror optics. Lenses employed are coated and range from 4 to 5 inch E.F. and *f*/1.7 to *f*/1.20 speeds. All mirrors have silver reflecting surfaces. Values in parentheses are estimated or obtained from limited measurements.

1. Screen lumen figure is for systems with no shutter, film or filter of any kind.

2. Distribution refers to ratio of light intensity at side of screen to that at the center of the screen.

3. Maximum light is value with system adjusted to produce maximum light intensity at the center of the screen.

4. Radiant energy flux at the center of the film aperture with the system adjusted to produce maximum intensity at the center.

5. Radiant energy flux higher than 0.80 w./sq. mm may require the use of a heat filter and/or other means to protect the film from the effects of the radiation—may result in some loss of light.

6. Experimental carbons burned with short protrusion in experimental water-cooled jaws.

*Data can be obtained from lamp manufacturer.

	OPTICAL SYSTEM MIRROR DIAM. (IN.)	MIRROR SPEED	RADIANT—ENERGY FLUX AT CENTER OF FILM APERTURE[4] W/SQ. MM	MAXIMUM LIGHT[3] STANDARD APERTURE 0.825" x .600" SCREEN LUMENS[1]	% DIST.[2]	0.839" x 0.715" APERTURE SCREEN LUMENS[1]	% DIST.[2]	0.825" x 0.446" APERTURE SCREEN LUMENS[1]	% DIST.[2]	APPROX. CARBON CONSUMPTION RATE IN./HR. POS.	NEG.
....	18	*	*	*	*	*	*	*	*	*	*
....	18	*	*	*	*	*	*	*	*	*	*
....	18	*	*	*	*	*	*	*	*	*	*
....	16-16½	f/1.9	.95[5]	24,000	65	28,800	65	(17,800)	(65)	19.5	2.4
....	16-16½	f/1.9	1.00[5]	25,000	65	30,600	65	(18,600)	(65)	25.0	2.6
....	16-16½	f/1.9	1.05[5]	26,500	65	31,800	65	(19,700)	(65)	32.0	1.7
....	18	f/1.7	1.00[5]	27,500	65	32,900	65	(20,400)	(65)	19.5	2.4
....	18	f/1.7	1.05[5]	29,200	65	34,900	65	(21,700)	(65)	25.0	2.6
....	18	f/1.7	1.09[5]	30,300	65	36,200	65	(22,500)	(65)	32.0	1.7
....	Exper.	f/2.0	(1.3)[5]	34,000	(60)	(41,000)	(60)	(25,300)	(60)	45	
....	Exper.	f/2.0	(1.3)[5]	35,000	(65)	(42,000)	(65)	(26,000)	(65)	45	
	CONDENSER SPEED										
....	f/2.0		.64	14,500	60	17,400	60	(10,800)	(60)	7.3	2.4
	f/2.0		.90[5]	19,500	60	23,000	60	(14,500)	(60)	14.0	1.9
.	f/2.0		1.00[5]	20,500	60	24,600	60	(15,200)	(60)	17.5	2.1
....	f/2.0		.97[5]	20,700	60	25,000	60	(15,400)	(60)	16.0	2.3
....	f/2.0		1.10[5]	24,800	60	29,800	60	(18,400)	(60)	21.5	2.5
....	f/2.0			(28,000)	(60)	(34,000)	(60)	(20,800)	(60)		
....	f/2.0		1.50[5]	(34,000)	(60)	(41,000)	(60)	(25,300)	(60)	45	

III. Screen Lumens (*continued*)

A. Determine the lumen figures for the amperage used from a light versus amperage curve which you can plot from data in the tables. *Amperage versus light is not always a straight line function.*

Q. How can I tell whether or not my system is adjusted for maximum light?

A. You can determine this by referring to the *side-to-center* ratio which you listed in Form No. 2. *If this ratio is 65% or less, you may assume a maximum light adjustment.* If it is greater than 65%, then assume the adjustment is *not* for maximum light.

IV. Comparison of Actual Lumen Output with Top Lumen Output

The *top lumen output* obtainable from your equipment may be determined by matching your conditions with those found in the tables which are located on pages 4, 5, 6 and 7.

The screen lumens for apertures other than the standard aperture (.825" x .600") can be calculated by multiplying the maximum screen lumens measured with the standard aperture by the ratio of the area of the aperture being used to the standard aperture. See example next page.

$$L_x = L_s \frac{A_x}{A_s}$$

where A_s = Area of standard aperture (.825″ x .600″)

A_x = Area of aperture being used

L_s = Lumens with standard aperture

L_x = Lumens with aperture being used.

For example, applying this formula to a .912″ x .715″ aperture, we get:

$A_s = .825 \times .600 = .495$

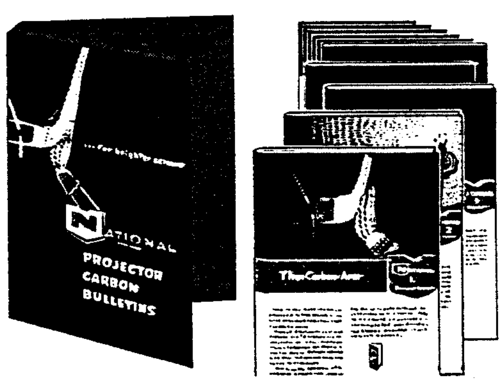
$A_x = .912 \times .715 = .652$

L_s = 16,600 (9mm x 14″ "Suprex" carbon at 80 amperes from the table on page 5), then

$$L_x = 16{,}600 \frac{.652}{.495}$$

$$L_x = 21{,}865 \text{ lumens.}$$

The ratio of the area of the 0.839″ x 0.715″ aperture to that of the 0.825″ x 0.600″ aperture is 1.21. By calculating the ratio of light through the 0.839″ x 0.715″ aperture to that through the 0.825″ x 0.600″ aperture from the measured lumen values given in the first two columns under *Maximum Light* in the tables it can be seen that the ratio varies from 1.18 to 1.25 or is $1.21^{+.04}_{-.03}$. The variations in this light ratio are due to slight variations in lamp and optical alignment in setting up the equipment, errors in measurement, and probably to a number of other factors.



Thus, it is seen that, in general, lumen values calculated by means of the formula are as accurate as the measured values.

This procedure cannot be applied with apertures used in the projection of 55mm, 65mm or 70mm film because complete data for these wide film systems have not yet been established.

The actual lumen output was calculated on Form No. 2, equation (4). *The actual lumen output you calculated should be at least 80% of the top lumen figure.* IF IT IS LESS THAN 80%, PROCEED WITH THE EQUIPMENT CHECK DESCRIBED IN BULLETIN NO. 4.

Even if it is greater than 80%, you may still continue the check in order to get all of the light you possibly can. (In the sample given in Forms 1 and 2, equation 4, the actual lumen figure without shutter for Projector 1 was 8000; for Projector 2, 9900. The top value was found to be 11,380 lumens; 80% of 11,380 lumens is about 9100 lumens. Thus, in this sample case, Projector 1 is operating below the 80% optimum and Projector 2 above.) From the differences in the light output figures between projectors, plus the high side-to-center ratio, possible gains can be made both by alignment and focus corrections. The suggested checks will reveal the cause of, and correct, the differences.

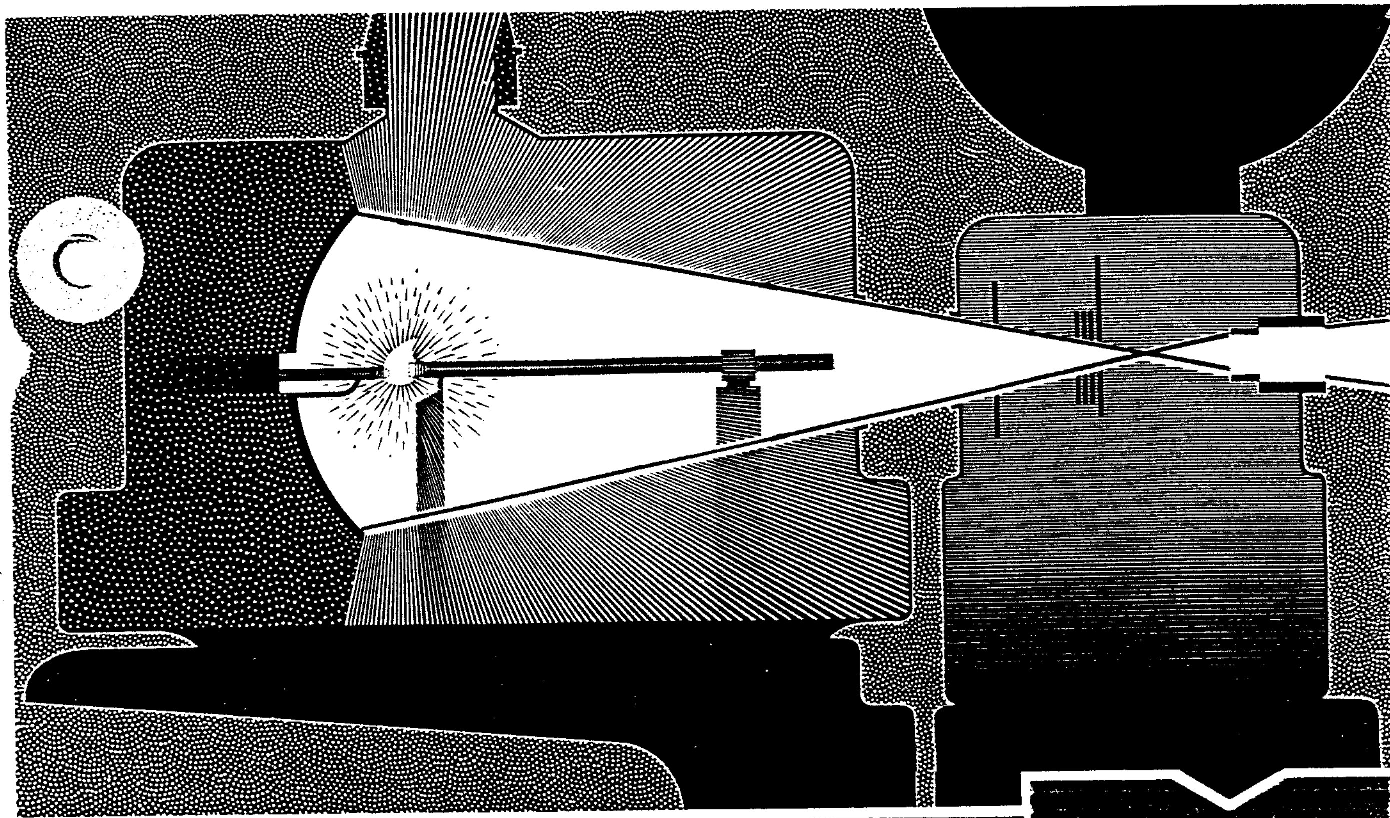
IMPORTANT

The next Bulletin will describe procedures for checking your equipment. The importance of these checks and adjustments cannot be overemphasized. *Whether or not you can get top light output will depend upon how carefully these instructions are followed.*

NATIONAL CARBON COMPANY

Division of UNION CARBIDE Corporation

30 East 42nd Street, New York 17, N.Y.



Screen Light Checking Procedure

Part II. Checking Your Optical System

NATIONAL
TRADE MARK
4.
Projector Carbons

Unless specifically stated, the discussions below are applicable to either mirror or condenser optics.

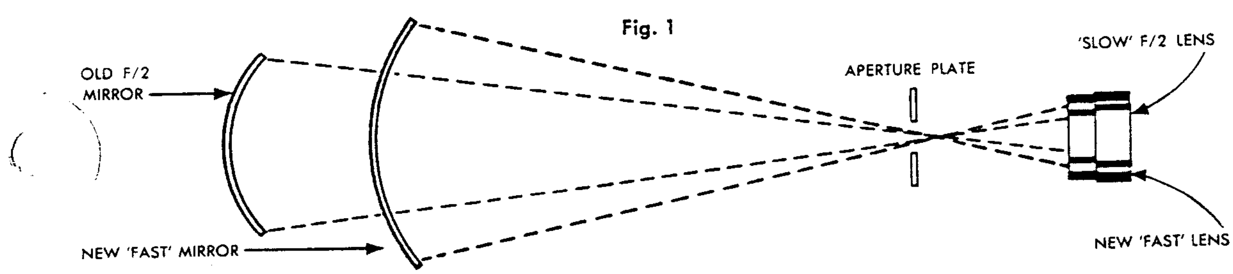
I. Check of Optical Train Opening

The lens speed is the governing factor in the lamp-projector-lens optical train. For example, the early *f*/2 lens was 'slow', with a small diameter and the early 'slow' lamp had a correspondingly small light angle. The newer 'fast' lenses have a larger diameter, so the lamp mirror has been made larger and moved forward, throwing more light at a wider angle. Consequently the projector's heat shields, shutter openings, etc. had to be enlarged to accommodate it. Thus, early model projectors or mis-matched equipment should be tested for obstructions that may block the passage of light.

A template for checking the optical train is available from the lamp supplier for use with *f*/2 mirror lamp optics.

(*a*) Insert the template through the cone of the lamphouse in a vertical plane. It

Fig. 1



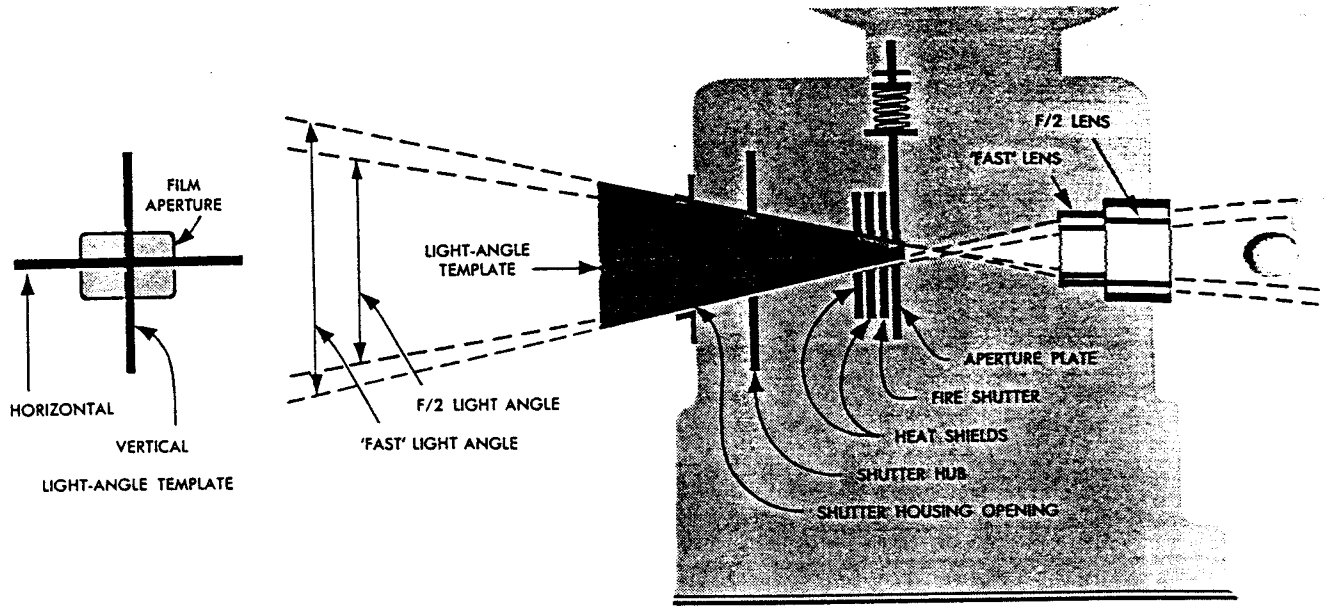


Fig. 2

should pass through all openings until the edges come in contact with the top and bottom of the aperture plate.

(*b*) Insert the template on a horizontal plane. The edges should contact the sides of the aperture plate.

If the template will not pass this far into the optical train opening, the obstruction will be evident and should be filed out, or the part should be replaced with one that will admit the template. In some cases the projector manufacturer may supply a conversion kit for this purpose.

Another practical method of checking the optical train opening to be sure it will pass the cone of light from the mirror follows: (This method can be used when templates are not available.)

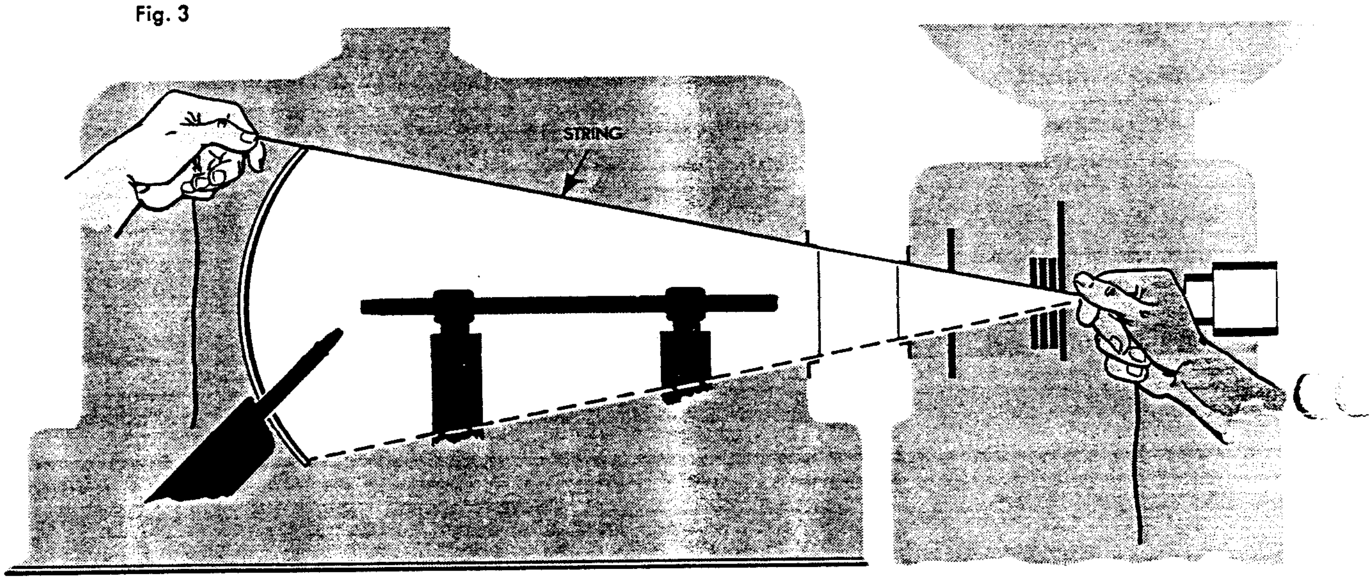
(*a*) Run a piece of string from the top of the mirror, through the aperture, to the top of the aperture plate opening at the film plane. If anything interferes with the straight line of the string, then it must be removed in order that the top of the film frame may see the top of the mirror. A similar check can be made with condenser lenses.

(*b*) Duplicate this procedure from the bottom of the mirror to the bottom of the film plane position, and also from each side. Clearing these optical paths will not only increase overall screen light but will provide better screen light distribution.

II. Shutter Transmission Check

For the purpose of screen light checking,

Fig. 3



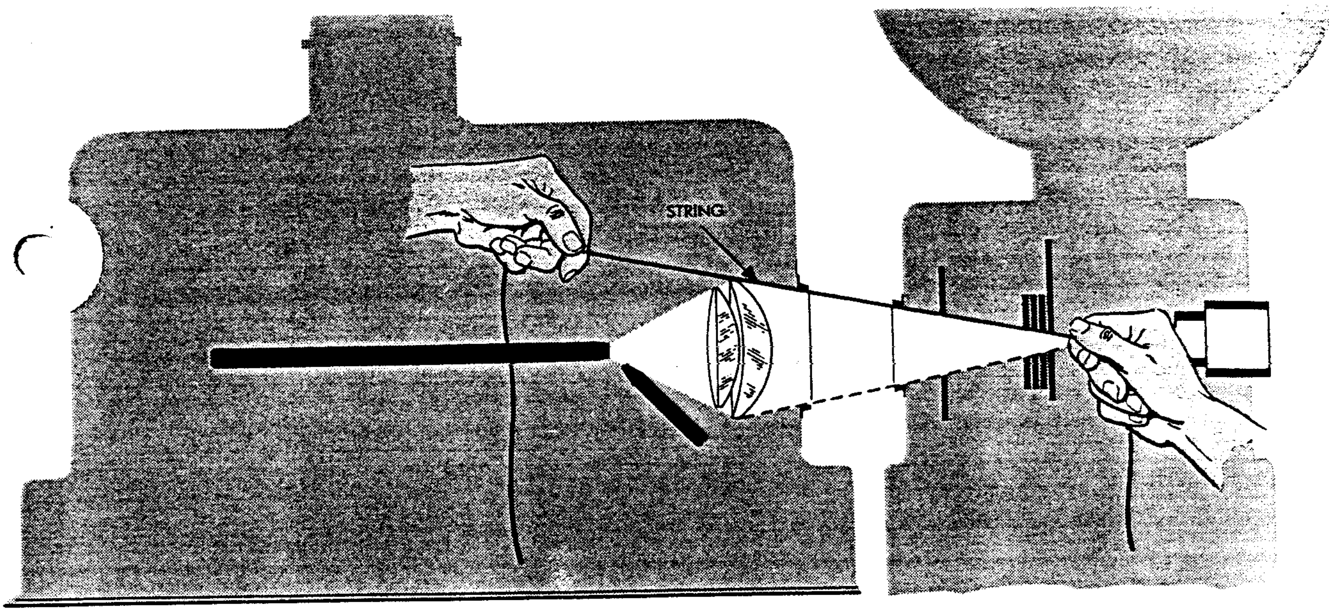


Fig. 4

a shutter transmission of 50% may be assumed as a good average. If your check reveals less than 50% shutter transmission it may be because of maladjusted shutter blades or from some other cause, and the supply house service department should be consulted in order to determine the specific reason.

With one person at the screen to read the light meter, and another to operate the projector, make the shutter-transmission check as follows:

(*a*) Open the shutter.

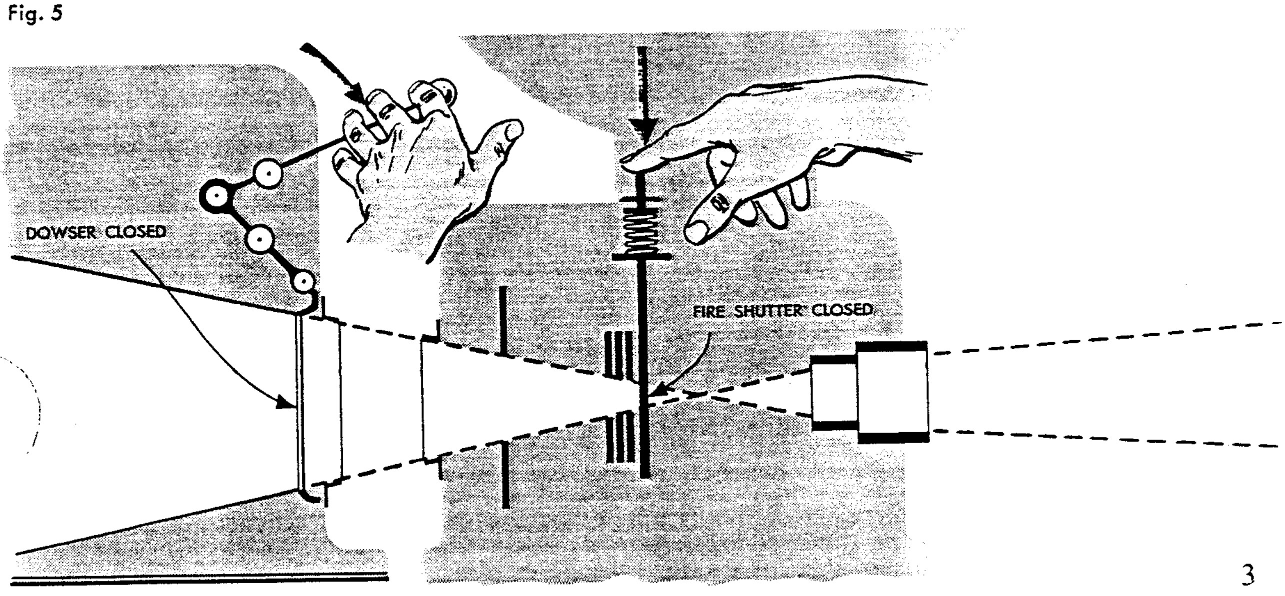
(*b*) Close the dowser.

(*c*) Strike the arc and make the settings as if to operate the projector.

(*d*) When the person at the screen is ready with the light meter, flash the light onto the screen by opening the fire shutter by hand and operating the dowser control. *WARNING: In this part of the check, only allow the light to pass through the objective lens for the shortest period in which a reading may be taken; otherwise, damage to the lens may result.*

(*e*) Start the projector and take the same reading. The ratio of the two readings will reveal the shutter transmission. For example, if the "flashed" reading, without the machine running, is 29 foot-candles, and the reading with the machine running is 13 foot-candles, the shutter transmission is 13/29 x 100 = 45%. This is too low. The shutter is cutting the light and should be adjusted.

Fig. 5



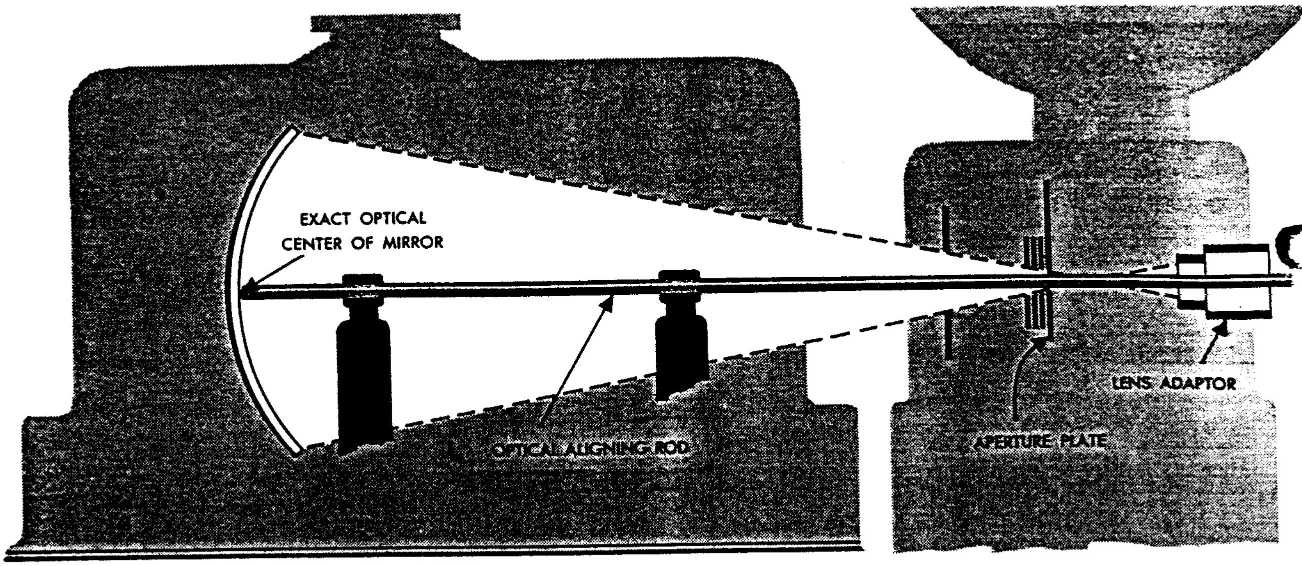


Fig. 6

III. Check of Optical Alignment, Working Distance, and Focus

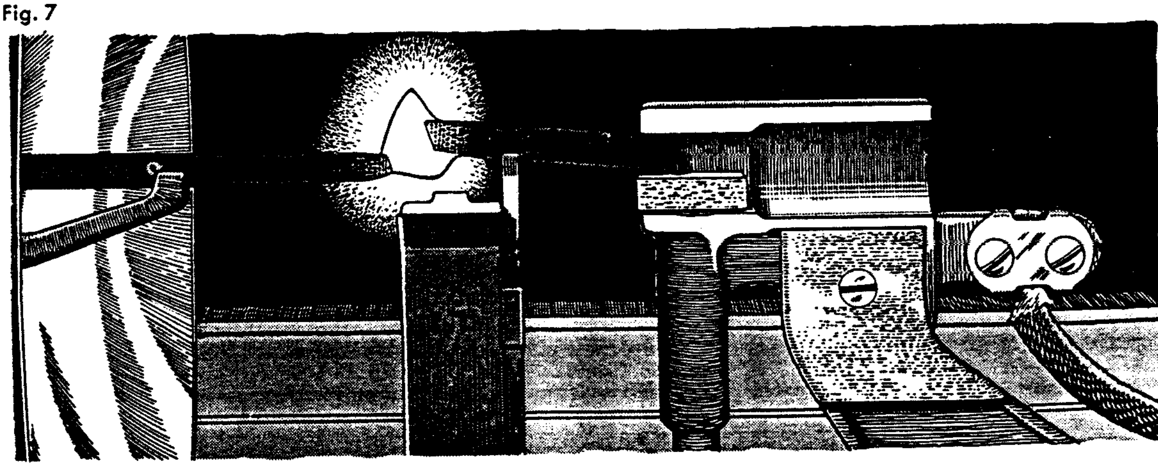
General Discussion:

In a high intensity carbon arc projection system, all of the brightest portion of the gas ball cannot be focused on the film plane unless the crater of the positive carbon is exactly on the optical axis of the mirror (or condenser), and the axis is then aligned to pass exactly through the center of the aperture. With misalignment, the plane in focus will include either shell light—which is of lower order of intensity, and more yellow—or arc stream light, which is also of lower intensity, and more blue. The image of the gas ball must actually fall precisely on the film plane if a maximum amount of light is to pass through the rest of the optical system. Finally, the optical axis of the projection lens must be exactly along the axis of the lamp-mirror-aperture system. (Fig. 6.)

It is thus evident that unless crater, mirror, aperture and projection lens are all in rifle-barrel 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 tilt the mirror in various ways. This fact often creates the belief that a given mirror is too inaccurate for suitable operation, but before discarding the mirror, you should test it under conditions of correct optical train alignment. Sometimes a quick check may be made, if the other lamp seems to give satisfactory coverage, by merely switching mirrors and testing the suspected mirror under conditions of alignment known to be satisfactory. *Basic alignment of the above elements is necessary for all successful optical adjustments.*

Not only must the mechanism be so

Fig. 7



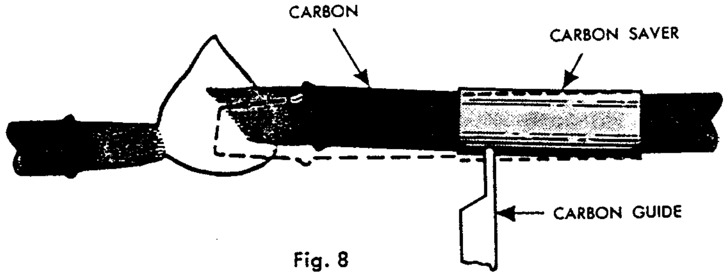


Fig. 8

aligned as to hold the carbon crater with the gas ball in its proper position with respect to the mirror, but operation must be maintained so that the crater remains in that position during the burning of the trim. (If, for example, a short grip on the positive carbon causes the crater to raise out of its proper 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 another.) (Figs. 7 and 8.)

Systematic procedure for optical train lignment and adjustment:

1. Align the lamphouse and burner mechanism with suitable alignment tools, according to the instructions accompanying the tools. (Alignment tools may be obtained from lamp manufacturers through supply dealers.) On some of the older type bases ingenuity may be required to determine means of shimming and adjusting, *nevertheless proper alignment is necessary for maximum brightness, a good field and correct color of screen light.*

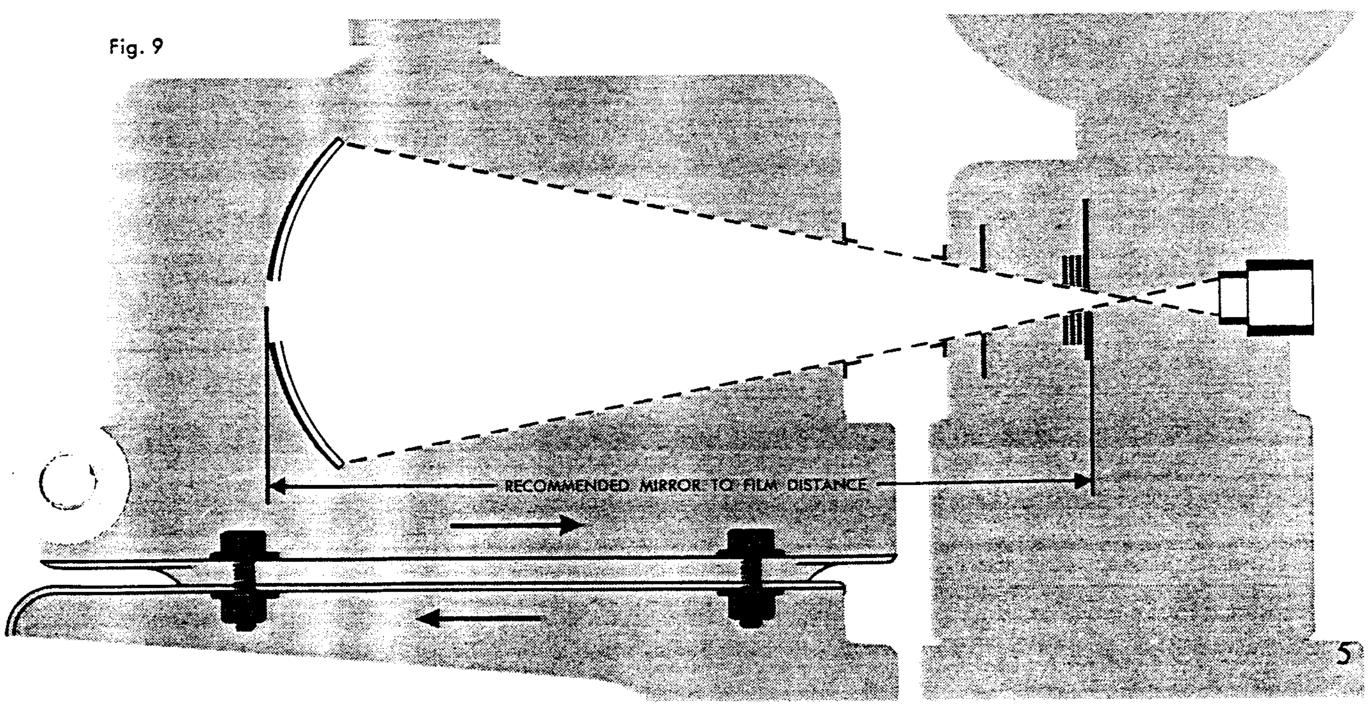
2. Check the numbers on the back of the mirror against the manufacturer's specifications to determine the proper working distance, which is measured from the center of the mirror or the inside edge of the mirror centerhole (non-rotating carbon lamps) to the film plane. (It is not safe to assume the working distance from the mirror diameter alone.)

Next, move the lamphouse on the base to within plus or minus ½ inch of the prescribed distance. (Fig. 9.)

3. Set the arc at the manufacturer's recommended arc-to-mirror distance.

4. Strike the arc, (shutter running, no film in gate) and by means of the lateral and vertical mirror adjustment knobs, clear the field as much as possible, to arrive at a light-field balance.

Fig. 9



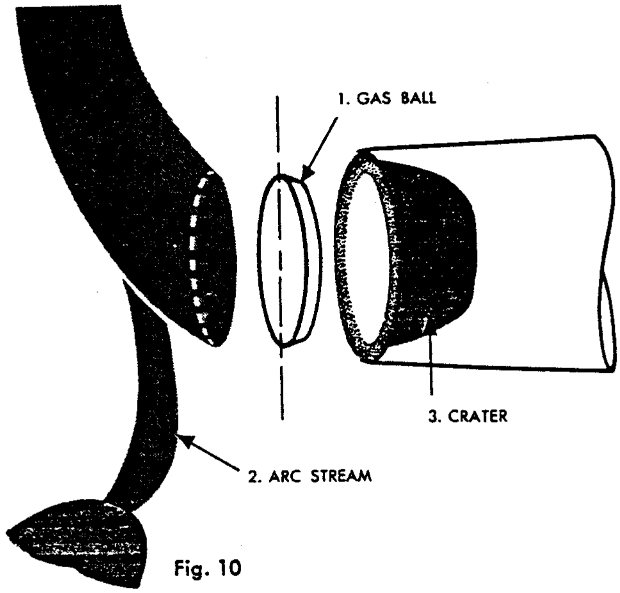


Fig. 10

5. The gas ball of the carbon arc may be considered as a flat disc with a 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 on the screen by the projection lens. (Fig. 11.)

(*a*) Explore the arc-to-mirror distance by moving the arc toward the mirror until the screen light becomes yellow;

(*b*) then away from the mirror until the light becomes blue;

(*c*) then toward the mirror again just into the white light zone where there is not too much fall-off at the edges of the screen.

Within the white-light range, it is possible for you to vary your total white-light 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.

(*d*) As the arc is moved toward the mirror, you will find that the spot on the aperture plate becomes larger, the screen light distribution becomes flatter, and the total screen light is reduced.

(*e*) As you move the arc away from the mirror, the spot on the aperture becomes smaller, the side-to-center difference becomes greater, and the total screen light is increased. Of course, light will decrease if the arc is withdrawn so far from the mirror that it is out of the white-light range.

If the crater gas ball is not facing correctly, it is impossible to clear the light field at anything like maximum screen light. When the plane of the crater has shifted because of a short grip in the holder, or misaligned carbon-savers, the probable result is that in attempting to avoid off-color light, you have set the arc position where the largest spot appears on the aperture plate. This position gives only the minimum light within the white-light range.

6. Secure lamp to base and recheck No. 1.

7. The position of the optical center of the mirror in relation to the center of the crater will usually be found to be satisfactory, but it can be checked roughly by measuring from the edge of the crater to the outside edge of the mirror at four equidistant points around the mirror circumference.

8. Check the position of the fire shutter and automatic dowser with the projector running. These should raise sufficiently to clear the entire light cone angle, from mirror to aperture.

After completing check of optical alignments, working distances and all arc focusing adjustments, be sure the arc image indicator is set at the proper position.

IV. Recheck of Incident Screen Illumination

As a final step it is necessary to redetermine the screen illumination by taking meter readings as described in Form No. 2, Bulletin No. 3. If all of the preceding instructions have been followed, you should obtain an average of between 80% and 100% of the top illumination.

V. Light Transmission of Port Glass

Typical port glass (plate glass) has a light

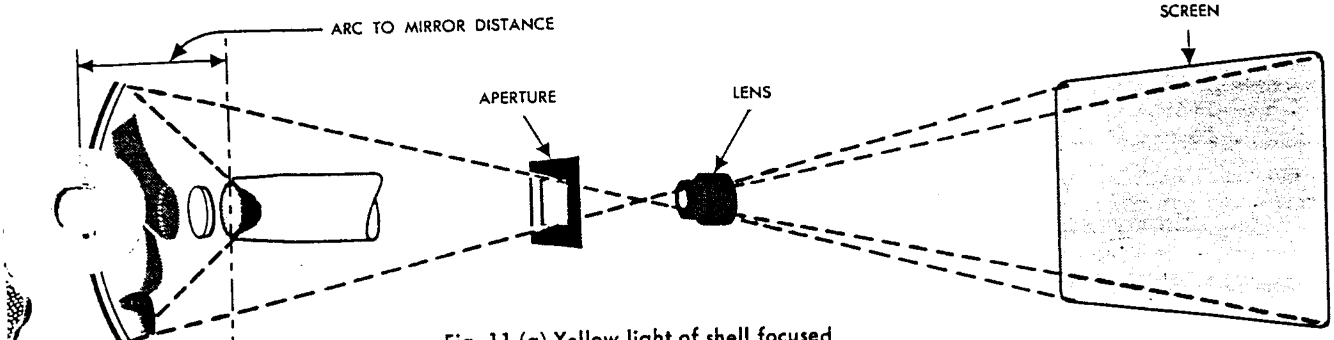
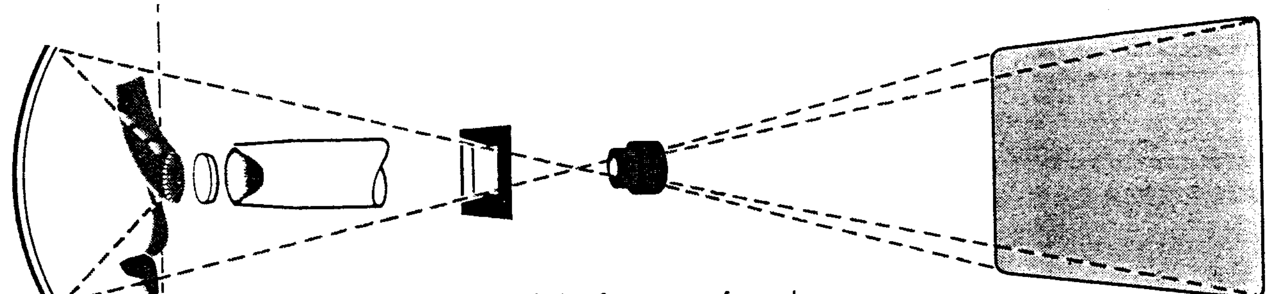
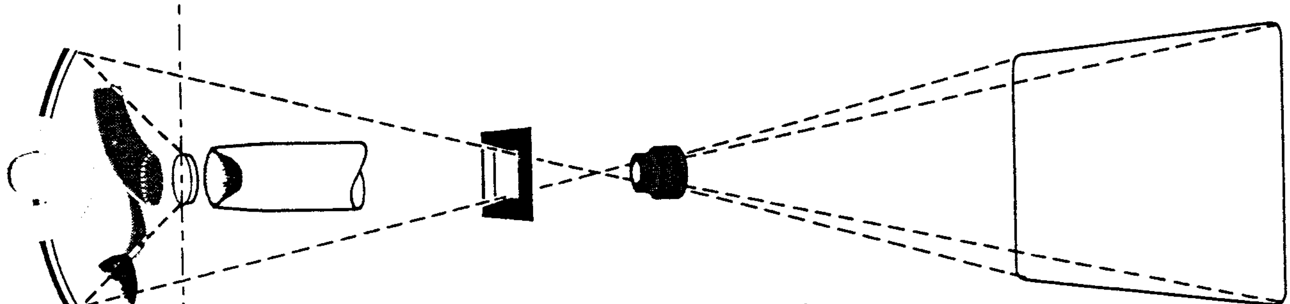


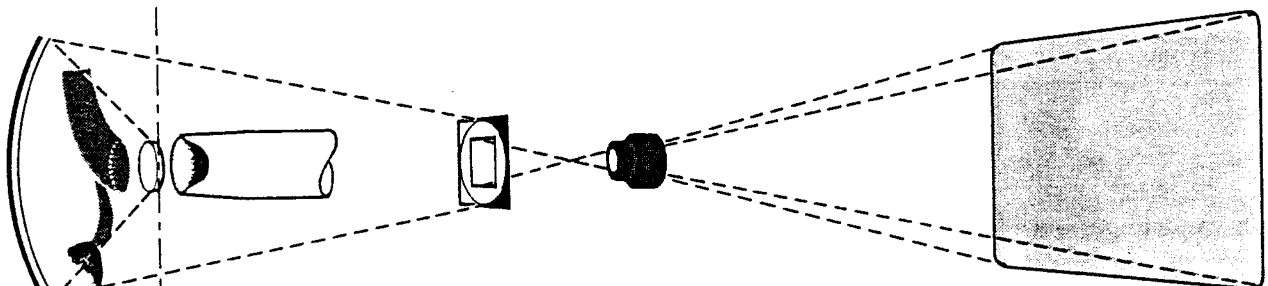
Fig. 11 (a) Yellow light of shell focused



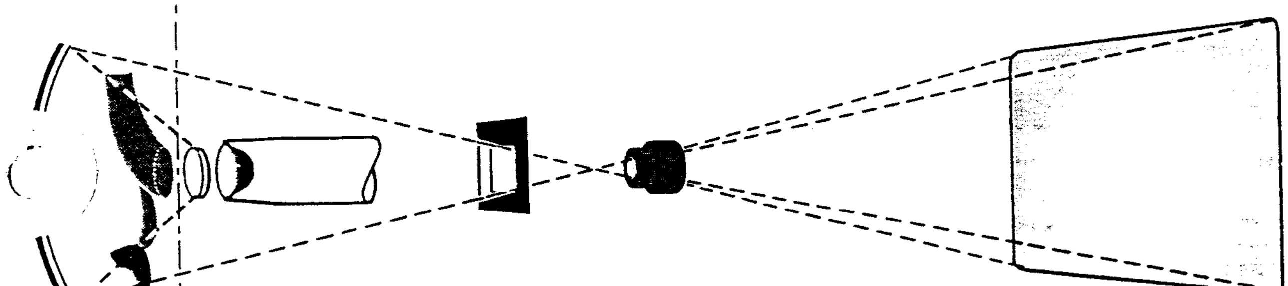
(b) Blue light of arc-stream focused



(c) White light of gas-ball focused



(d) White light range . . . focused for flat field



(e) White light range . . . focused for maximum light

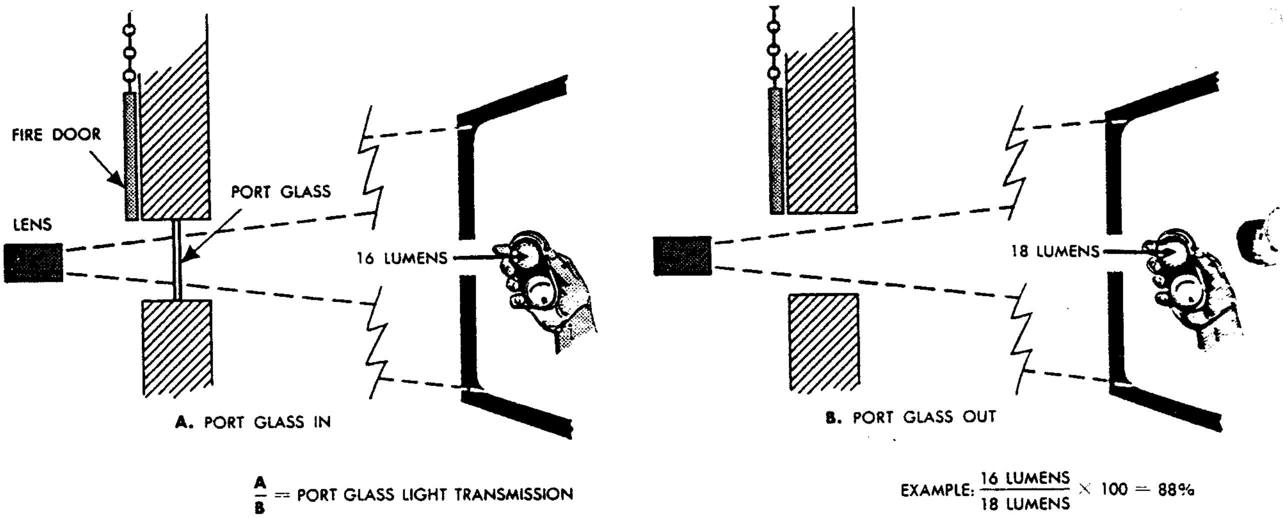


Fig. 12

transmission of from 92% to 86%. Inferior grades of glass or dust may lower this transmission considerably. If the surfaces of the glass are not exactly parallel, the picture may be distorted and out of focus over certain areas.

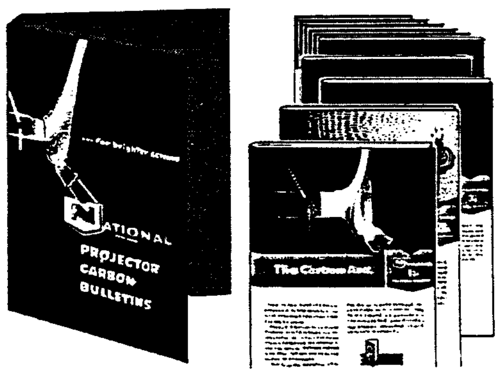
To check the transmission of the port glass, remove it and again take meter readings. The light output will, of course, be greater without the glass. The ratio of the readings with glass in place to the readings without the glass will give the transmission of the port glass.

This method can also be used to check transmission of heat filters.

AN INVITATION . . .

If you have an individual problem of carbon arc projection which is not included, please contact the Sales Office of National Carbon Company nearest you.

New York 17, New York	292 Madison Avenue	MUrray Hill 6-1700
Pittsburgh 22, Pa.	The Oliver Building, Mellon Square	EXpress 1-3800
Atlanta 3, Georgia	41 Marietta St., N.W	MUrray 8-7700
Kansas City, Mo.	910 Baltimore Avenue	BAltimore 1-2400
Chicago 1, Illinois	230 N. Michigan Avenue	FInancial 6-3300
Dallas 1, Texas	1511 Bryan Street	RIverside 1-9176
San Francisco 6, Calif.	22 Battery Street	YUkon 2-1360
Los Angeles 58, Calif.	2770 Leonis Blvd.	LUdlow 3-3061



THE NEXT ISSUE . . .

Look for "National" Projector Carbon Bulletin No. 5. It will contain useful information on *Operating Precautions.*

The terms "National," "Hitex," "Orotip," "Suprex," "Ultrex" and "Union Carbide" are trade-marks of Union Carbide Corporation

NATIONAL CARBON COMPANY

Division of UNION CARBIDE Corporation

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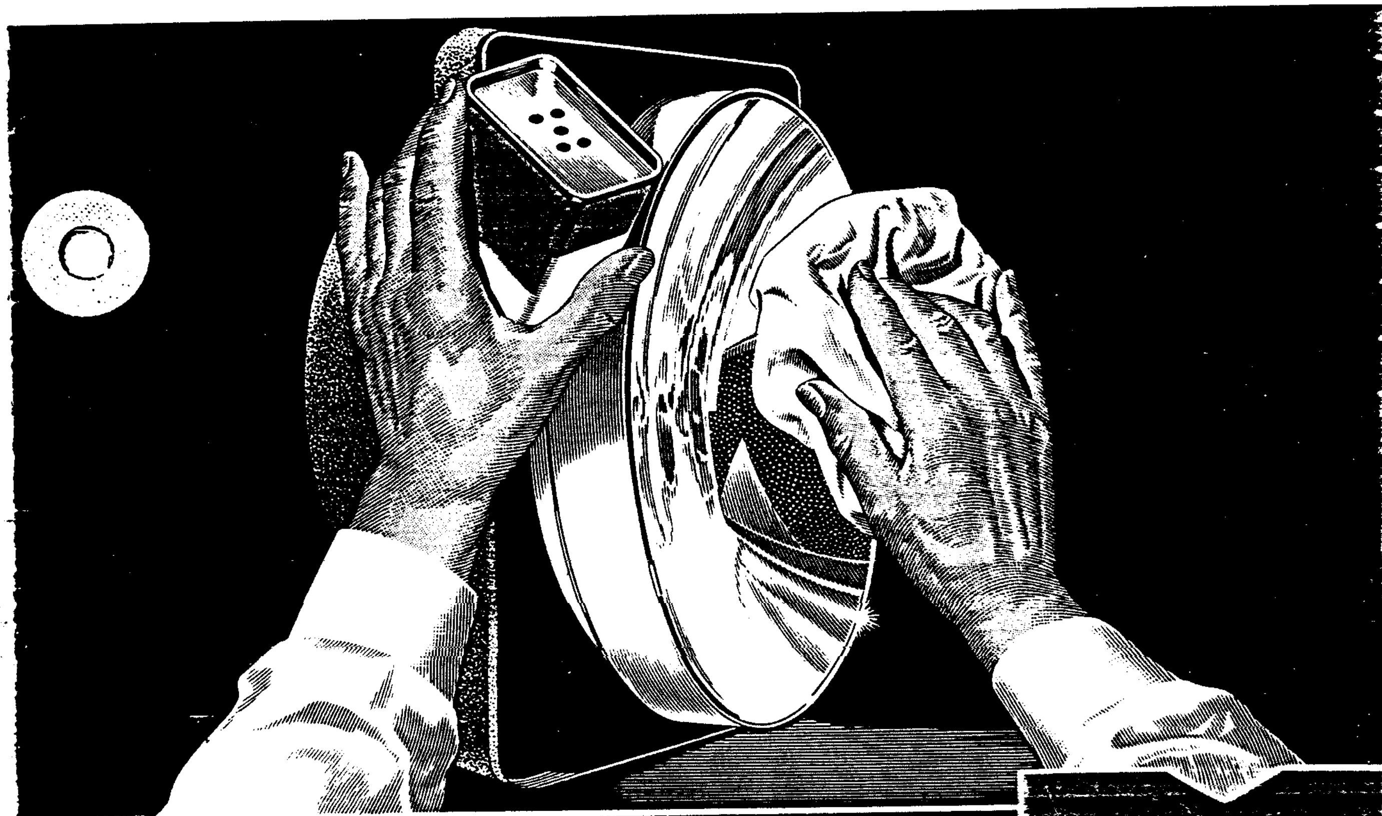


Operating Precautions

NATIONAL
TRADE MARK

5.

Projector Carbons

The modern motion picture projector is a very reliable mechanism. Although subjected in some instances to intense heat it will, if given proper care, last a long time and give excellent service. It is essential, however, that reasonable attention be given to the maintenance of all elements of the projector, and particularly to the projection lamp. For that reason this Bulletin is devoted to a resume of operating precautions which aid the projectionist in obtaining maximum efficiency and reliability in the operation of projection lamps.

Use the Right Carbons

It is highly important that the correct type and combination of carbons be used, as given in the tables (see Bulletin No. 3) covering each type of projection lamp. Projector carbons are manufactured to meet the specific requirements of a certain type of lamp and the combinations recommended have been carefully determined by laboratory and service tests. Maximum light per unit of current is obtained at the maximum recommended current for practically all types of carbons. (Fig. 1.)

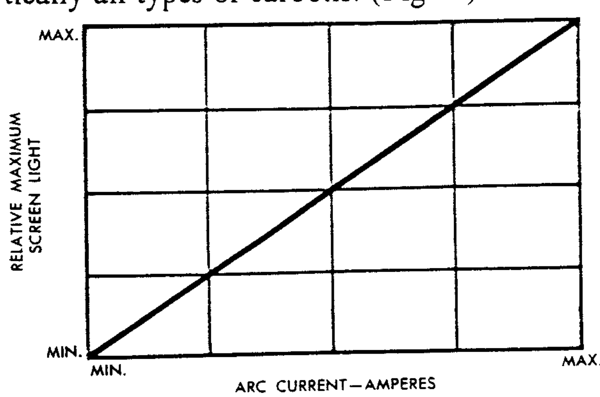


Fig. 1 Typical light-amperage curve

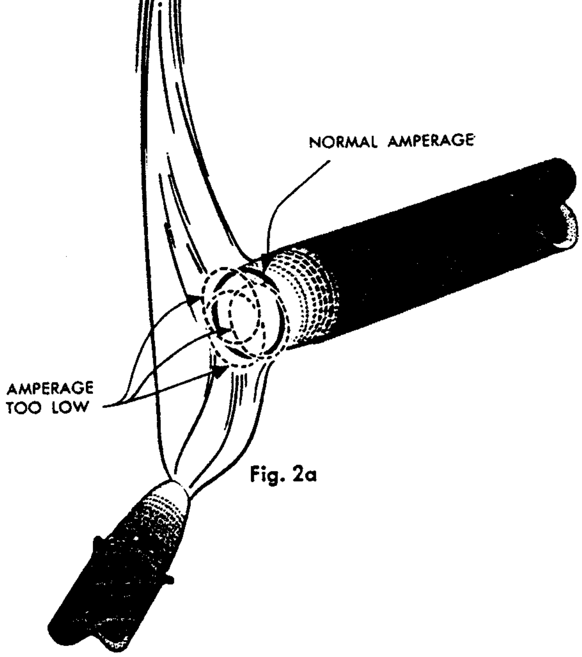


Fig. 2a

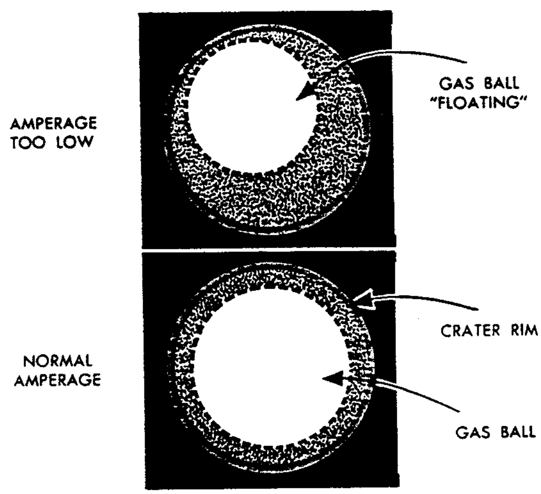


Fig. 2b

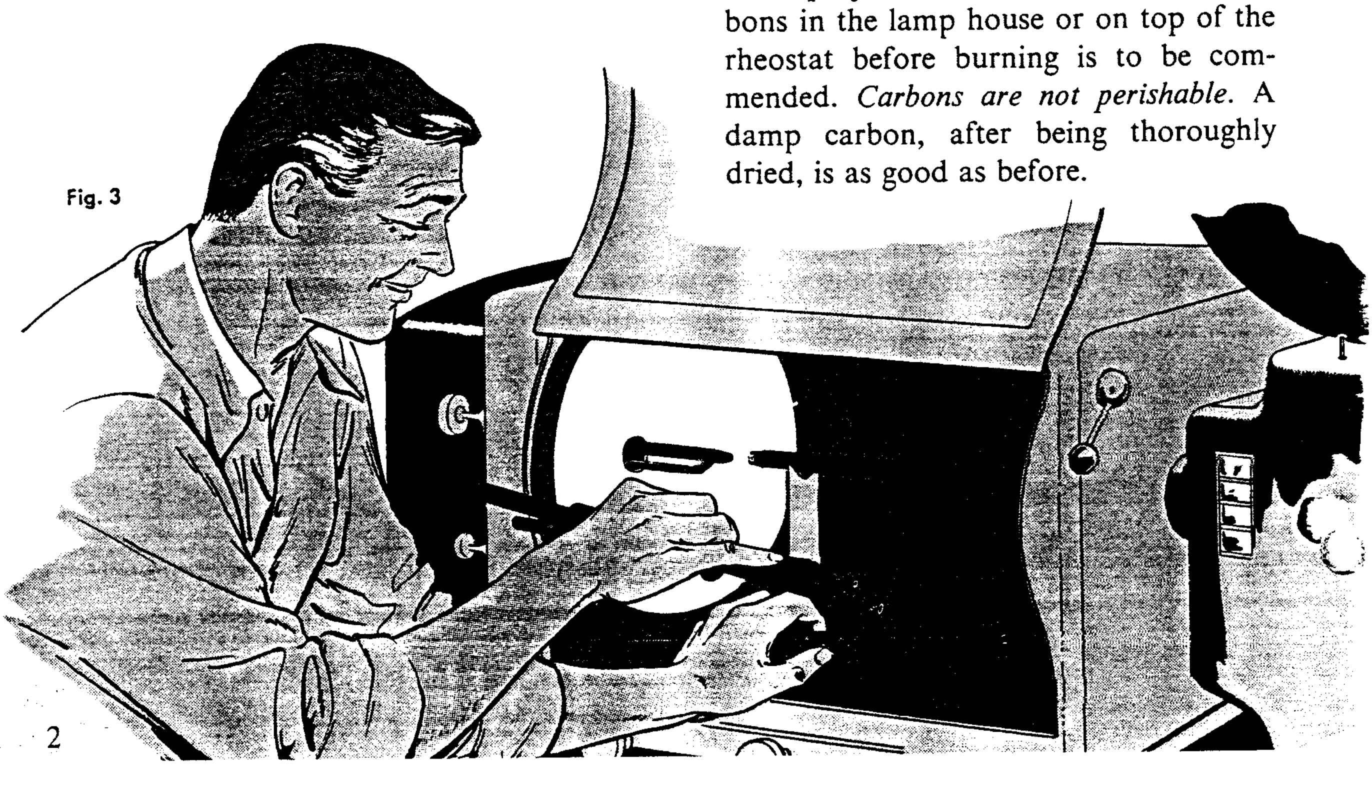
If the arc is operated below the minimum recommended values it may become unstable and fail to hold the gas ball in place with resulting unevenness of screen illumination as well as screen light discoloration. Even if no unsteadiness effect is visible on the screen the picture itself, due to low light levels, will lose contrast and sparkle because the picture is a modified image of the carbon arc light source that the audience sees.

If the arc is operated above the maximum recommended values it may become unsteady from overload and the carbon may not even feed fast enough to hold its relative optical position. Furthermore, the light output increase under these conditions is not proportionate to the increase in carbon burning rate.

Store Carbons in a Dry Place

Carbons should always be stored in a dry place. They will absorb moisture if stored in a damp location, and the result is sputtering or flashing at the arc. "National" Projector Carbons are thoroughly dry when they leave the factory but there is always the possibility of exposure to dampness during shipment or storage. For this reason, the practice of some projectionists of laying a few carbons in the lamp house or on top of the rheostat before burning is to be commended. *Carbons are not perishable.* A damp carbon, after being thoroughly dried, is as good as before.

Fig. 3



Maintain Correct Positive-Negative Alignment

In the case of a rotating type high intensity trim the lateral, or side-to-side negative position is equally as important as the vertical position with respect to the positive. If the lateral position is incorrect, then the tail flame may split, the crater burn unevenly, and the screen light may start to fluctuate. (Fig. 4.)

With the "Suprex" carbon trim, incorrect positive-negative alignment may result in in-and-out of high intensity effects where the current will fluctuate more or less widely, dependent upon the type of power source and operating conditions. The resulting screen light will become discolored and of a low value of brightness. Furthermore, mechanical alignment of the carbons should be checked to see that they maintain their relative position during their burning length. As an example, if a positive carbon guide were too high the carbon would be travelling uphill and therefore the crater of the short stub would be higher above the negative tip than would be the case with a full trim. Incorrect trim alignment will also result in crooked craters which reduce screen light.

Optical problems involved in improper positive-negative alignment are described in Bulletin No. 4.

Give Trim Time to Burn In

For a few seconds after striking the arc on a new trim, materials are being fed into the arc stream at a rate faster than normal. This means that small amounts of incandescent solids or soot are being thrown from the crater area. Either a solid dowser between the mirror and the arc, or a stream of air under pressure, is required to keep these incandescent solids off the mirror. If the arc is allowed to burn in properly before the changeover the amount of this material reaching the

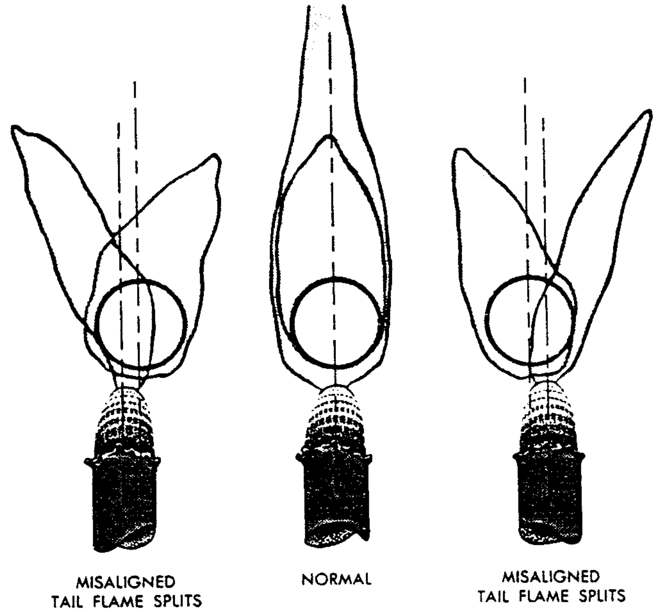


Fig. 4

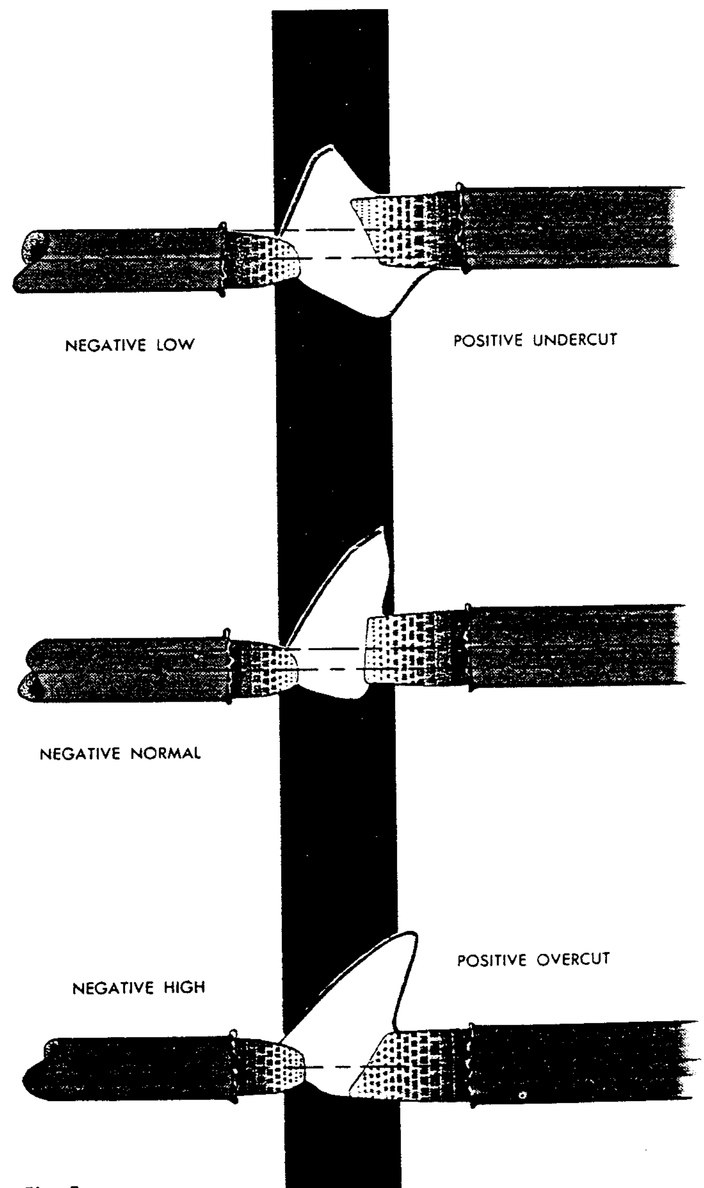


Fig. 5

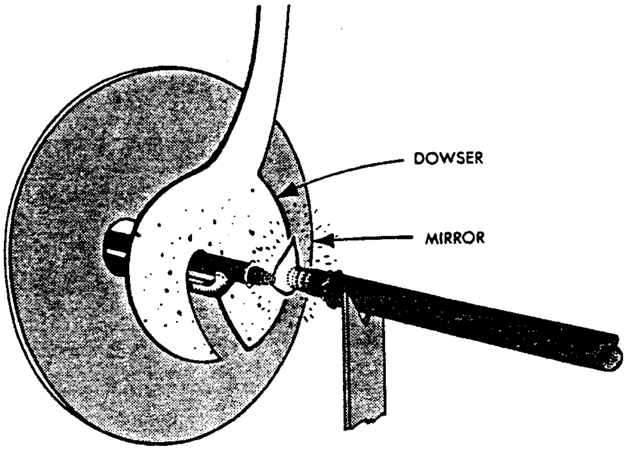


Fig. 6

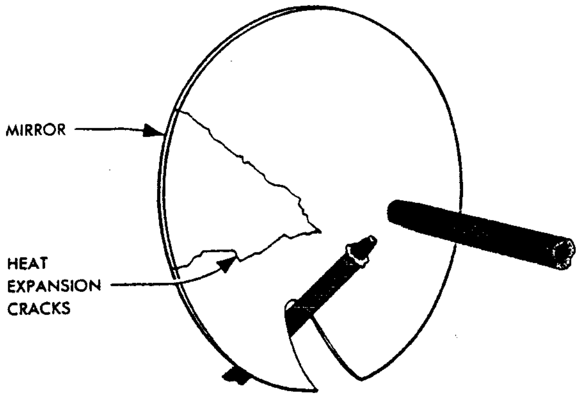


Fig. 7

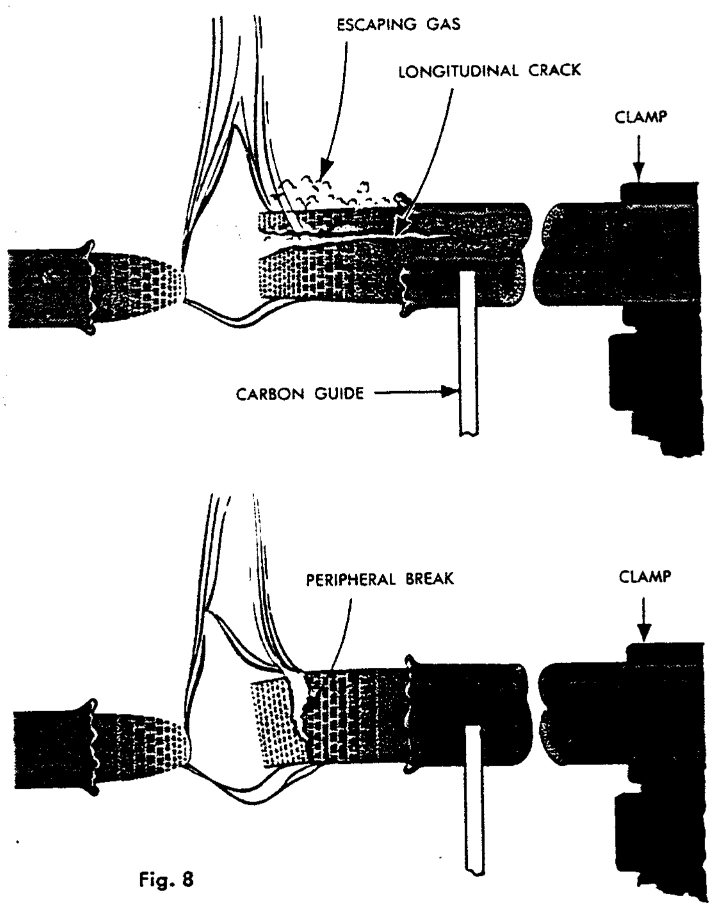


Fig. 8

mirror will be negligible.

In striking the arc, the carbons should be separated immediately since a delay in separating the carbons can possibly lead to excessive sooting.

If for some reason, the carbons are not separated quickly and a soot deposit is noticed on the mirror it should be wiped off as soon as possible. Soot spots have a tendency, depending on size, to absorb more heat energy than other areas of the mirror and this heat differential can possibly lead to mirror damage.

Other causes of mirror damage are inadequate space for heat expansion when installing, sudden cold drafts when mirror is hot, insufficient heat removal and mirror edges accidentally chipped while servicing the lamp house.

Avoid Carbon Breakage

Some clamping devices, particularly with "Suprex" positive carbons, are such that too firm a pressure on the clamping arm will crack the carbon under the copper coating. This longitudinal crack becomes an escape area for the crater gasses when the arc burns the copper away and uneven screen light is the result. Dropping a copper-coated carbon on a hard surfaced floor may cause a break in the carbon that is not discovered until the protective copper is burned away at the arc. This will allow a short piece of the positive carbon to drop off, carrying the crater with it.

Adjust Arc Controls Methodically

If the carbon trim drifts from optical position and requires hand feeding, or frequent adjustment, it is best to refer to the manufacturer's recommendations for the particular lamp and carefully follow these recommendations on a routine basis rather than make adjustments piecemeal. If all elements are adjusted in the recommended manner and sequence, very little if any manual control will be needed during the running of a reel. Often one adjustment made out of proper sequence will cause even greater unbalance.

Keep Lamp Parts Clean

Carbon holders must be kept clean and their contact with the carbons firm. The projectionist should give frequent and careful attention to the holders, removing all effects of corrosion or burning so that smooth, firm contact of full area is maintained. Defective contact between carbons and holders is a frequent cause of spindling or arc instability.

It is likewise essential that feed rollers in rotating carbon type high intensity reflector lamps be kept clean and in good condition to insure steady and accurate rotation of the positive carbon, to maintain a symmetrical crater and prevent improper feeding.

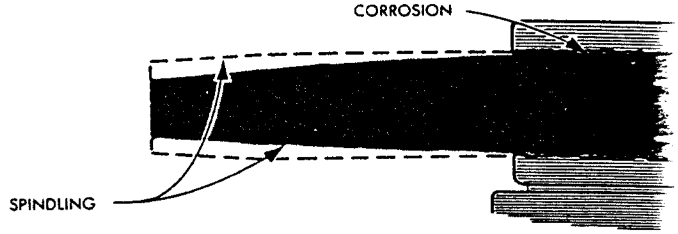
The lamp housing and mechanism should be cleaned regularly and thoroughly and all moving elements of the lamp kept lubricated with oil or grease as *specified by the lamp manufacturer.* Complaints sometimes arise from hard grease clogging the feeding mechanism and interfering with the feeding of the carbons. Such troubles can be eliminated by cleaning out the hard 'gunk' and replacing with the proper lubricant.

Magnets

If the magnet becomes too weak the arc will show an in-and-out of high intensity effect causing the current to increase rapidly for short durations. This results in very unstable screen light. If weak magnets are in use they should be replaced with new magnets as recommended by the lamp manufacturer.

Care of Rheostats

Damage to rheostats sometimes results from operation with a short arc at an arc voltage appreciably below normal. This



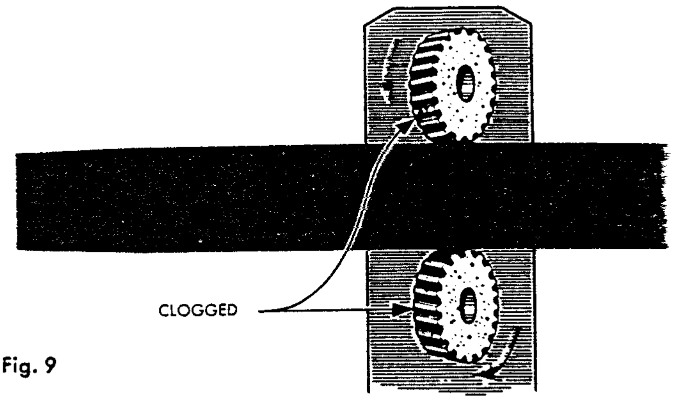


Fig. 9

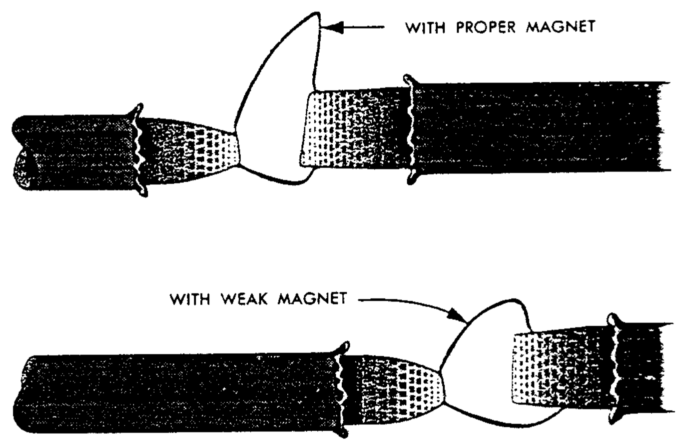


Fig. 10

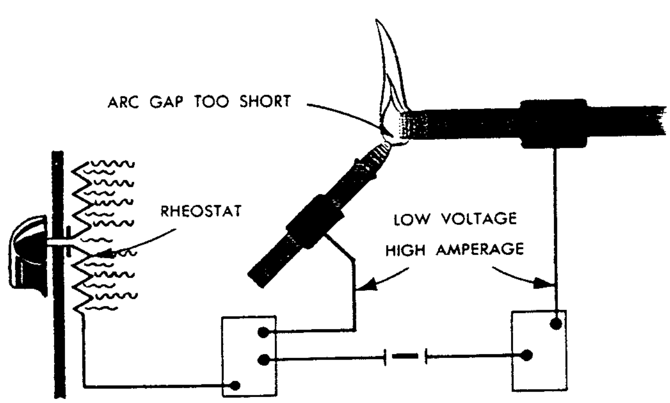


Fig. 11

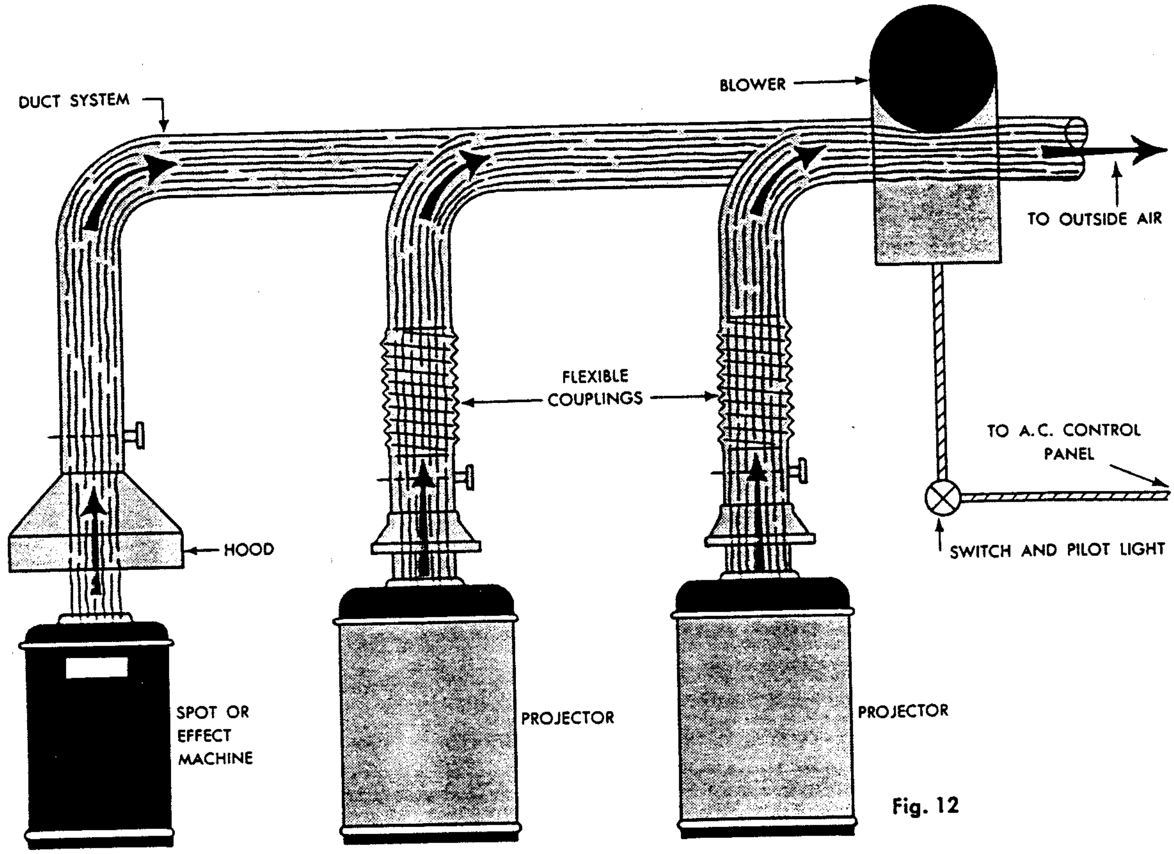


Fig. 12

practice throws a greater load on the rheostat than it is designed to carry, so that the arc current can be held down to normal value only by cutting out some of the resistance. This may force the remaining resistors to absorb so much wattage in excess of their radiating capacity that destructive temperatures result. With correct adjustment of arc gap, ample range of current control should be afforded by normal operation of the rheostat.

Keep all electrical contacts clean and firmly tightened so that the full area of contact is maintained.

Effect of Draft on the Arc

All projection lamps should be adequately ventilated. The recommended practice as set forth in the report of the Projection Practice Sub-Committee of the Society of Motion Picture and Television Engineers (Journal of the S.M.P.T.E.,Vol., XXXIX, September 1942, pp. 158) is as follows:

"The carbon arc exhaust system shall be a positive mechanical exhaust system independent of all other ventilating systems of the theatre. Each projector, spotlamp, stereopticon, or floodlight machine, of the carbon arc type, shall be connected by a flue to a common duct, which duct shall lead directly out of doors. Reduction of the ventilation to each projector as required shall be accomplished by means of a local damper between the projector lamp-house and the projection room ceiling, and, in addition, by means of the damper on the lamp-house proper if provided.

"This exhaust system shall be operated by an exhaust fan or blower having a capacity of not less than 50 cubic-feet of air per minute for each arc lamp connected thereto. The exhaust fan or blower shall be electrically connected to the projection room wiring system and shall be controlled by a separate switch, with pilot lamp, within the projection room proper. There shall be at no time less than 15 cubic-feet of air per minute through each lamp-house into this exhaust system. Figure above shows the general arrangement. The ducts shall be of non-combustible material, and shall be kept at least 2 inches from combustible material or sepa-

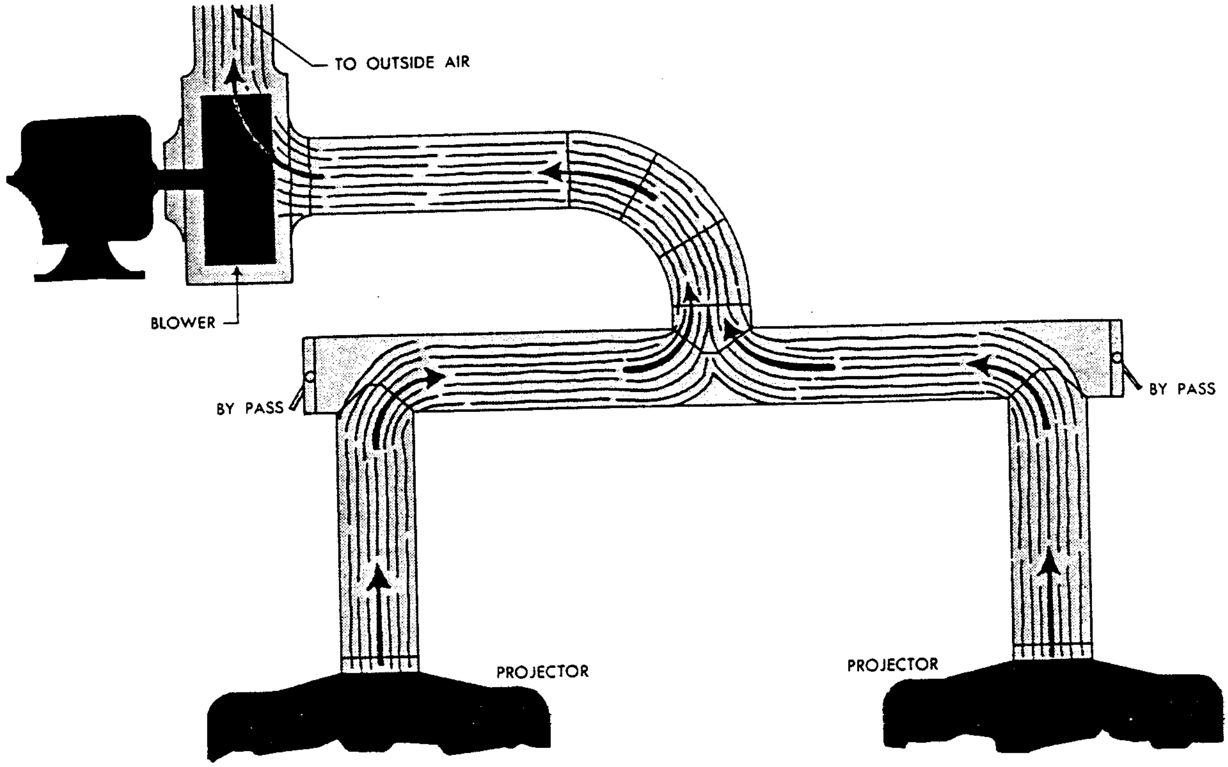


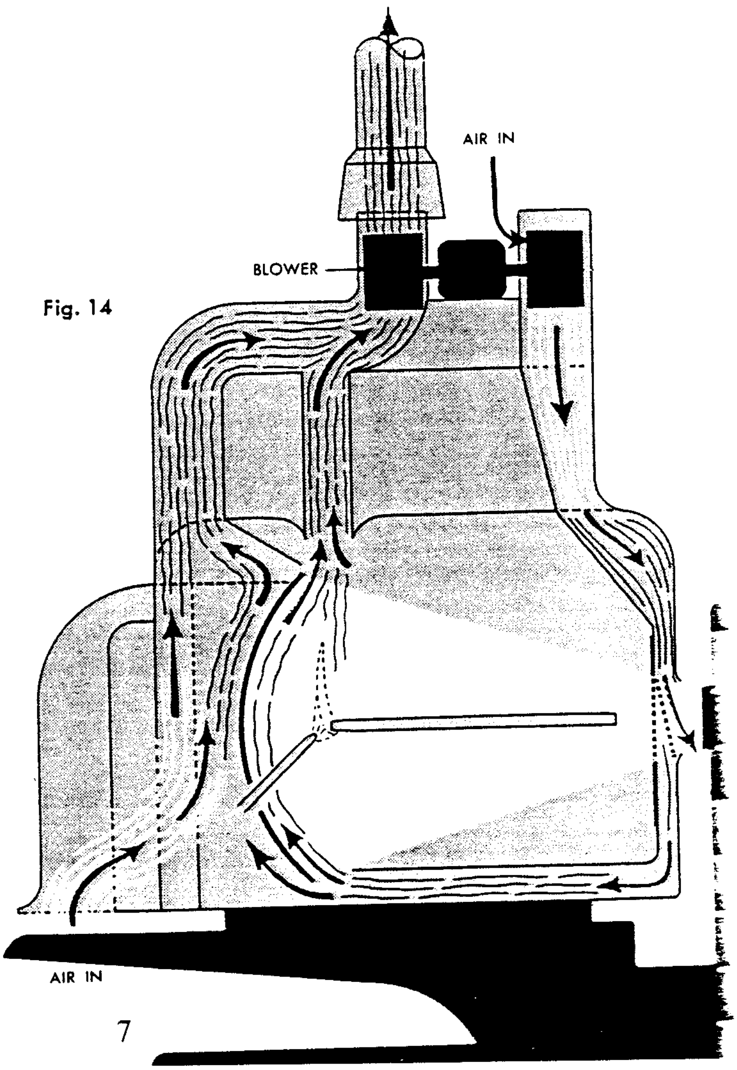
Fig. 13

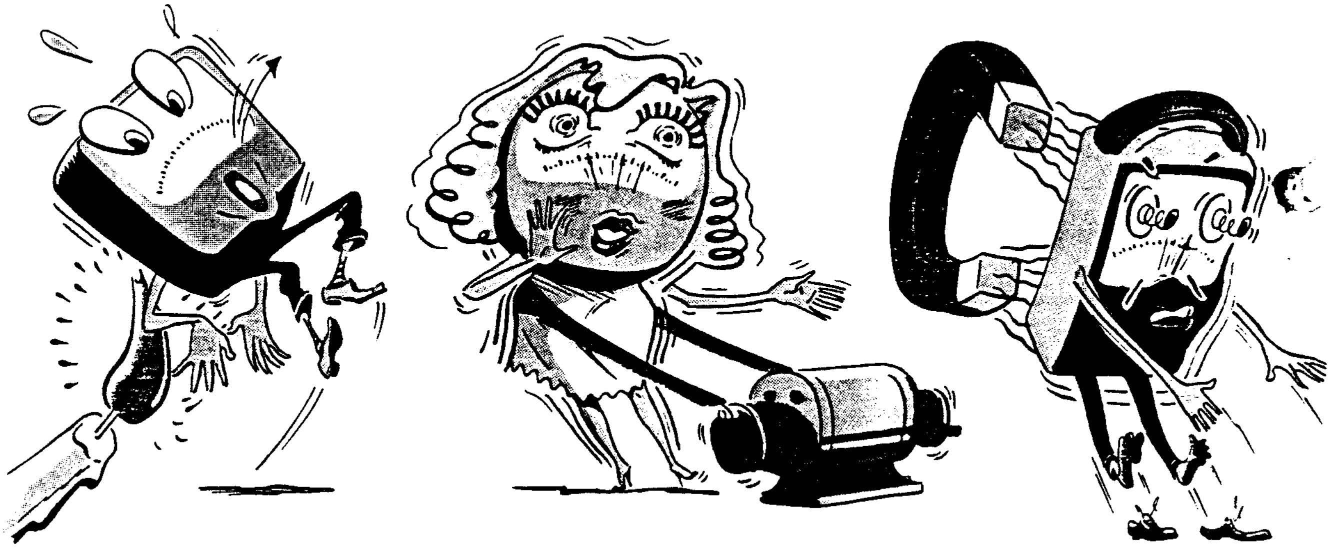
rated therefrom by approved non-combustible material, not less than 1 inch thick."

Frequently, exhaust fans or blowers are used which exhaust too great a volume of air causing the arc to waver with resultant unsteady light on the projection screen. This condition can be corrected by placing a by-pass in the exhaust duct to regulate the volume of air drawn from the lamphouse. Air intake areas should not be blocked to reduce ventilation as this interferes with the air circulation pattern within the lamphouse. If no exhaust fan or blower is used and the exhaust from the lamp is connected to a chimney to the outside of the projection room some method of preventing downdraft must be provided such as a directional hood over the chimney. Downdraft will cause arc wavering and may even cause outages by actually blowing the arc out.

For those lamps now available which contain their own exhaust system, the amount of air that should be exhausted is established by the lamp manufacturer. The ventilating system should be designed to handle the specified amount of air.

Fig. 14





Electrical Instruments

Particular attention to the care of electrical instruments will be well repaid. Ammeters, voltmeters and wattmeters are necessarily of somewhat delicate construction and the best instrument may be ruined by misuse.

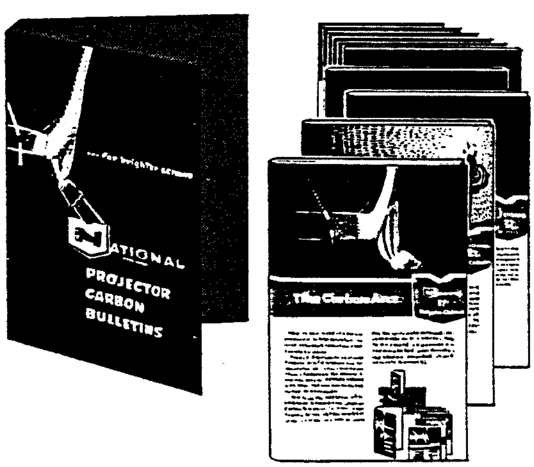
Meters should never be placed where they will be exposed to high temperature, vibration, or strong magnetic fields. Such conditions may quickly impair their accuracy.

They should be calibrated at regular intervals, at least once a year.

When adjustment or repair of meters is required they should be returned to the supplier who either has proper facilities for making the needed repairs and adjustments or will send them to the manufacturer.

The contacts on all external connections to electrical meters should be kept clean and firmly secured.

Careful attention to the foregoing precautions, and to the more specific instructions given in other Bulletins for the type of lamp in use, will afford the projectionist using "National" Projector Carbons screen illumination of maximum steadiness, brilliancy and uniformity.



THE NEXT ISSUE . . .

of "National" Projector Carbon Bulletins will start discussion of arc operation in high intensity lamps.

The terms "National," "Hitex," "Orotip," "Suprex," "Ultrex" and "Union Carbide" are trade-marks of Union Carbide Corporation.

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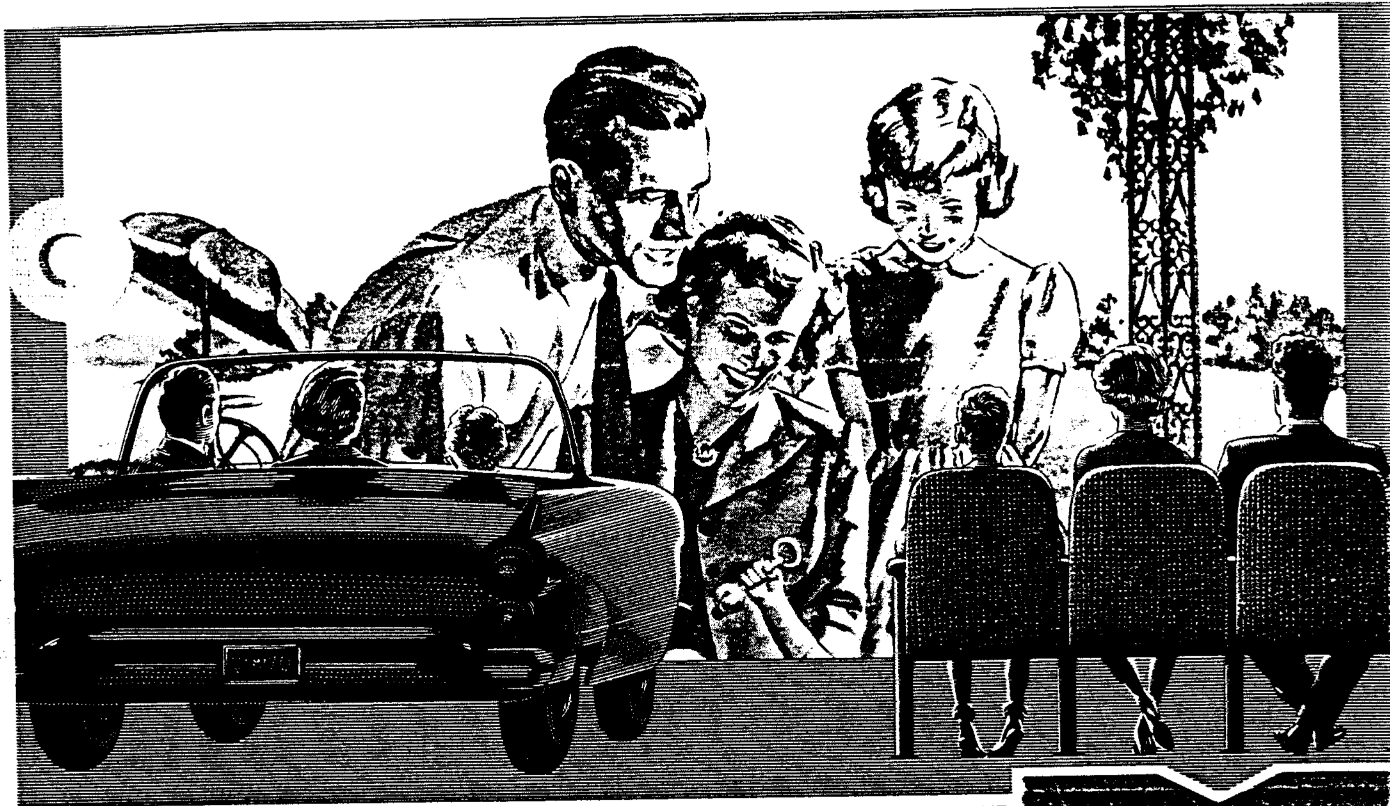


High Intensity Arcs with Rotating Positive Carbons

NATIONAL
TRADE MARK
6.
Projector Carbons

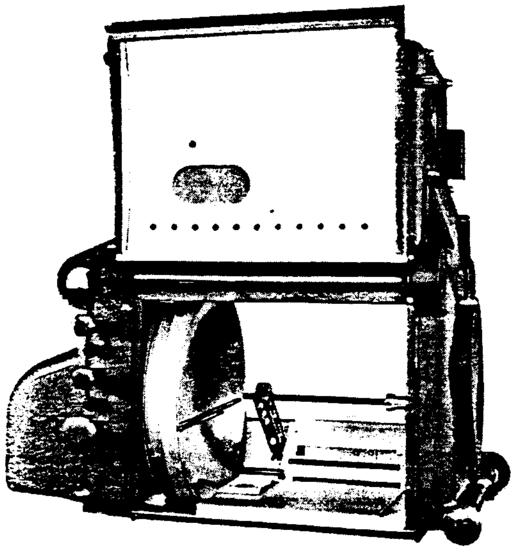
Recent years have seen important technological changes in motion picture production and correspondingly in new projection systems. Many of the new projection systems call for larger screens for both drive-in and indoor theatres. New lamps employing mirror optics, and the earlier condenser type lamps, both with rotating positive carbons, are widely used to supply the enormous amount of light essential for these large screens. This bulletin will discuss arc operation in both mirror type and condenser type high intensity lamps.

Mirror Type High Intensity Lamps With Rotating Positive Carbons

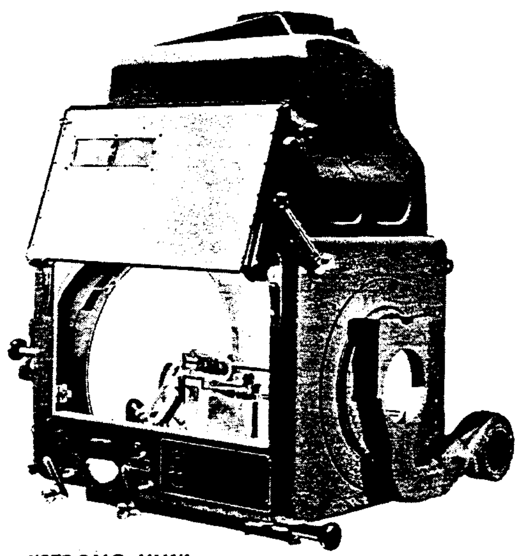
Figures a, b, and c (next page) are typical examples of mirror type high intensity lamps with rotating positive carbons.

National Carbon Company has designed, especially for these lamps, 9mm, 10mm, 11mm and 13.6mm high intensity positive carbons and 10mm "Hitex" and "Ultrex" positive carbons, together with the negative carbons suitable for the current range of each of these carbons.

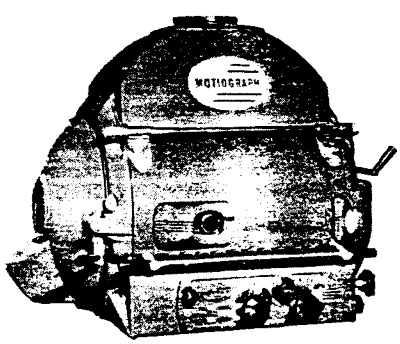
The tables in Projector Carbon Bulletin No. 3 give data on carbon trims, catalog numbers, current and voltage values, optical systems, screen illumination and consumption rates of rotating positive carbon trims for mirror type and condenser type lamps. The performance of the lamps in determining the values in those tables is typical of high quality, carefully adjusted and aligned optical systems so that light outputs are in the upper range obtained from well operated equipment



"ASHCRAFT SUPER CINEX"



"STRONG UHI"



"MOTIOGRAPH HI POWER"

Figs. a, b, c
Typical mirror type high intensity arc lamps with rotating positive carbons.

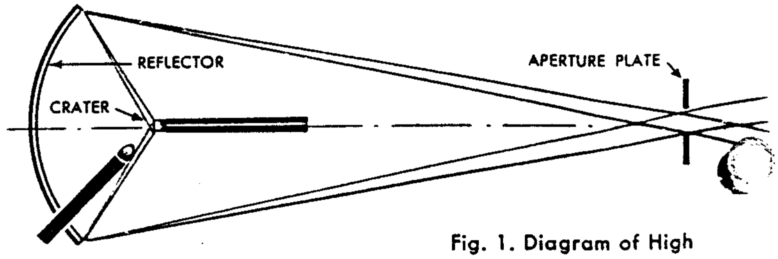


Fig. 1. Diagram of High Intensity Rotating Positive Mirror Arc Lamp

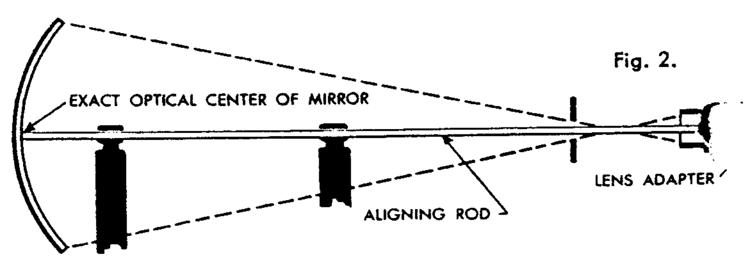
in theatres. Screen values are with no shutter, film or filters.

Figure 1 is a schematic diagram of a mirror type high intensity arc lamp with rotating positive carbon. The crater of the positive carbon faces the mirror and the crater is focused by reflection on the film aperture. At maximum screen light only the crater light (as contrasted to total light from the crater, the tail flame, the arc stream and the incandescent negative carbon) is focused on the aperture; therefore, distribution of light on the screen is determined by the distribution of brightness across the crater face and the size of the crater image on the film aperture. Some spill-over around the aperture is necessary to insure adequate coverage of the rectangular opening by the circular crater image.

Operation

Lamp manufacturers specify the distance from the positive carbon crater to the mirror, the distance from the mirror to the film aperture, the protrusion of the positive carbon from the contact jaws or flame shield and, in some cases, the arc gap. These distances should be maintained accurately and the positive crater should be accurately aligned with the mirror, film aperture and projection lens.

Fig. 2.



Individual mirrors vary slightly in focal length so it becomes necessary to make light adjustments when installing a different mirror in the lamp. One method of obtaining proper alignment involves the use of a dummy projection lens and a straight steel rod. (See Fig. 2.) The respective elements are moved so that when the end of the steel rod touches the center of the mirror, or when the steel rod passes through the center hole in the mirror (when the mirror has a hole in its center), the rod will pass through the positive carbon contact, the center of the aperture and the center of the dummy projection lens. The optical alignment should be checked periodically and always checked after any adjustment of the equipment involving movement of the lamp house or projector head.

In some lamps fixed magnets are used to control the position of the tail flame. The magnetic field is so adjusted that the tail flame is directed upward and away from the optical system. A properly directed air stream may be used to prevent the tail flame from striking the mirror.

All "National" high intensity projector carbons are pre-cratered to reduce the time necessary to burn in the crater of a new carbon; however, when burning in a new carbon sufficient time should be allowed to form a good crater of proper depth before the changeover is made.

When a high amperage arc is struck the positive crater is subjected to both thermal and mechanical shock, particularly if the arc is struck at full current. Occasionally this shock causes the lip of the crater to be cracked or a chip to break away so that the burn-in time necessary to form a symmetrical crater is increased. (See Fig. 3.) This will occur more frequently when contact is made on the lip of the crater. The ballast resistance should be wired so that the operating current upon striking is about one-third full load. The current

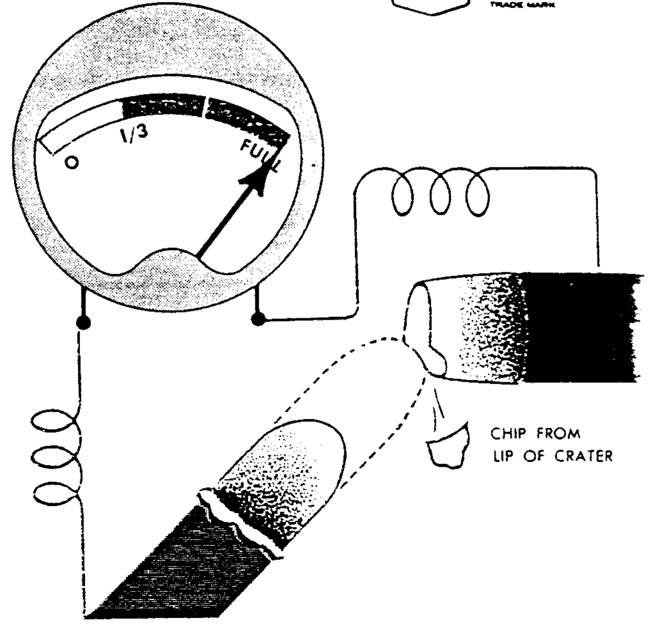


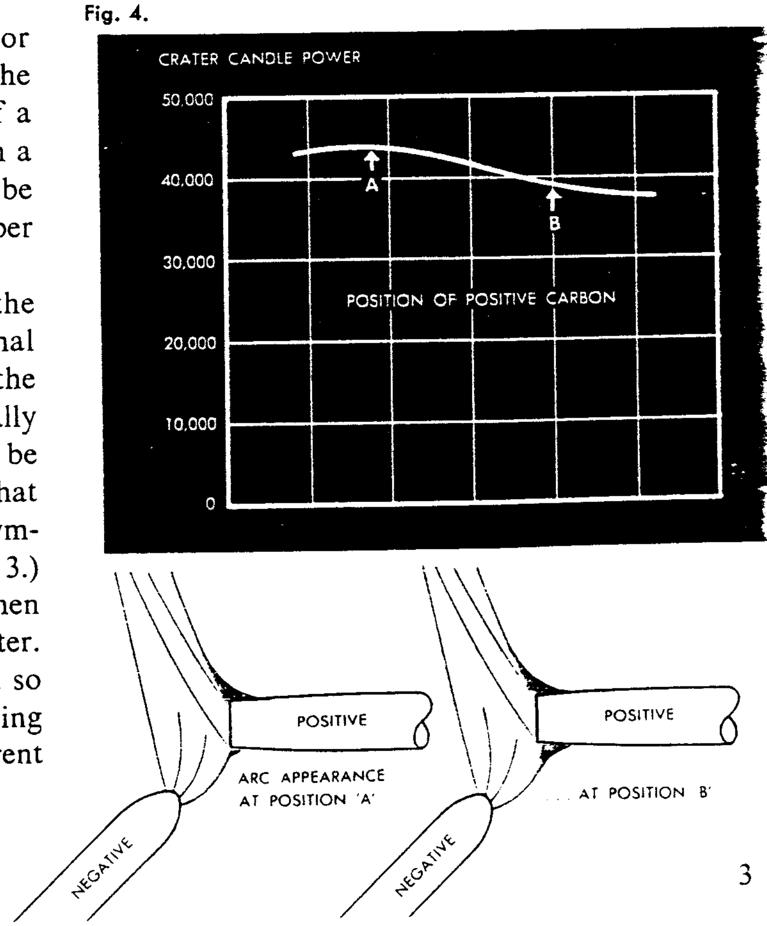
Fig. 3. Thermal and mechanical shock at crater tip

is promptly boosted to normal after the arc is struck. A step-up switch is available for this purpose.

Positioning of Carbons

In order to obtain the best results from high intensity carbon arcs particular attention should be paid to the proper position-

Fig. 4.



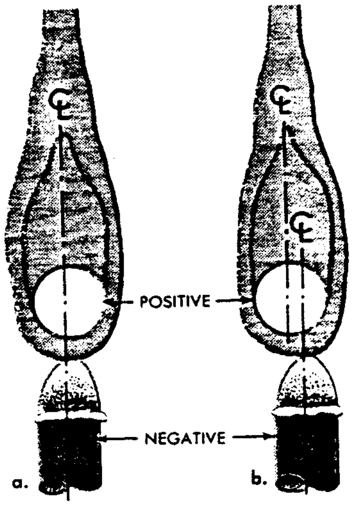


Fig. 5. a. Carbons are normally aligned in same vertical plane b. Some carbons are normally positioned off center

ing of the positive and negative carbons. (See pages 6 and 7, Bulletin No. 4.) The effect on the crater candle power by a variation in the position of the positive carbon with respect to the negative is shown in Figure 4. The arc current is held constant in these tests. The letters A and B on the curve indicate the values of crater candle power corresponding to the positions A and B of the carbons illustrated in the sketches below the curve. At position A the bottom edge of the arc flame between the two carbons is located so that its continuation passes through the crater face of the positive carbon. At position B the positive carbon has been moved forward so that the flame sweeps underneath it. The arc will burn steadily in either position. However, it is evident from the curves that maximum crater candle power is obtained with the carbons at position A. At position B the crater candle power is reduced by as much as 10 per cent.

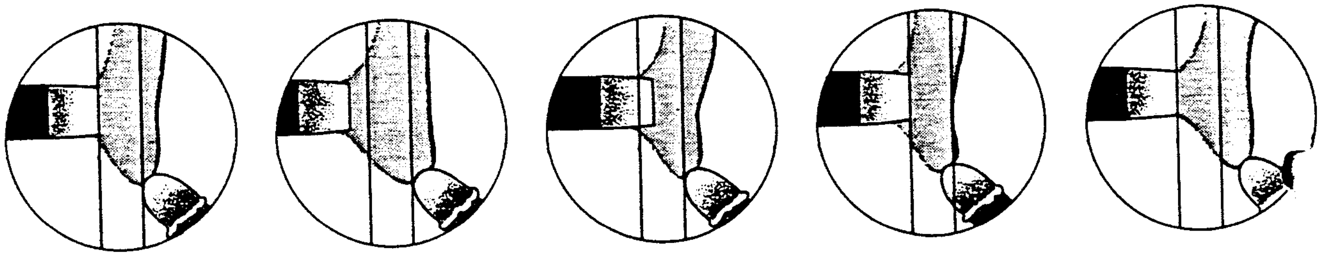
Operation of the lamp with the positive carbon set ahead of its correct position not only reduces the volume of light but may also result in short carbon life. A protrusion of ⅛ inch beyond the proper setting may decrease the life of the positive carbon as much as 10 per cent.

In most high intensity lamps with rotating positive carbons the negative should be in the same vertical plane as the positive; that is, the carbons should be accurately aligned as viewed toward the positive crater. (See Fig. 5a.) Due to the current lead arrangement in some lamps, however, better positive crater formation is obtained by positioning the center line of the negative slightly off the center line of the positive. (See Fig. 5b.) The lamp manufacturers' instructions for positioning the carbons should be strictly adhered to, because certain lamp characteristics may alter the generally recommended positioning of the carbons.

The use of too short an arc gap may make it impossible to adjust the positive carbon feed to the rate at which the carbon is being consumed. Likewise, if the negative carbon feed is adjusted to feed the negative carbon faster than it is being consumed, the arc will be shortened and the same difficulty encountered. (See Fig. 6.)

The position of the crater of the rotating positive carbon with respect to the mirror also determines the color of the light on the screen, just as it does in mirror type high intensity lamps with *non-rotating positive carbons*. This is to be discussed in some detail in Bulletin No. 7.

Fig. 6.



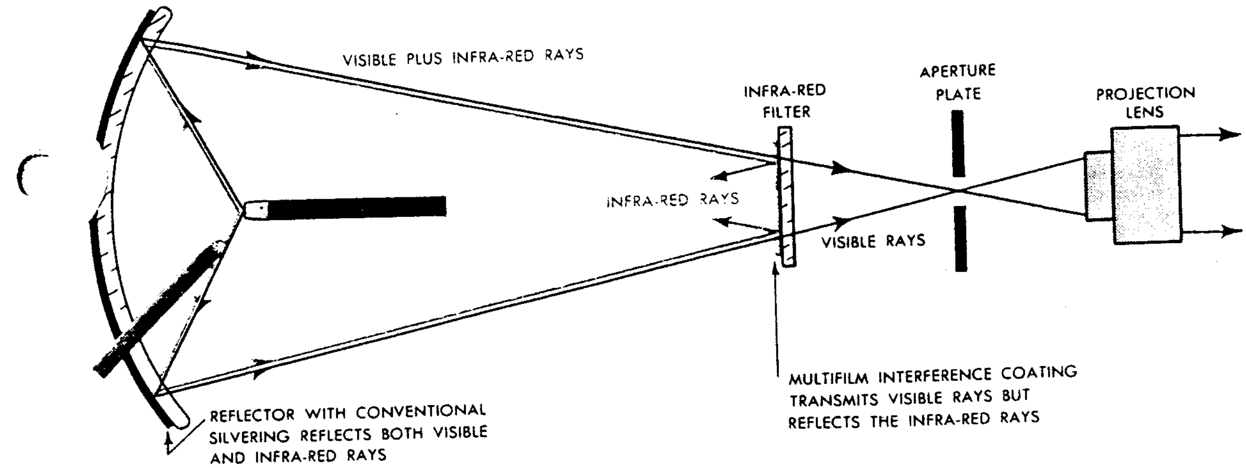


Fig. 7.

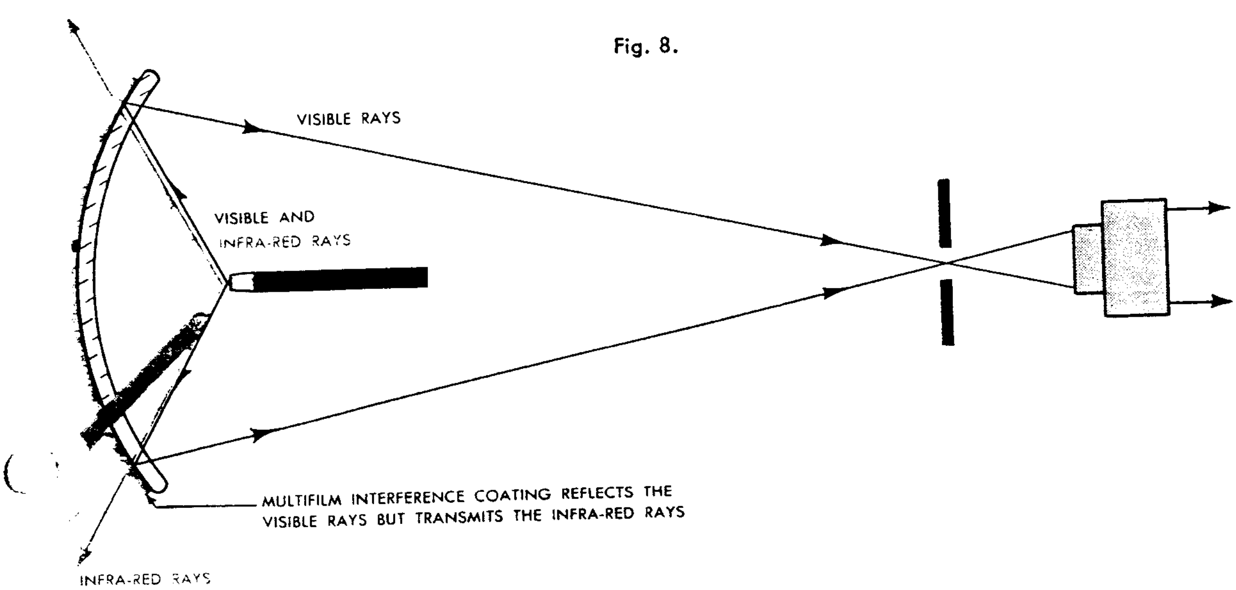
Effect of Heat on Film

When certain high intensity carbons are used with the highest speed optical systems, it may be necessary to provide means of filtering out some of the heat in the light beam to prevent damage to the film.

It is known that other factors besides the intensity of radiant energy emitted by the carbon arc have an influence on the ppearance or non-appearance of undesir-.ble effects of heat on film. Some of these factors are the past history of the film, the spectral reflection and transmission characteristics of the optical system and the per cent shutter opening. Experience shows that 7mm, 8mm and 9mm "Suprex" carbons have generally been free from any heat-on-film problem. The 9mm and 10mm high intensity carbons employed in rotating type mirror lamps have in some cases encountered difficulty and in others have been free from it.

We do not attempt to specify means of protection of the film from high levels of radiant-energy flux. However, use of infra-red absorbing filters, infra-red reflecting filters, infra-red transmitting mirrors, controlled air blast and the use of a water-cooled film gate have all been claimed to provide some protection to the film. Infra-red absorbing filters can remove 40% to 50% of the total radiant energy at the film aperture with an accompanying loss of 10% to 20% of the visible light. Some infra-red reflecting filters and infra-red

Fig. 8.



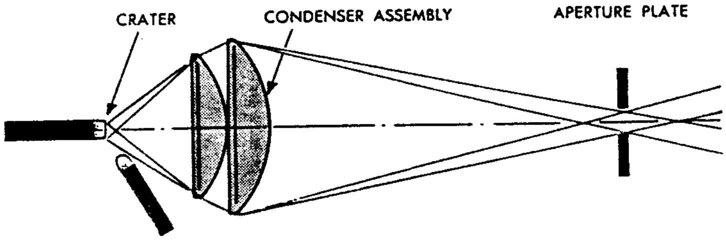
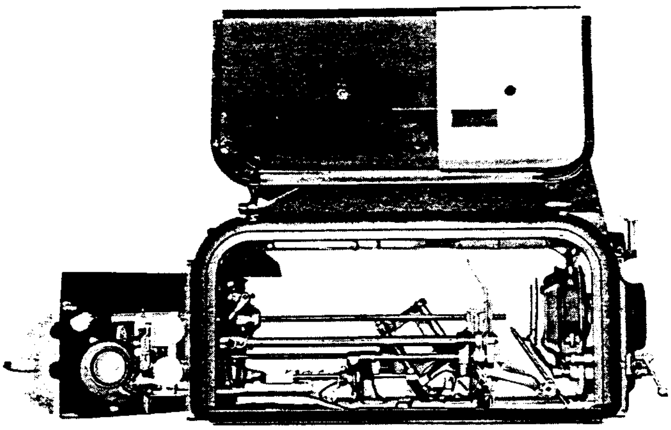


Fig. 9. Schematic of Typical Condenser Type Lamp



"PEERLESS HY-CANDESCENT"
Fig. 10. Typical Condenser Type Lamp

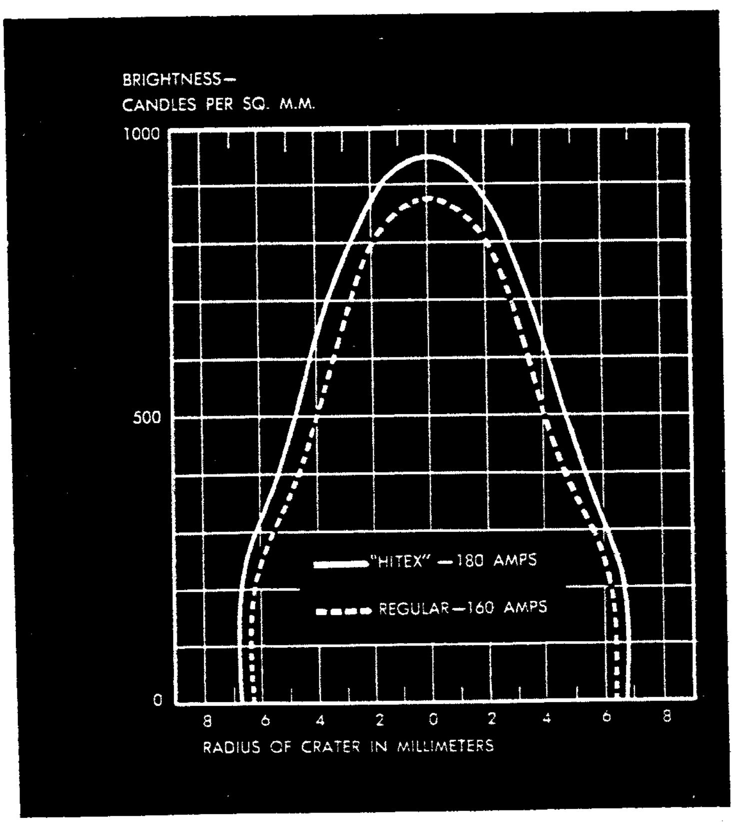


Fig. 11. Brightness Distribution Across Crater of 13.6mm H. I. Carbons

transmitting mirrors can reduce the total energy at the aperture 30% to 40% with not more than 10% loss of visible light. It has also been concluded that suitable "air-cooling" of the film might permit increases of 30% to 60% in the safe maximum light intensity. Consult lamp manufacturer.

Condenser Type High Intensity Lamps With Rotating Positive Carbons

The first application of the high intensity arc to projection was through the medium of a condenser lens optical system. It gave three to four times as much light on the screen as the original low intensity arc and further improved the efficiency of light production. Subsequent improvements in the condenser lens system for high intensity lamps raised the efficiency of the optical system to more than five times that obtained from the earliest projection lamps. Thus improved, these lamps delivered about forty times the amount of light projected on the screens of the first motion picture theatres. This figure, in turn, has been more than doubled by the latest improvements in high intensity carbons and optical systems, making the screen illumination now available ninety times that originally used.

Figure 9 is a schematic diagram of a condenser type high intensity lamp with rotating positive carbon. The crater of the positive carbon faces the condenser lens system and the crater is focused on the film aperture. The total light from the high intensity arc is made up not only of the crater light but the light from the tail-flame, arc stream, and incandescent negative carbon as well. The total candle power is generally about 40 per cent higher than the candle power of the crater alone. However, it is impossible to use all of the light for projection purposes because of the large size and shape of the complete source. At maximum screen light, only the crater is focused on the aperture so that the distribution of light on the screen is essentially determined by the distribution of the brightness across the face of the crater and the size of the crater image on the film aperture. It is necessary to have some spill-over around the aperture to insure adequate coverage of the rectangular opening by the circular crater image.

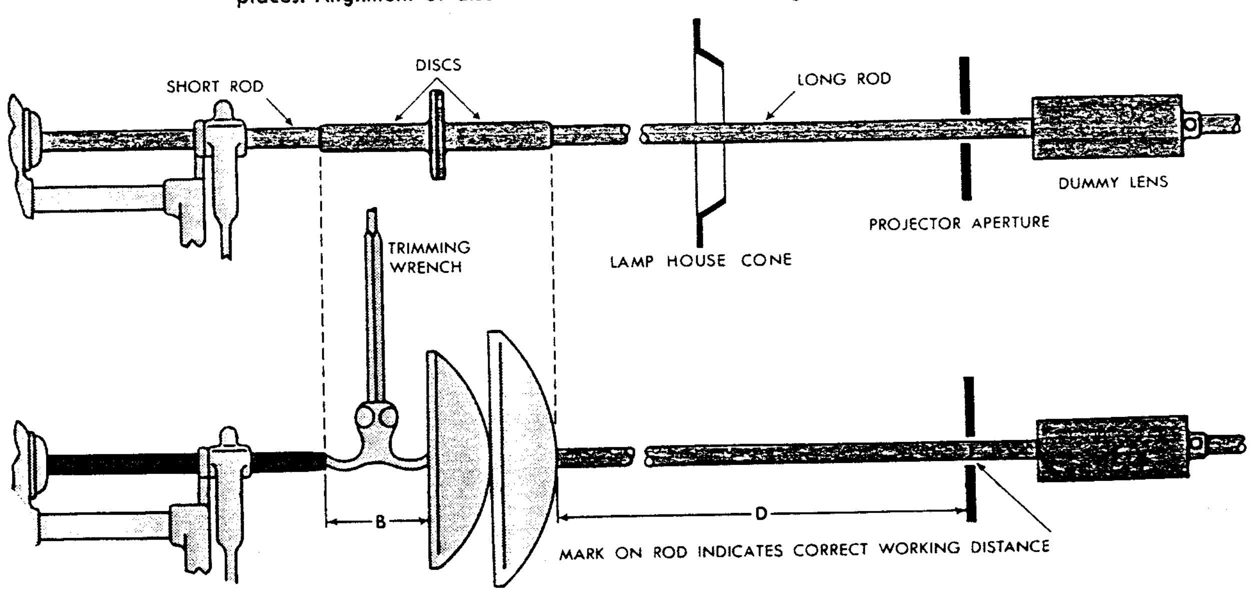
Early high intensity arcs with rotating positive carbons were operated at currents of from 50 to 110 amperes but subsequent development of carbons by the laboratories of National Carbon Company permits operation up to 160 amperes with the regular trim and 180 amperes with the "Hitex" carbon trim. Experimental carbons have been operated at currents well over 1,000 amperes.

A comparison of brightness distribution across the crater of 13.6mm high intensity carbons is made in Figure 11. The increase in light with the "Hitex" carbon is shown in the higher and broader brightness curve. The brightness curve shows the amount of light emitted in the forward direction per unit area across the crater. For example, assume we are looking directly into the crater. For each square millimeter (0.00155 square inch) at the center of the crater of the "Hitex" carbon, the light coming toward us would be equivalent to that from 940 candles. For the same point on the crater of the regular carbon we would have an intensity equal to that of 860 candles. For a given optical system, i.e., condensers and objective lens, the light on the screen is governed by the brightness of the carbon plus the area of the usable high-brilliancy portion of the crater. Thus it is apparent from the curve why the available lumens on the screen for a given optical system and screen light distribution are higher for the "Hitex" carbon than for the regular carbon.

Operation

Operation of high intensity arcs in condenser type lamps is similar to that in mirror type high intensity lamps. Details of operation, such as the distance from the positive carbon crater to the rear condenser lens, the distance from the front condenser to the film aperture, and the protrusion of the positive carbon from the contact jaws or flame shield, are specified in instruction booklets issued by lamp manufacturers. (See Fig. 13.) As is the case

Fig. 12. Step 1. After removing carbons, condenser and projection lens, mount rods and discs in their places. Alignment of disc faces and rims indicates alignment of optical axis.



Step. 2. Replace carbons, condenser lenses. Adjust distances by using wrench handle as gauge.

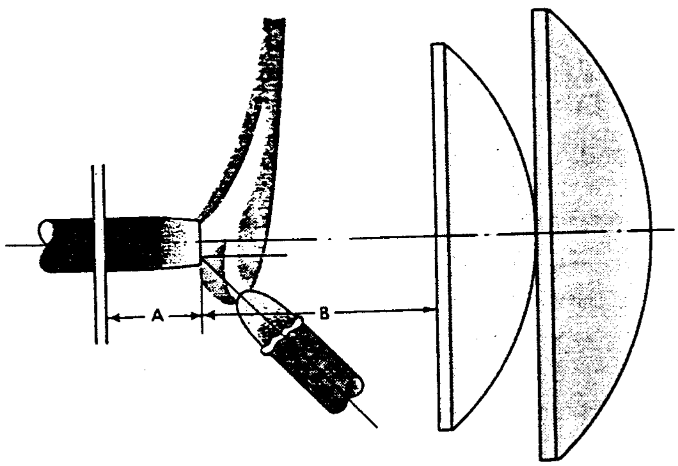
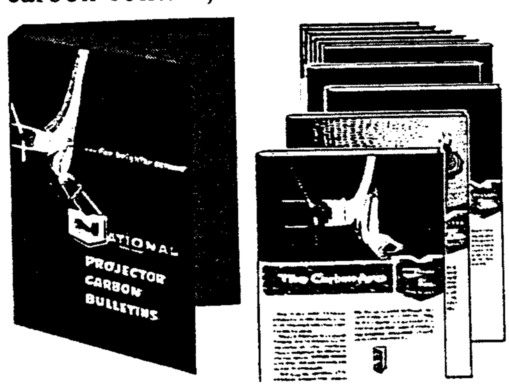


Fig. 13. Check lamp manufacturers' manuals for details of adjustment.

with all high intensity lamps, these distances should be maintained accurately and the positive crater should be accurately aligned with the condensers, film aperture and projection lens. Some lamp manufacturers supply devices for properly aligning the carbons and optical system. One device employs a dummy condenser and a dummy projection lens, each made of light weight metal to fit the respective holder, and mounted in place of the real lens where alignment is to be checked. This is accomplished by removing the respective elements so that a straight steel rod will pass in turn through the positive carbon contact, the center of the dummy condenser lens, the center of the aperture, and the center of the dummy projection lens. (See Fig. 12.) In all other respects, the principles of operation of condenser type high intensity lamps are the same as those for the mirror type with rotating positive carbons, as described on pages 2 to 4 in this Bulletin, under the headings "Operation" and "Positioning of Carbons."

Heat on Film

In condenser type lamps, 13.6mm high intensity carbons have been free from heat-on-film problems in the lower part of the current range. It has been quite generally recognized, however, that this trim, when burned in the upper part of its current range, and the 13.6mm "Hitex" carbon throughout its entire current range, require some protection of the film from the effects of radiant energy. Another case where more radiant energy flux is passed through the aperture than can be accommodated by film without suitable preventive and corrective measures is the 13.6mm "Ultrex" carbon. Multiple usage of more than one of the protective measures described on pages 5 and 6 of this bulletin may be necessary to accommodate such extremely bright sources as the "Ultrex" carbon arc.



THE NEXT ISSUE . . .

"National" Projector Carbon Bulletin No. 7 will discuss Mirror Type Lamps using "Suprex" Carbons.

The terms "National," "Hitex," "Orotip," "Suprex," "Ultrex" and "Union Carbide" are trade-marks of Union Carbide Corporation

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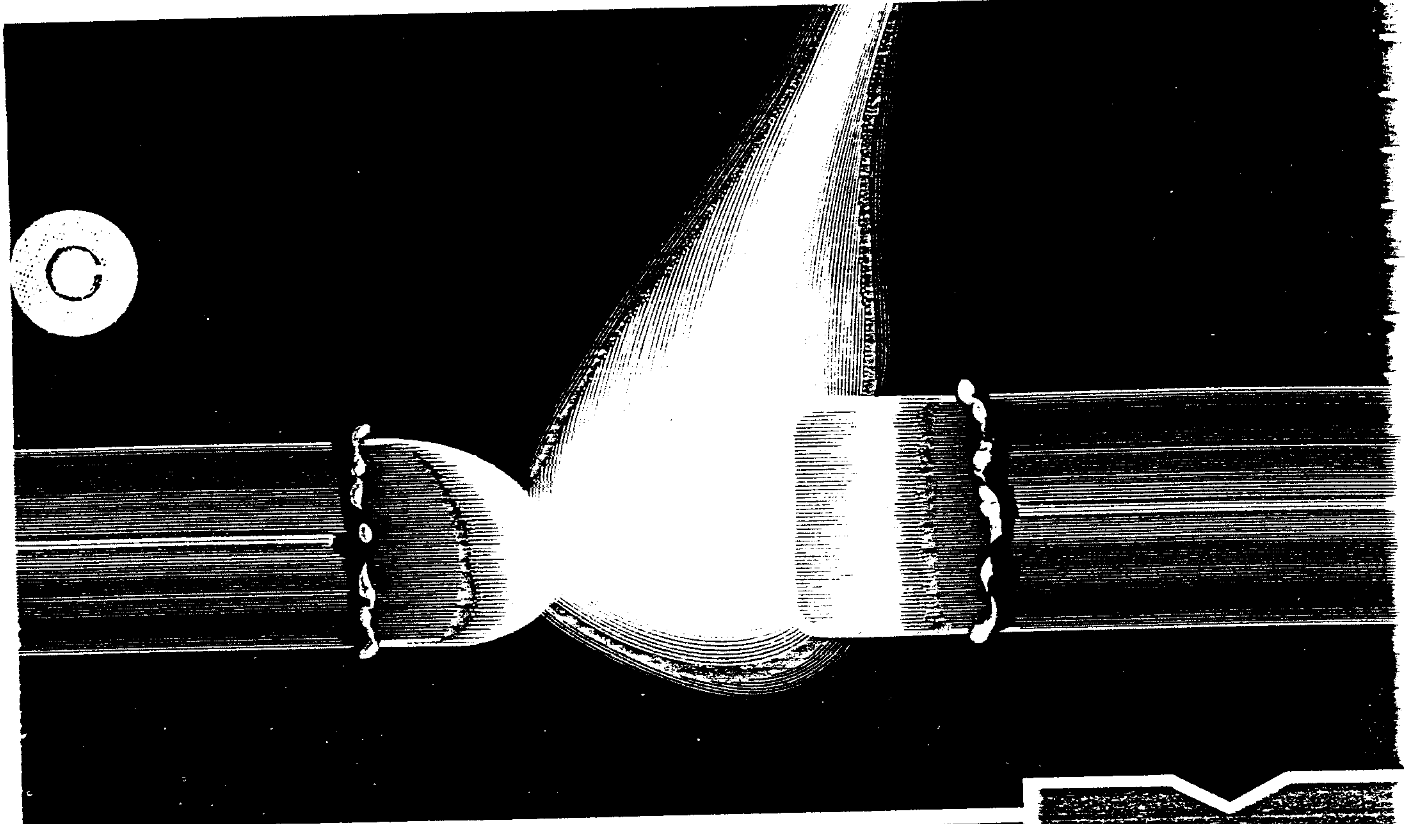


Mirror Type High Intensity Lamps Using "Suprex" Carbons . . . Non-rotating Positive

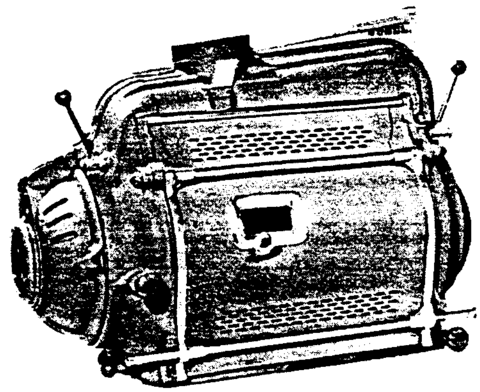
NATIONAL

7. Projector Carbons

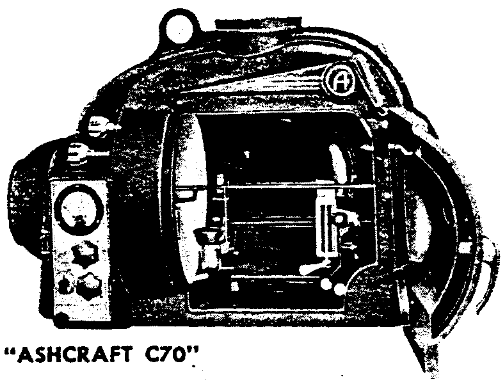
The mirror type direct current arcs using "Suprex" carbons and the "One Kilowatt" direct current and alternating current arcs with coaxial non-rotating carbons brought to both the medium and small size theatres the same high levels of screen brightness and the same snow-white quality of light as the rotating positive type high intensity arc provides for the largest theatres.

As pointed out on page 1 in Bulletin No. 5, maximum light per unit of current is obtained at the maximum recommended current for practically all types of carbons. Here and there a situation is found where a trim of larger diameter than indicated is used in an attempt to cut carbon cost. By so doing quantity, quality and steadiness of light is sacrificed. Compared with other expenses in a theatre, the cost of carbons is negligible—only a few cents an hour. The product which the theatre sells to its audience is the picture on the screen. A film costing hundreds of thousands of dollars, poorly lighted, loses its effectiveness with probable loss of patronage. It is sound economy, therefore, to use only the best quality of carbons, in correct combination and operated within the manufacturer's recommended current range.

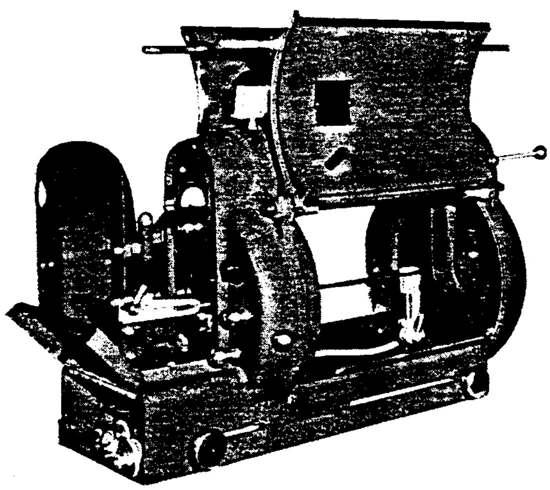
The tables in Projector Carbon Bulletin No. 3 give data on carbon trims, catalog numbers, current and voltage values, optical systems, screen illumination and consumption rates for non-rotating positive carbon mirror type lamps. As in the other similar tables, the performance of the



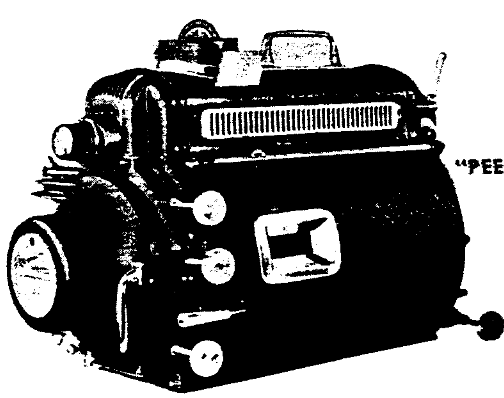
"STRONG MOGUL"



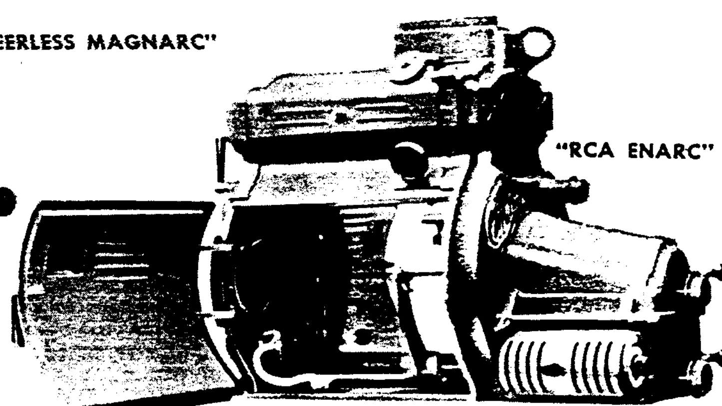
"ASHCRAFT C70"



"BALLANTYNE LIGHTMASTER"



"PEERLESS MAGNARC"



"RCA ENARC"

Fig. 1. Five typical mirror-type High Intensity Arc Lamps with non-rotating positive carbons.

lamps in determining the values in these tables is typical of high quality, carefully adjusted and aligned optical systems so that light outputs are in the upper range obtained from well operated equipment in theatres. Screen values are with no shutter, film or filters.

While the lamps designed to operate these arcs are fully automatic there are certain operating precautions with which the projectionist must be familiar to obtain maximum efficiency from these arcs. The fundamental factors important to the operation of the reflector type high intensity arcs described in this bulletin under sub-headings are not necessarily listed in order of relative importance, because any one factor if neglected will result in lowered efficiency of light production.

Effect Upon Screen Light of Changing the Position of the Arc and Arc Current

The principles presented in this section also apply to mirror type lamps with rotating positive carbons described in Bulletin No. 6. In short, the effects of throwing the arc out of focus with respect to the reflector are explained. It is important that Figures 2 and 3 be studied at the same time.

In Figure 2, the light source and the film aperture are placed at the two foci, F and F_1 respectively, of the elliptical reflector, which gathers the light from the crater of the positive carbon and directs it to the film aperture. The light at the aperture in turn is imaged on the screen by the projection lens.

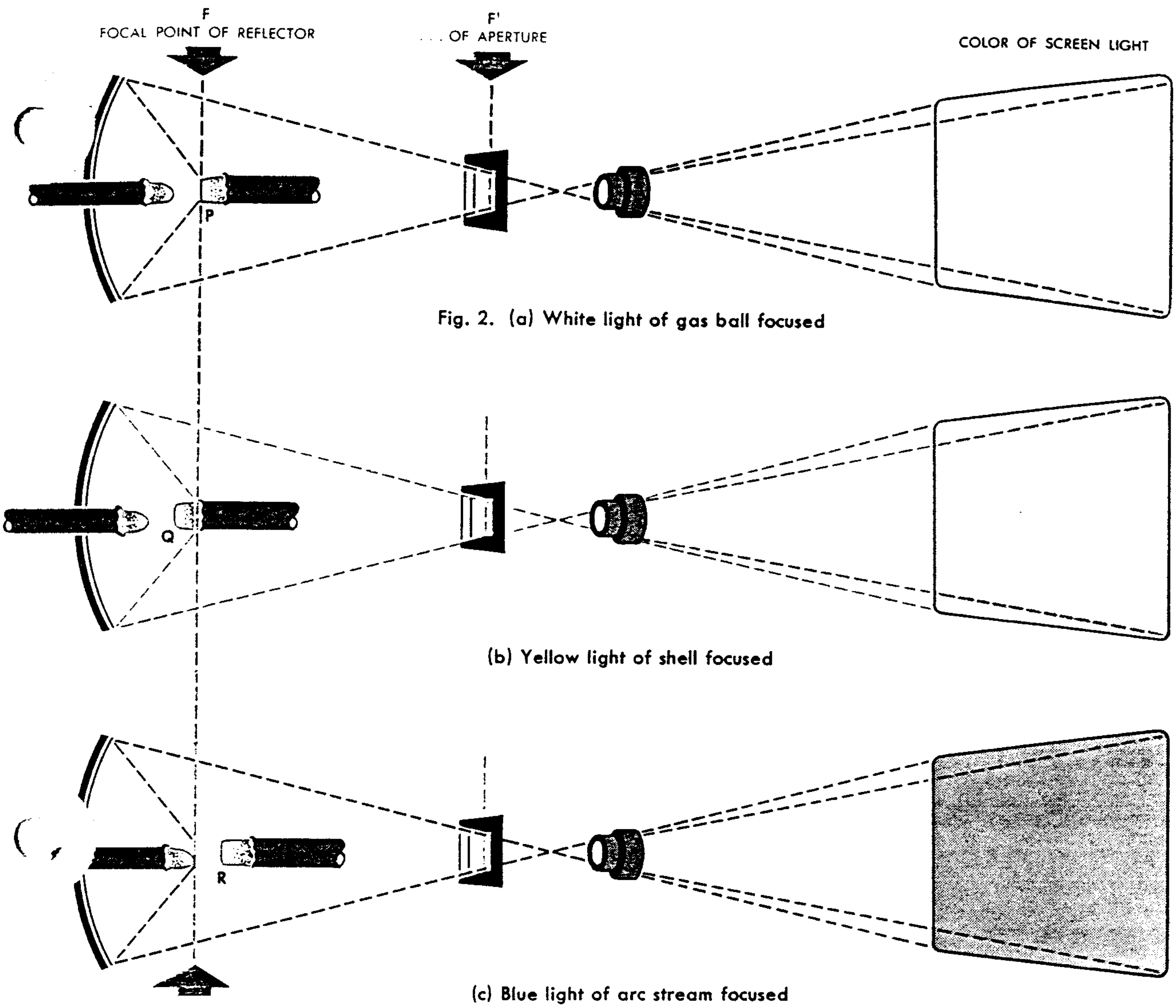


Fig. 2. (a) White light of gas ball focused

(b) Yellow light of shell focused

(c) Blue light of arc stream focused

The path of the projected ray is from one focal point F to the margin of the mirror and to the other focal point F_1, which is located at the center of the aperture. Three positions of the crater of the positive carbon, namely P, Q and R are shown by the sketches in Figure 2. A diagram of a typical non-rotating high intensity arc, Figure 3, identifies the colors of light at various positions in the arc stream. It can be seen that if the crater is positioned at P the white light from the center of the crater is focused at the center of the film aperture and projected on the screen. This is the ideal location to obtain the best quality and intensity of screen light. If the crater is moved ahead to posi-

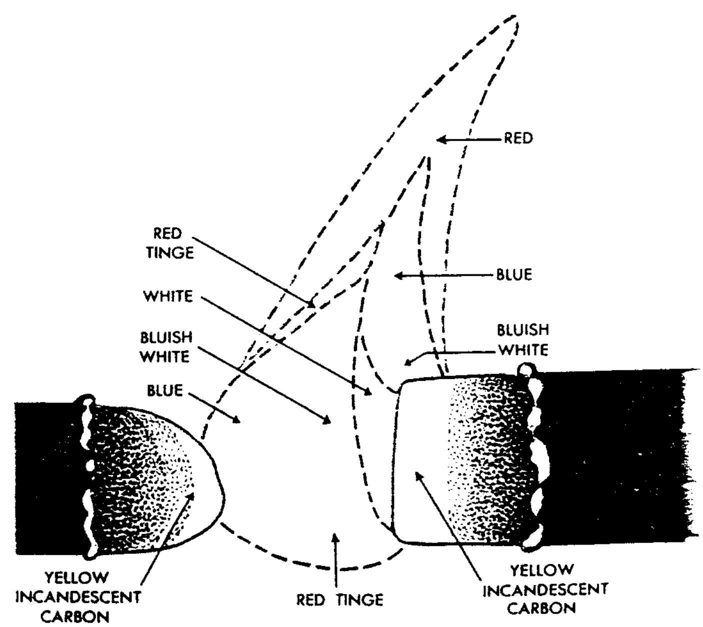
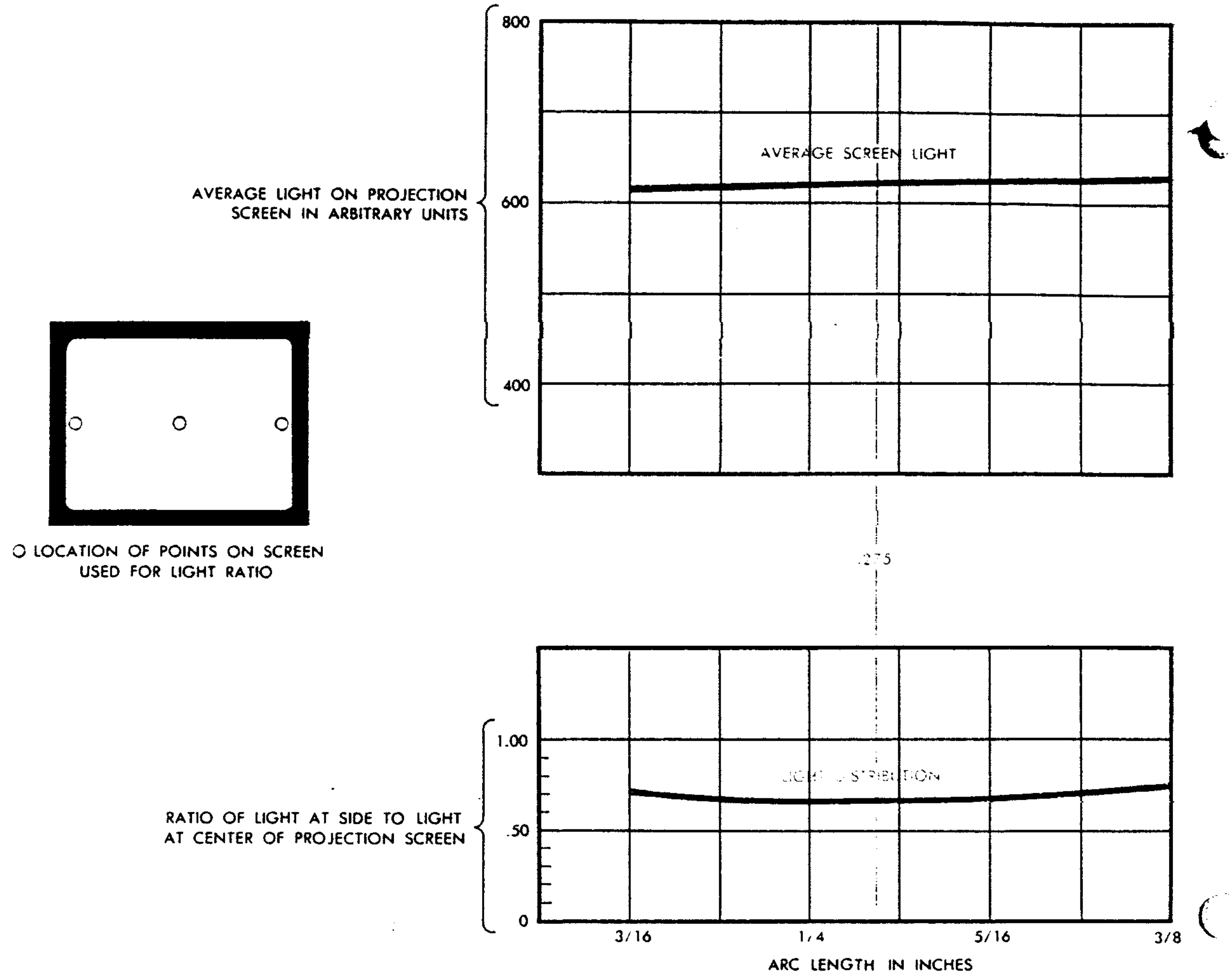


Fig. 3. Typical arc flame ("Suprex" carbon arc) detailing the color areas



Carbons used: 8mm positive, 7mm negative

Fig. 4. Light on Projection Screen vs. Arc Length: Positive Carbon 5.00 Inches from Reflector; Constant Current, 70 Amperes

tion Q, the ray traveling to the center of the aperture originates from the cooler position of the carbon back of the crater. This results in a change of color and intensity of the light at the center of the aperture and projection screen thus giving it a yellowish or reddish tinge. Similarly, if the carbon recedes to position R, the ray traveling to F_1 originates from the arc stream in front of the crater, which is blue in color and the screen light is affected correspondingly.

Even within the range of allowable movement of the crater for satisfactory screen color, there are changes in total screen light and distribution of light over the screen. The relations between screen light and screen distribution, and arc length, current, and arc position are shown in Figures 4, 5 and 6. The arbitrary units assigned to the ordinates in these curves are merely illustrative; exact values are dependent on the optical system employed.

In ordinary practice the arc length of an 8mm positive—7mm negative trim is usually maintained at .275 inch. The effect upon the screen light of varying the arc length, while keeping the current constant and the positive crater at exactly the same position with respect to the reflector, is shown in Figure 4. It is obvious from these curves that both the total light on the screen and the distribution of the light are affected by changing the arc length

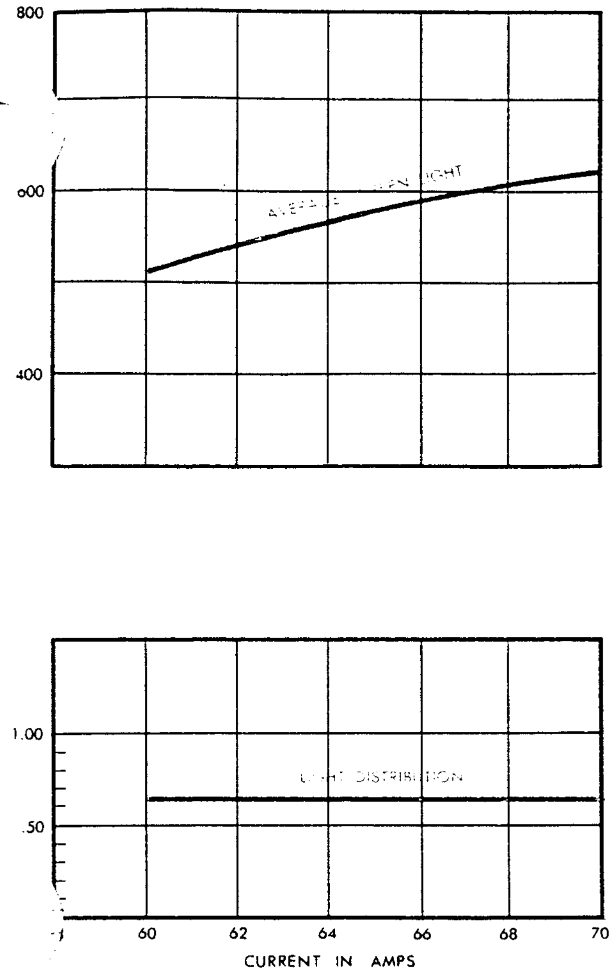


Fig. 5. Light on Projection Screen vs. Current: .275 Inch Arc Length, Positive Carbon 5.00 Inches from Reflector

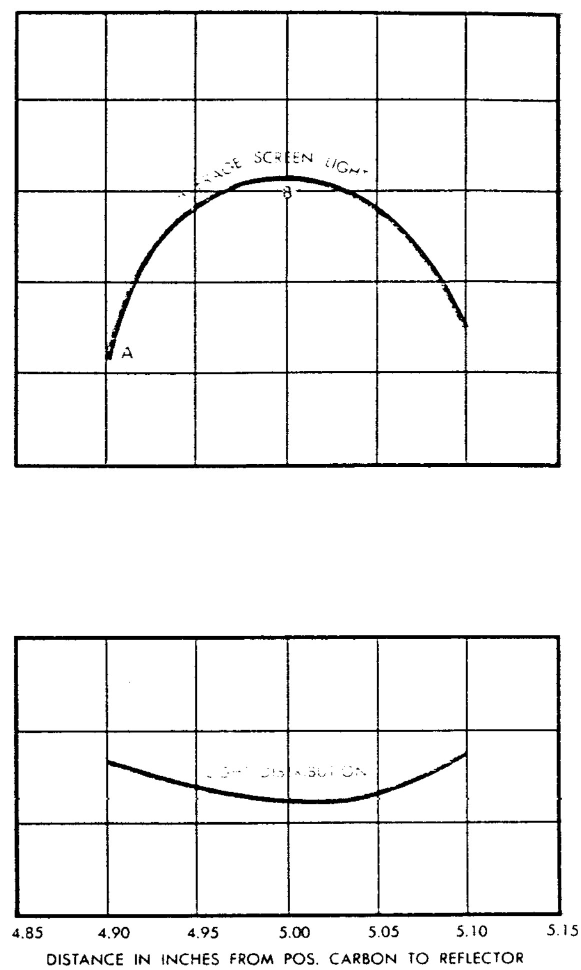


Fig. 6. Light on Projection Screen vs. Position of Arc: 70 Amperes; .275 Inch Arc Length

from 3/16 to ⅜ inch. It may be a temptation to use a long arc length to take advantage of a small increase in light. If, however, the arc length is comparatively great there is a perceptible wavering of the arc which tends to cause a fluctuation of the screen light. An arc length of .275 inch is a good compromise between total light, distribution on the screen, and arc steadiness. The gain in light obtained by increasing the arc length from .275 to ⅜ inch is only 2 per cent, which is offset by wavering of the arc.

If the current is increased but the arc length and position of the arc with respect to the mirror are held constant, there is a very definite increase in screen light, but very little change in light distribution, as illustrated in Figure 5, determined for 8mm carbons. For an increase in current from 60 to 70 amperes, or 17 per cent, the light on the screen is increased by 20 per cent. This increase in light is accompanied by an increase in crater depth and carbon consumption. If the arc current is too low, the crater is very shallow and the light is not uniform in color. If the current is too high, the carbon consumption is excessive and the light is unsteady.

If the current and arc length are maintained constant but the arc itself is moved with respect to the reflector, the screen light and distribution vary as indicated in Figure 6. To maintain a good distribution

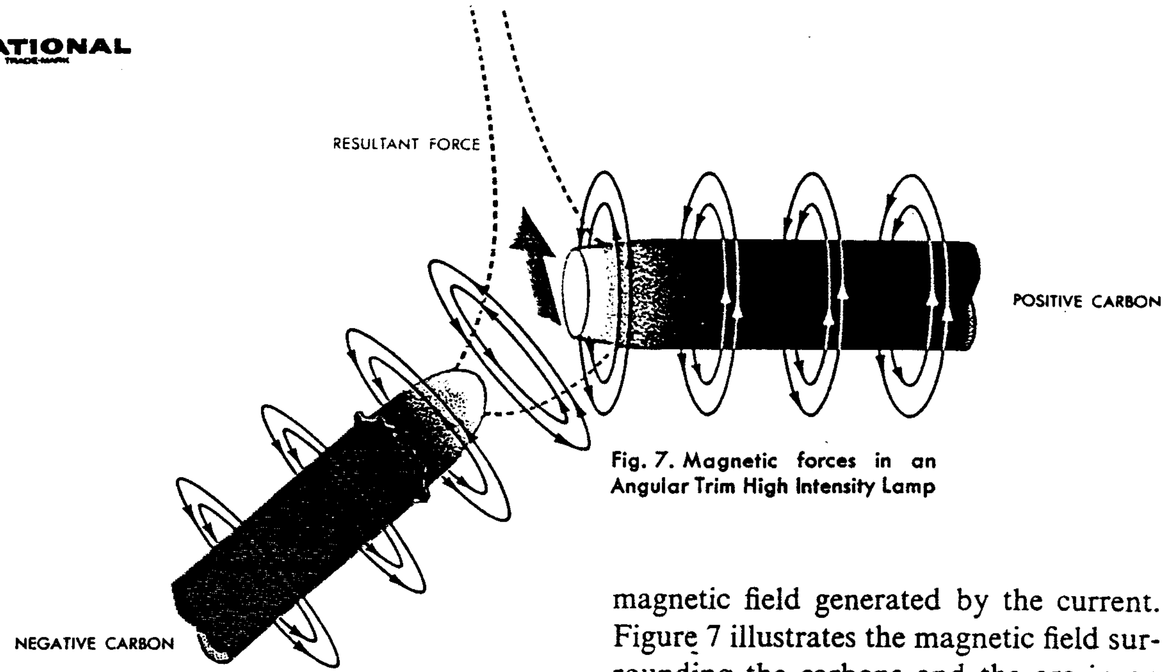


Fig. 7. Magnetic forces in an Angular Trim High Intensity Lamp

of light upon the screen, it is necessary to hold the position of the crater within close limits.

At A in Figure 6, the light at the sides of the screen is equal to 83 per cent of that at the center of the screen, and the edge of the positive crater is 4.90 inches from the center of the reflector. If the arc is moved closer to the reflector, the distribution of light on the screen becomes more uniform but the average light on the screen decreases. If the arc is moved away from the reflector, the average light on the screen increases until the point B on the curve is attained, at which the average light is at its maximum, and the ratio of light at the sides of the screen to the light at the center of the screen decreases to a minimum. Continuing the movement of the arc away from the reflector results in a decrease in average screen light and an increase in the ratio of light at the sides of the screen to the light at the center of the screen.

Magnetic Flux Used To Stabilize the Arc

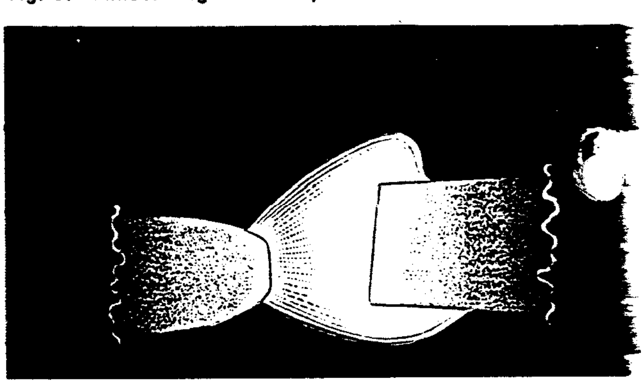
Angular trim

It is a fact that every conductor carrying an electric current is surrounded by a magnetic field generated by the current. Figure 7 illustrates the magnetic field surrounding the carbons and the arc in an angular trim high intensity lamp. Because of the angular position of the carbons in these lamps the magnetic lines of force generated by the current are crowded below the arc and are less dense above the arc. The resultant effect of this combination of magnetic lines is a force upward (indicated by the arrow) which, in conjunction with the natural flow of the arc stream, projects the tail flame of the arc in an upward and forward direction from the positive crater. In certain applications, sufficient magnetic flux is not provided by arc current flow. In these instances, auxiliary magnets are included in lamp construction.

Horizontal trim

In the "Suprex" carbon high intensity type lamps where both carbons are held in a horizontal position the magnetic lines of force are distributed uniformly around the carbons and there is no concentration of magnetic flux beneath the arc such as

Fig. 8. Without magnetic force, tail flame surrounds arc



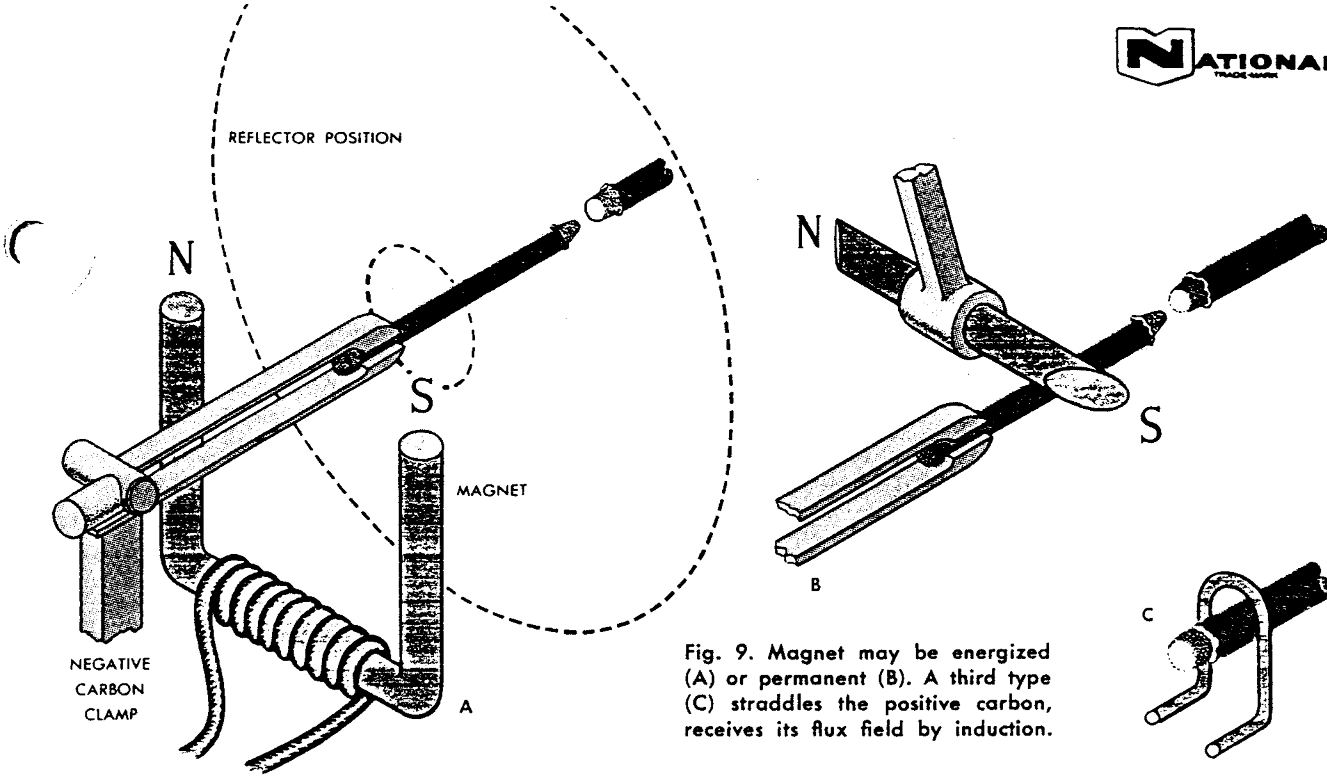


Fig. 9. Magnet may be energized (A) or permanent (B). A third type (C) straddles the positive carbon, receives its flux field by induction.

that which occurs when the negative carbon is inclined to the positive as in Figure 7. Consequently there is no magnetic force in any direction influencing the position of the arc stream. Operated under these conditions the tail flame surrounds the arc in almost a uniform layer as shown in Figure 8. To obtain an efficient high intensity effect from these arcs the lamps are equipped with an auxiliary magnet, Figure 9. The magnetic flux from this auxiliary source is illustrated diagrammatically in Figure 10, and is of such direction as to supply the required upward force on the arc stream, thereby causing the tail flame to be lengthened and driven upward as illustrated in Figure 11. Under these conditions the tail flame becomes comparatively stationary and constant in both length and direction. The axis of the negative carbon is placed slightly below that of the positive to compensate for the angular direction of the arc stream and to maintain a well formed crater on the posi-

Fig. 10. Magnetic forces in a "Suprex" carbon arc

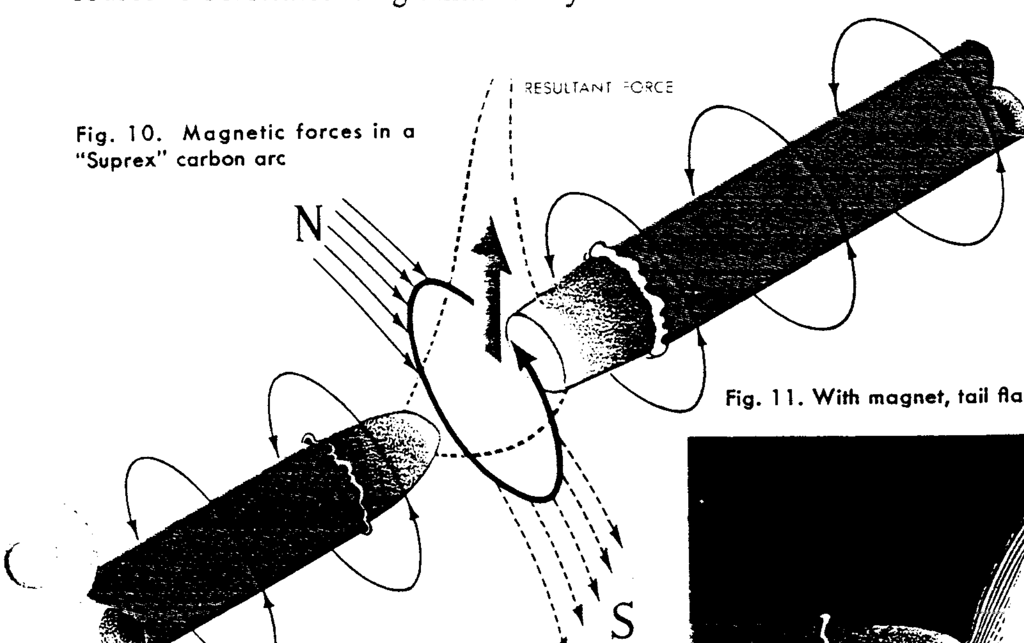
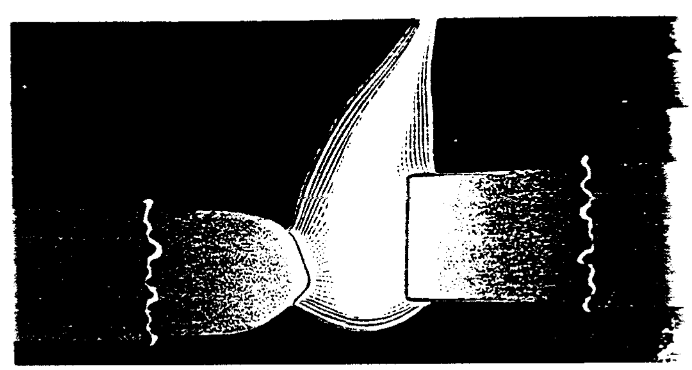
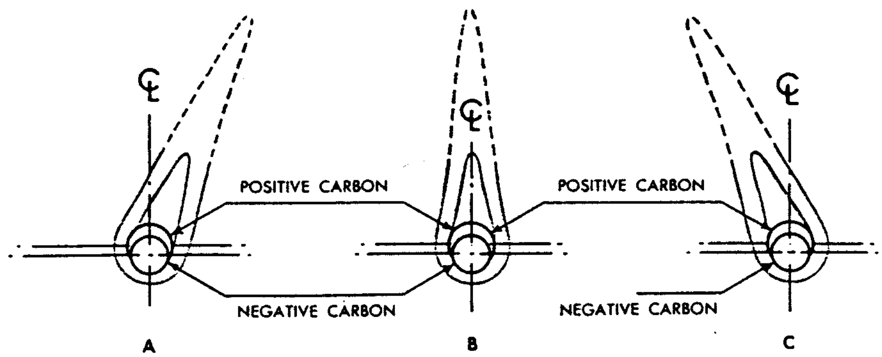


Fig. 11. With magnet, tail flame is driven upward

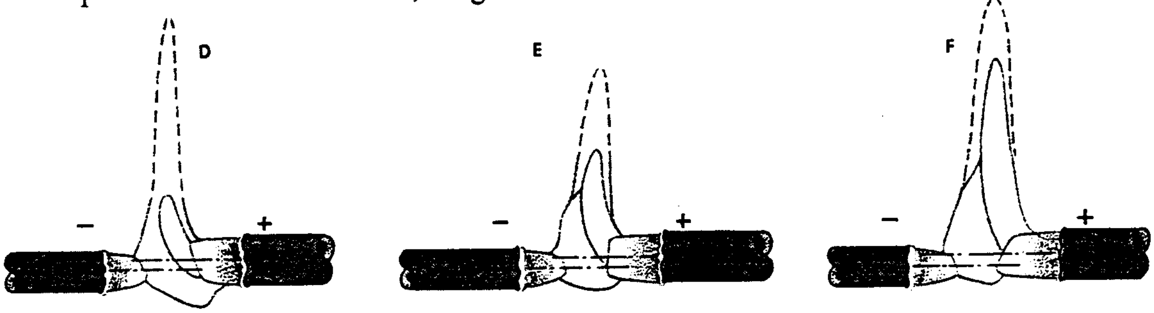




tive carbon. If the supplementary magnet is too weak the arc will go in and out of the high intensity effect, causing current fluctuations which result in very unstable screen light.

Provision is made, in most instances, so that the flux field of the magnet can be adjusted in all directions to offer complete control of burning characteristics. When a lamp is viewed from the rear, diagrams a, b, c show the arc flames that result when the magnet is (A) too far to the right, (B) correctly centered, (C) too far to the left.

When the magnet is moved co-axially with the carbons, diagrams d, e, f show the arc flames that result when the magnet is set (D) too far away from the arc, (E) the correct distance away, (F) too close.



AN INVITATION

. . . If you have an individual problem of carbon arc projection not discussed here, please contact the Sales Office of National Carbon Company nearest you.

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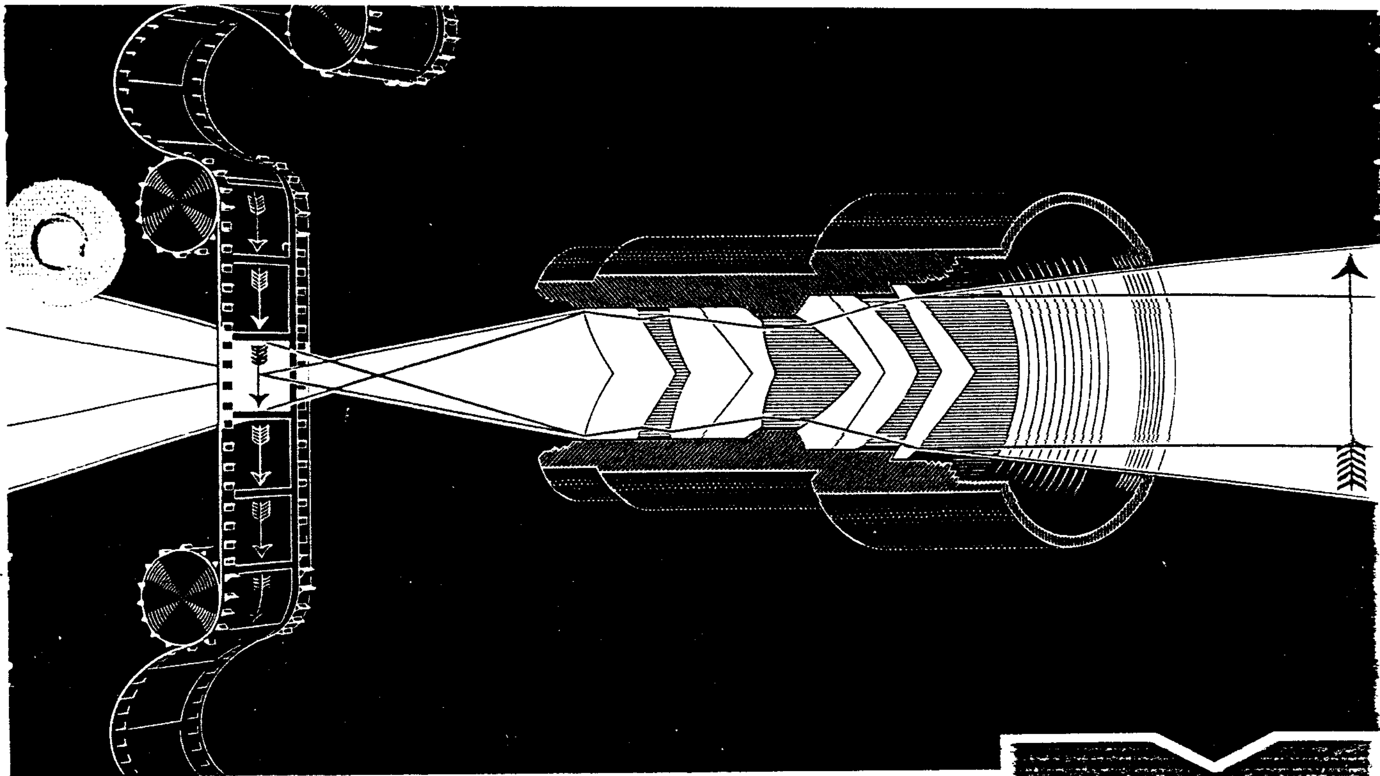

The Optics of Projection

NATIONAL

8.

Projector Carbons

In discussing the optics of projection, the usual and most direct procedure is to start with the light source and follow the path of a light ray through the system. However, the sole purpose of the light source is to illuminate the film and we wish to emphasize here some of the important points which must first be understood in order to properly correlate the light source with the optical system. In this instance, it is important that the film, projection lens, and screen sequence be examined first.

The Formation of the Image on the Screen

Figure 1 shows the optical essentials of a motion picture projector from film to screen. Assume the film is illuminated in some unspecified manner from the left. Then through the center of the film, rays of light will pass toward the projection lens. If these rays fall inside the cone shown in Figure 1, they will pass through the lens and will be united again at the center of the projection screen. Similarly, rays passing through other points on the film will strike the lens and be united at their proper places on the screen. It is in this manner that the image is formed on the screen.

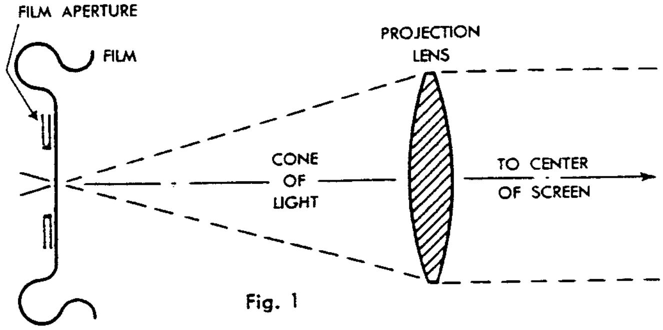

Fig. 1

Forget the film for the moment, and consider only the illuminated aperture. Through every point of the aperture, rays pass in a large number of directions, diverging toward the lens, and in the example just cited, the size of the cone of the half angle Θ determines how much light is picked up by the lens from the center of the aperture and sent to the center of the screen. (Fig. 2.)

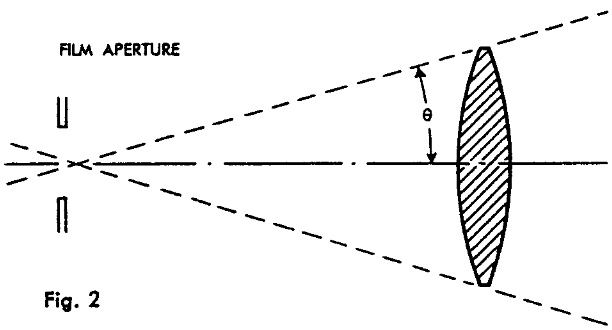

Fig. 2

In other words, this angle is a measure of the light gathering power, or "speed" of the projection lens. The "speed" of a lens is designated by its *f* number, which is defined by the equation —

$$f \text{ number} = \frac{1}{2 \sin \Theta.}$$

Thus, for an *f*/2.0 lens, Θ is approximately 14½° and for an *f*/1.7 lens Θ is approximately 17°. (Fig. 3.)

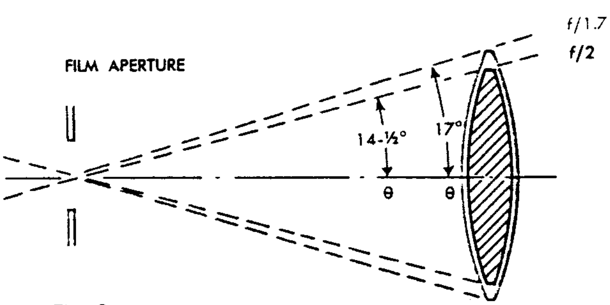

Fig. 3

Since angle Θ is larger for the *f*/1.7 lens than for the *f*/2.0 lens, its light gathering power is greater, and it is said to be the faster lens.

The *f* number is generally said to be the ratio of the focal length of the lens F. L. divided by the diameter of the lens D. (Fig. 4.) This is only approximately true, and is accurate only when the angle Θ is small.

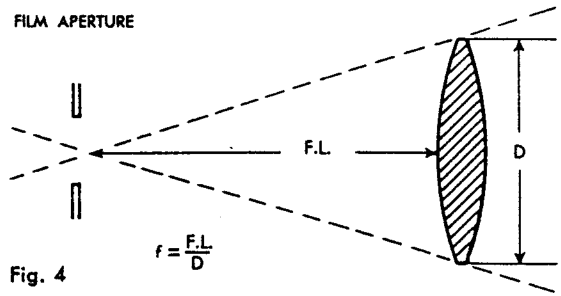

Fig. 4

It is readily evident that if the rays of light passing through the center of the aperture have greater angular spread than the angle Θ, then the rays outside the angle Θ will not pass through the lens and will contribute nothing to the screen brilliancy. (Fig. 5.)

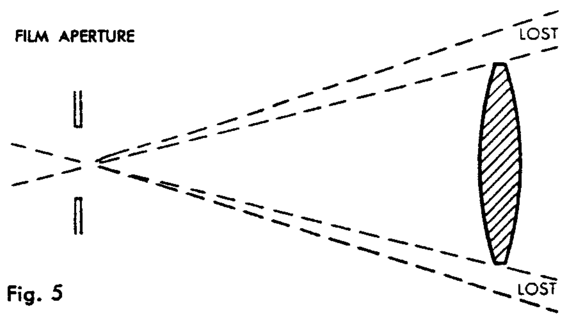

Fig. 5

A simple lens has been used for the above discussion. Practical projection lenses are more complicated, consisting of a number of individual elements, and it is more difficult to determine the angle Θ accurately. (Fig. 6.)

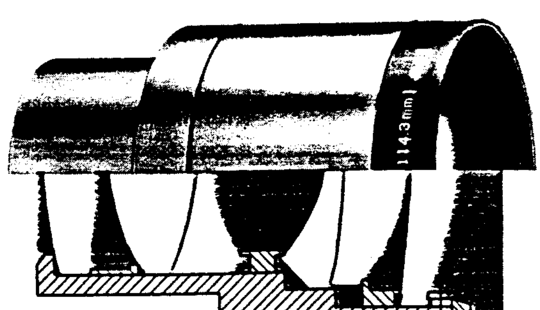

Fig. 6

So far, nothing has been said about the factors that determine the light on the screen. It is a law of optics that the total image illumination depends only on the object brightness and the lens speed. Referring to Figure 7, it can be seen that this result is reasonable. Figure 7a shows an $f/2.0$ lens with a given object brightness. If brightness over the film aperture is increased (Fig. 7b) then the radiation on all parts of the lens and likewise the screen illumination are increased proportionately. If the lens speed is increased (Fig. 7c), that is, if the angle Θ is increased, the lens picks up more light and the screen illumination is increased. For the same object brilliancy the screen illumination will vary *roughly* as the square of the speed. This variation of illumination with lens speed is true only when the lens is filled. If the lens is not filled, then the speed of the portion filled determines the screen illumination.

Lens speeds available are limited by certain necessary compromises which the lens manufacturer must bring into effect between the various desirable properties of a lens such as speed, image definition and freedom from distortion. Therefore, we find that lenses of focal length longer than 7″ are not generally available at present with speeds faster than $f/1.9$.

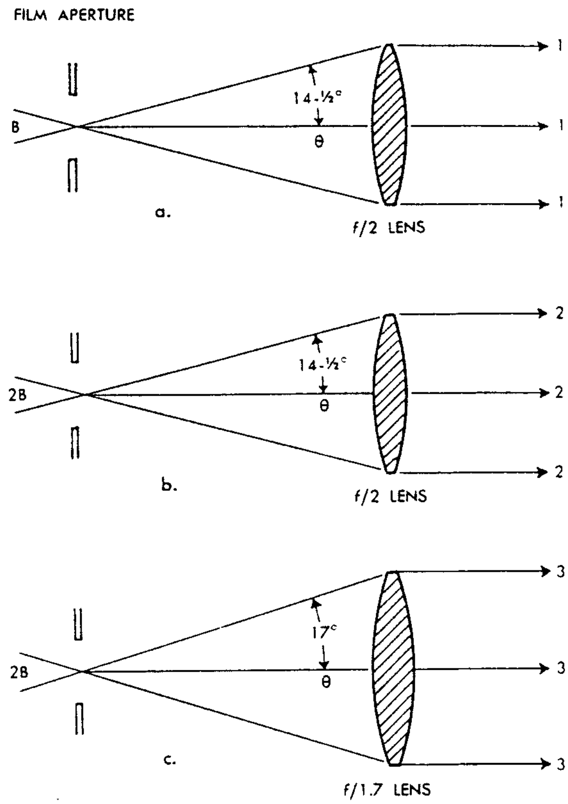

Fig. 7

Some of the shorter focal length lenses, 2″ to 4″, are available as $f/1.8$ and $f/1.7$ lenses. (Fig. 8.) Consequently, any efficient system for illuminating the film aperture must be adjusted to the lens speeds available and should be so designed that it will just fill the projection lens.

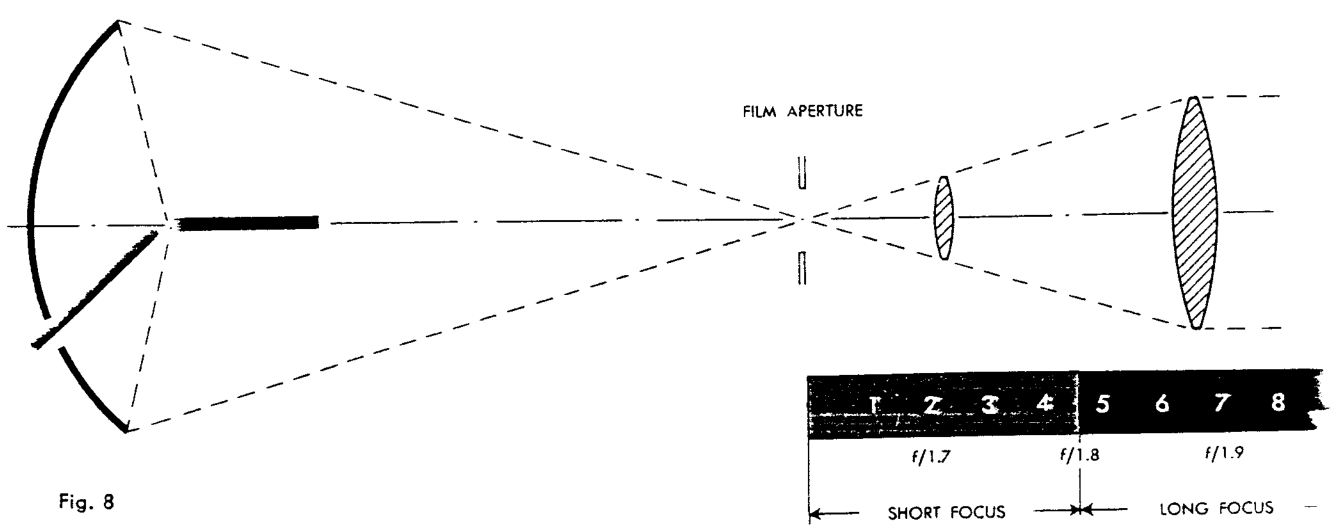

Fig. 8

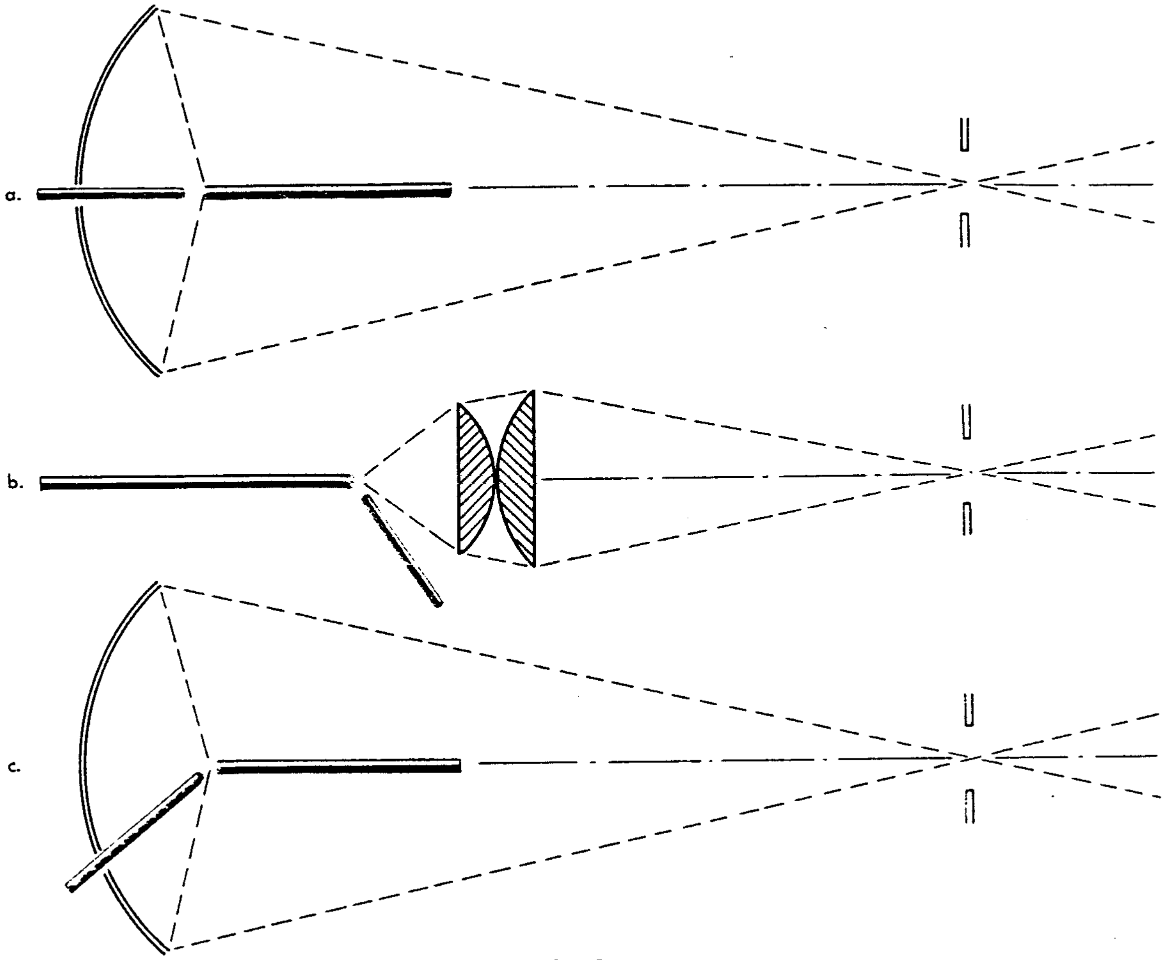

Fig. 9

Illuminating the 35mm Film Aperture and Film

Figures 9a, 9b and 9c show the most common methods of illuminating the film aperture. In all three systems an image of the positive crater of a carbon arc is formed on the film aperture. In two cases elliptical mirrors are used, and in the other case a pair of condenser lenses. However, the fundamental principles are the same.

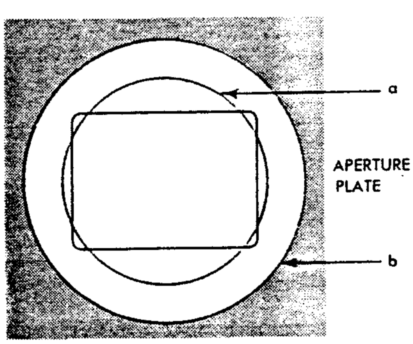

Fig. 10

There are three important numerical quantities for each system in Figure 9 which determine the performance. These are:—

1. The magnification of the image on the aperture,
2. The collecting angle of the mirror or lens at the arc, and
3. The convergence angle of the beam passing toward the aperture.

Since the arc is imaged on the aperture (Fig. 10.), the magnification determines whether the image covers the aperture properly; with too small a magnification (a) the image will not completely cover the aperture; with too large a magnification (b) there is a large spill-over of light on the aperture and, therefore, consider-

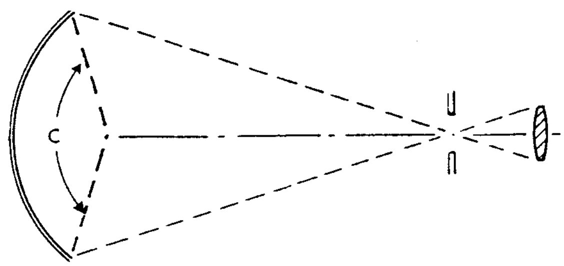

Fig. 11

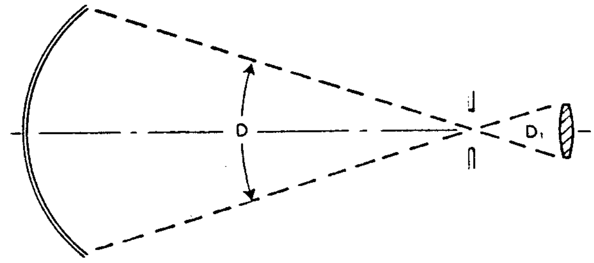

Fig. 12

able wasted illumination.

The collecting angle C (Fig. 11.) determines how efficiently and completely the radiation from the crater is utilized.

The convergence angle determines the speed, or *f* number, of the projection lens necessary for efficient use of light. This convergence angle D (Fig. 12.) of the beam on the aperture is exactly the same as the angle diverging from the film toward the projection lens (D_1).

While the considerations for mirrors and condensers are similar, the discussion will be limited to elliptical mirrors. The three numerical quantities enumerated above are all related mathematically by the geometry of the ellipse. To illustrate the interrelation of these quantities we have constructed two different elliptical mirrors in Figure 13. These two ellipses have the same distance between foci F_1 and F_2 but have different magnifications. One of them has a magnification of 5.4 : 1 and when it fills an *f*/1.7 lens it collects the radiation in an angle of 152° at the arc. When the collecting angle is made larger, a faster lens is needed and no increase in screen light is obtained unless such a lens is provided. The other ellipse in Figure 13 is drawn with a magnification of 4.0 : 1. Notice that the collecting angle has decreased to 120° for the same convergence angle. This illustrates a quite general result valid for all types of optical systems: a decrease in magnification is necessarily accompanied by a decrease in collecting angle for the same projection speed or convergence angle.

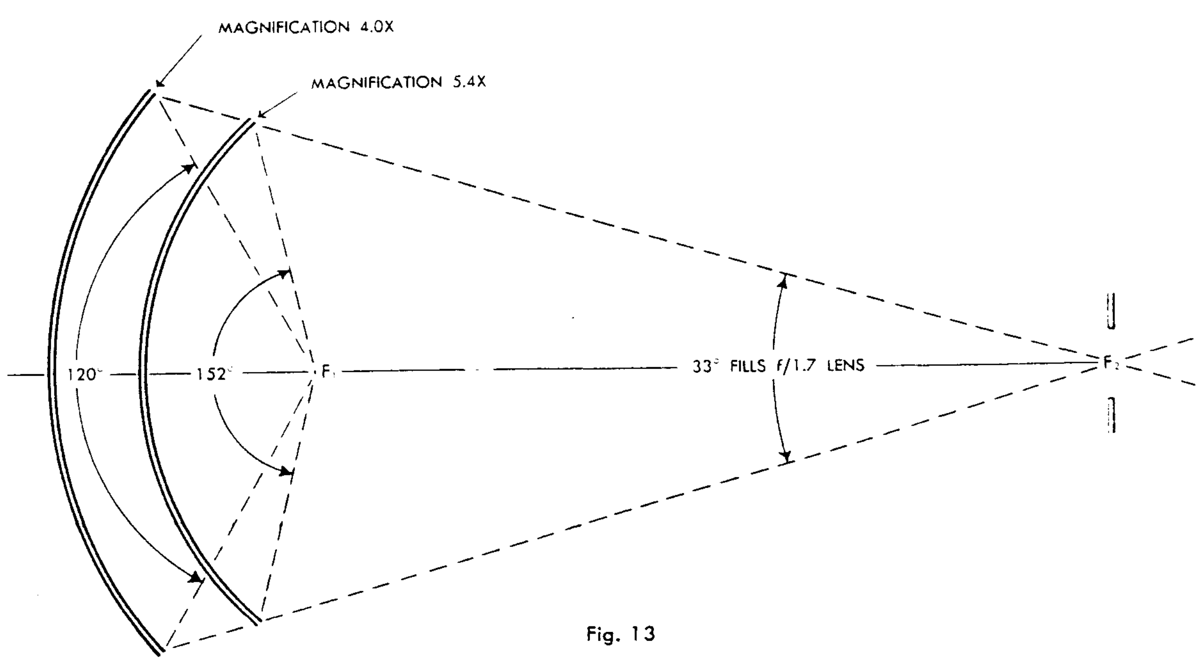

Fig. 13

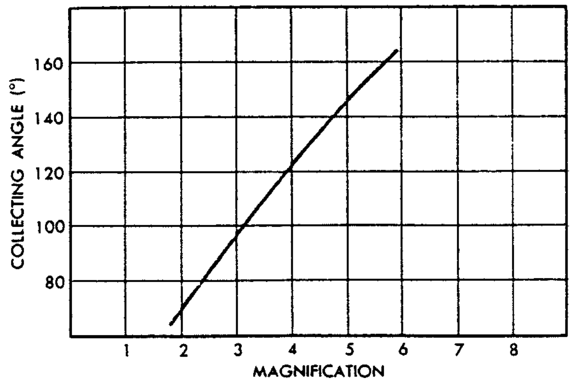

Fig. 14—Relationship between collecting angle and magnification for elliptical mirrors to fill an *f*/1.7 lens.

The complete relationship between collecting angle and magnification is shown in Figure 14 for elliptical mirrors which will fill a lens with the speed of *f*/1.7. This speed of *f*/1.7 has been chosen because it represents about the fastest projection lens in general use. From Figure 14 the proper collecting angle for any magnification to fill an *f*/1.7 lens can be determined, and it can be seen that this lens can be filled in a large number of ways. Here again it is a law of optics that if the convergence angle of the beam approaching the aperture (which is synonymous with speed and *f* number) is the same, then the light intensity at the center of the aperture will be the same for a given source brightness and will vary proportionately with this source brightness. Therefore, the two systems of Figure 13 will give exactly the same light intensity at the center of the aperture and if the source is of uniform brightness and sufficient size, so that its image will cover the aperture, then the total light on the aperture will be the same. Therefore, as far as total light is concerned, there is no choice between the 4.00 : 1 magnification with 120° collecting angle and the 5.4 : 1 magnification with 152° collecting angle.

The proper choice of collecting angle and magnification is, therefore, dictated by other considerations. It can be seen that it is doubly desirable from efficiency considerations to use the combination in Figure 14 of large collecting angle and high magnification because (1) the large collecting angle uses most completely the total radiation from the arc crater and (2) the high magnification allows the use of a smaller carbon and lower arc power. However, there are limitations in this direction due to the fact that when the collecting angle reaches 155°, most of the total radiation from the crater of the carbon arc is included and there is not much point in going beyond this value. From Figure 14 it can be seen that, for example, with the restriction of keeping an *f* 1.7 lens filled with 155° collecting angle, a magnification higher than 5.5 : 1—5.6 : 1 should not be used.

The discussion so far applies to a light source which is more or less two dimensional, such as the carbon arc when used in the conventional manner (see Bulletin 4, page 6). In a blown arc (Fig. 15.) the arc flame is confined to a cylinder between the positive and negative carbons, and the cylinder may be considered a three dimensional light source. The collecting angle of a three dimensional light source is limited only by convenience of operation. This permits the use of a small diameter auxiliary mirror mounted back of the crater of the positive carbon and facing the main mirror, (Fig. 16.). The total collecting angle of this type of optical system is the collecting angle of the main mirror plus

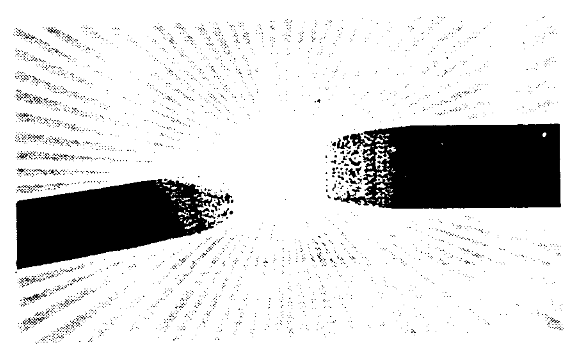

Fig. 15

the collecting angle of the auxiliary mirror. The total collecting angle in existing blown arc lamps is said to be more than 260°.

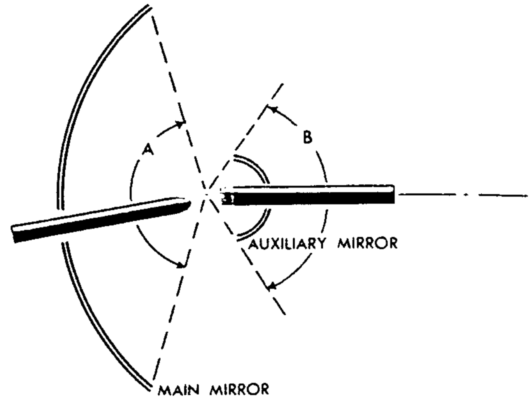

Fig. 16

Illuminating the Wide Film Aperture and Film

Elliptical mirrors have two focal points. The crater of the positive carbon is located at one focal point (F_1 in Fig. 13.), and in general, the film aperture is located at the other (F_2 in Fig. 13.). Lamps of this design, even when used with the largest available carbon (13.6mm diameter) do not adequately fill the wide film aperture (Fig. 17.), and insufficient light is projected to the sides and corners of the screen. The reason for this is illustrated in Figure 18, which shows the relative intrinsic brilliancy across the crater of a typical positive carbon. This figure shows in a relative way the portions of the crater which fall on the side of a 35mm aperture, and on the sides of a 70mm aperture. The table on "Screen Illumination," in Projector Carbon Bulletin No. 3, gives the ratio of light intensity at the side of the screen to that at the center of the screen for various carbon diameters, and for 35mm film apertures. In the case of a 13.6mm diameter carbon the ratio is .60 to .65, or 60-65%. It is much less when the system is used to illuminate a wide film aperture.

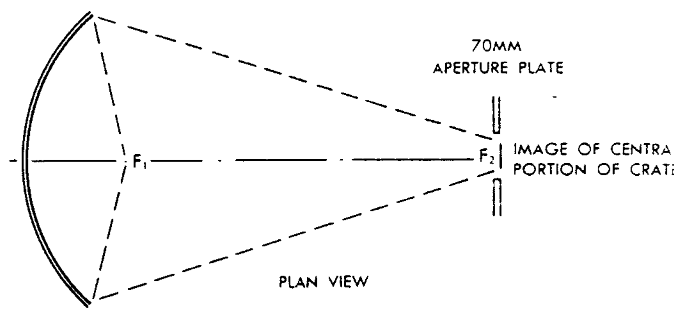

Fig. 17

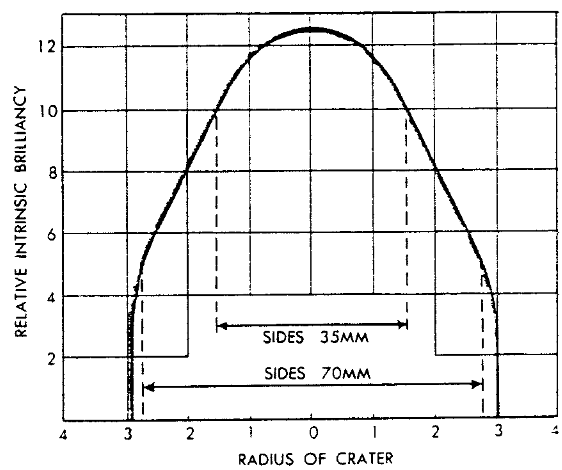

Fig. 18—Relative intrinsic brilliancy across crater face of a typical H.I. positive carbon.

Carbon arc projection lamp manufacturers have solved the problem by designing special lamps for wide film projection. The film aperture is not located at the second focal point, F_2 (Fig. 17.), but is located several inches nearer the first focal point, F_1. Thus, the film aperture is situated in a wider portion of the light beam, and is more completely filled with light (See Fig. 19.). Manufacturer's instructions tell how these special lamps can be converted to 35mm film projection in a matter of seconds.

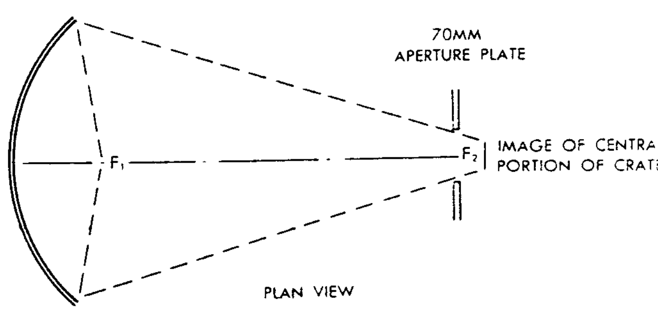

Fig. 19

A Dozen Ways to Receive SERVICE

Over the past 42 years National Carbon Company provided free screen lighting technical assistance to the industry. To-day, 12 sales engineers are ready to assist you on any screen lighting problem.

Their service kits contain: brightness and foot-candle meters, clamp-on am-meter, volt-ohmmeter, aperture plates, stop watch, slide rule, dummy lens, align-ment rods, rod accessories, etc.

If you have an individual problem of carbon arc projection, or one which is not included in these bulletins, we invite you to contact the Sales Office of National Carbon Company nearest you.

SALES OFFICES

New York 17, New York	292 Madison Avenue	MUrray Hill 6-1700
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LITHO IN U.S.A.

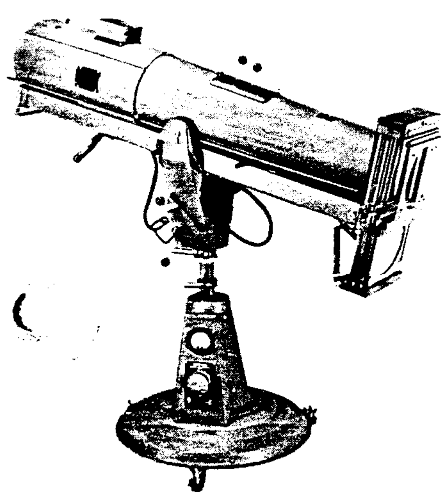
Carbon Arc Spot and Flood Lamps
Stereopticon and Effect Machines
Low Intensity Projection Lamps

NATIONAL
TRADE MARK

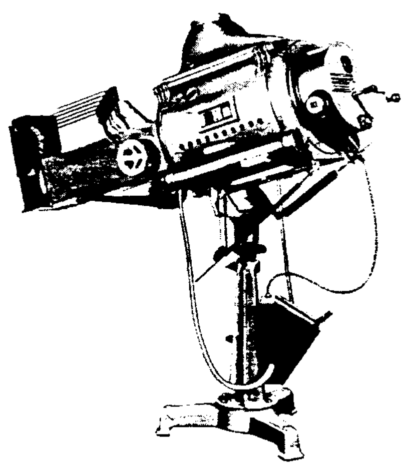
9.
Projector Carbons

Theatres, night clubs, auditoriums and sports arenas are frequently called upon to use arc spot or flood lights. The projection distance is usually so great that only a manually operated carbon arc lamp affords sufficient illumination. Choosing the proper carbon size for such lamps is often difficult because many of the lamps, unlike the models pictured below, may be so old that they are unfamiliar to the projectionist. National Carbon Company continues to furnish carbons for these older arc lamps and it is to assist the projectionist in these instances that this bulletin has been prepared.

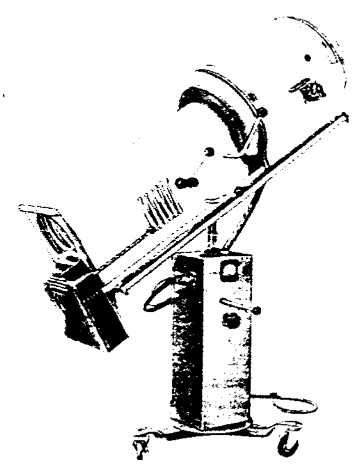
"STRONG TROUPER"



"GENARCO METRO-LITE"



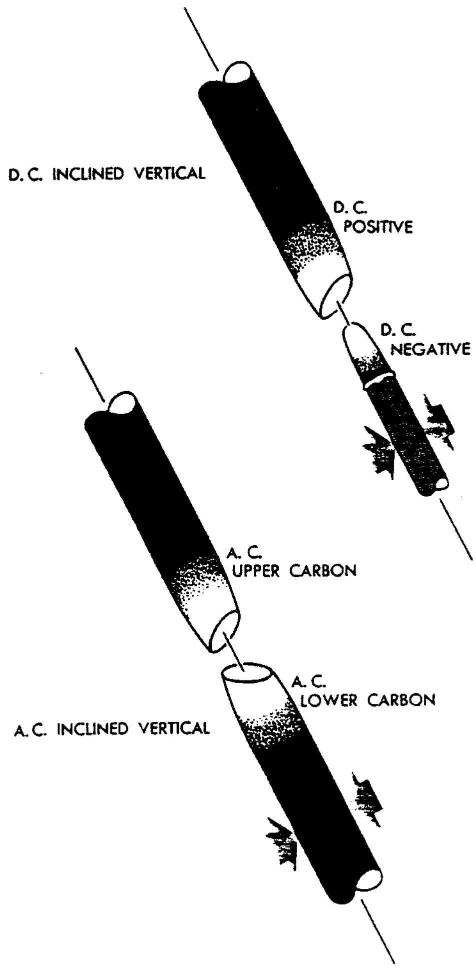
"GENARCO SUPER ACE"



NATIONAL Carbon Combinations

TRADE-MARK

Spot and Flood Lamps



Two general types of spot lights used for stage lighting in theatres, night clubs and similar locations are the low intensity condenser types and the high intensity condenser types.

Low Intensity • Condenser Type

D.C. INCLINED VERTICAL

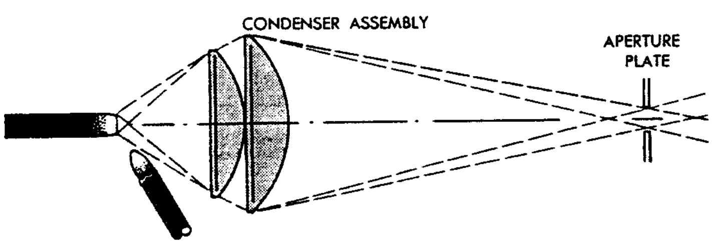
The older types of condenser lamps known as low intensity "Inclined Vertical" or straight arc are illustrated at left. The D.C. arc uses a plain upper or positive carbon and a copper coated lower or negative carbon. See Table 1.

A.C. INCLINED VERTICAL

The A.C. arc uses two plain carbons of the same diameter. The A.C. carbons are sold in combinations of one 12″ upper and two 6″ lower carbons. Recommended trims for these types of spot and flood lamps are shown in Table 2.

High Intensity • Condenser Type

D.C. ANGULAR TRIM



The high intensity spot lights are of two types—the first is known as the condenser type with rotating positive carbon and copper coated negative trimmed at an angle. The arc burners in these lights are the same as the high intensity projection lamps shown in Fig. 9, Bulletin No. 6. Recommended carbon trims for these lamps are shown in Table 3.

for Miscellaneous Lamps

Table 1. Spot and Flood Lamps

D.C. LOW INTENSITY • INCLINED VERTICAL

ARC AMPS	ARC VOLTS	CATALOG NUMBER	CORED POSITIVE	CATALOG NUMBER	"OROTIP" CORED NEGATIVE
40-50	54-56	L 1321	5/8″ x 12″	L 1103	5/16″ x 6″
50-55	56-57	L 1327	3/4″ x 12″	L 1103	5/16″ x 6″
55-65	57-59	L 1327	3/4″ x 12″	L 1112	11/32″ x 6″
65-70	59-60	L 1330	7/8″ x 12″	L 1112	11/32″ x 6″
70-85	60-63	L 1330	7/8″ x 12″	L 1121	3/8″ x 6″
85-100	63-66	L 1333	1″ x 12″	L 1127	7/16″ x 6″

Table 2. Spot and Flood Lamps

D.C. LOW INTENSITY • INCLINED VERTICAL

ARC AMPS	ARC VOLTS	CATALOG NUMBER	UPPER CARBON	LOWER CARBON
25-40	25-28	L 1500	1/2″ x 12″	1/2″ x 6″
40-60	28-32	L 1503	5/8″ x 12″	5/8″ x 6″
60-75	32-35	L 1506	3/4″ x 12″	3/4″ x 6″
75-100	35-40	L 1509	7/8″ x 12″	7/8″ x 6″

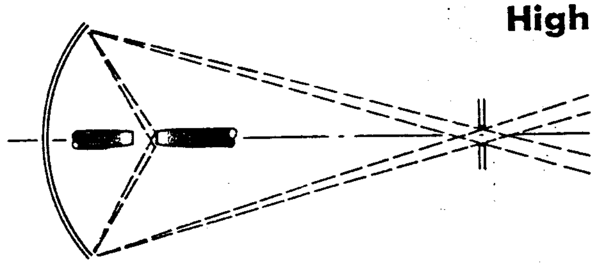
Table 3. Spot and Flood Lamps

D.C. HIGH INTENSITY • CONDENSER TYPE • ANGULAR TRIM

ARC AMPS	ARC VOLTS	CATALOG NUMBER	CORED POSITIVE	CATALOG NUMBER	"OROTIP" CORED NEGATIVE
85-95	58-62	L 0109	11 mm x 20″	L 1115	11/32″ x 9″
125-135	68-72	L 0115	13.6 mm x 22″	L 1130	7/16″ x 9″
40-160	72-78	L 0115	13.6 mm x 22″	L 1139	1/2″ x 9″

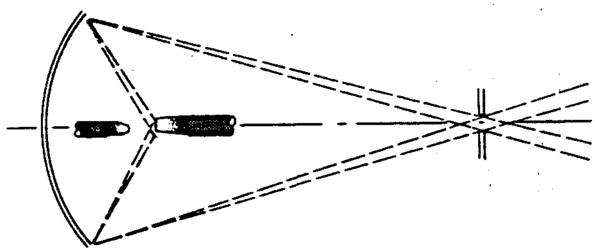
Spot and Flood Lamps (continued)

High Intensity • Mirror Type



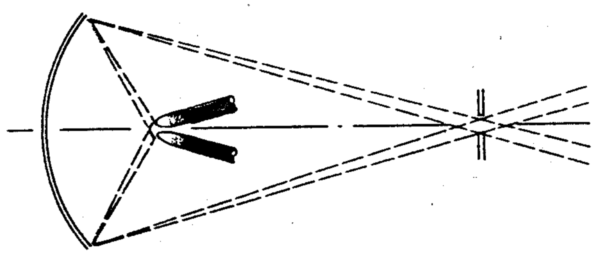
A.C. COAXIAL TRIM

The A.C. coaxial trim is illustrated on the left. It uses two copper coated carbons of the same diameter. See Table 4.



D.C. COAXIAL TRIM

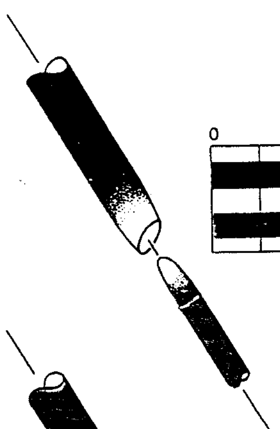
The D.C. coaxial trim as illustrated on the left uses a non-rotating copper coated positive and a smaller copper coated negative. See Table 5.

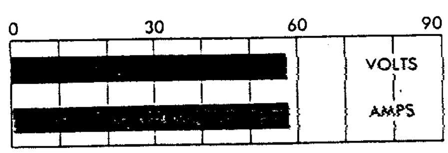


A.C. ANGULAR TRIM

The angular trim operates on A.C. only. It uses two identical carbons trimmed at a sharp angle. Recommended carbon trims are shown in Table 6.

Stereopticon and Effect Machines

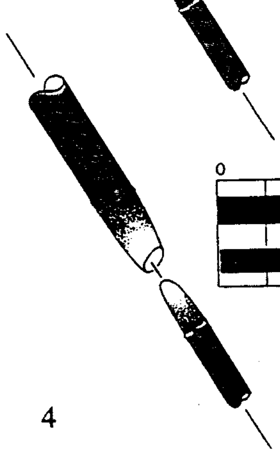


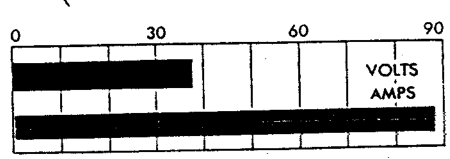


These machines are of the condenser type with inclined vertical trims. They operate on D.C. only. They may use low intensity or high intensity carbons.

D.C. LOW INTENSITY • INCLINED VERTICAL

The plain cored positive is large, the "Orotip" cored negative is smaller. Note that the voltage used is relatively high, while the amperage is lower. See Table 7.





D.C. HIGH INTENSITY • INCLINED VERTICAL

An appreciably whiter light is obtained when high intensity copper coated carbons are substituted for low intensity carbons. Note that the voltage drops, the amperage increases. See Table 8.

for Miscellaneous Lamps (continued)

Table 4. Spot and Flood Lamps

A.C. HIGH INTENSITY • MIRROR TYPE • COAXIAL TRIM

ARC AMPS	ARC VOLTS	CATALOG NUMBER	SIZE	USED IN
45	21	L 0700	6 mm x 7″	Both Holders

Table 5. Spot and Flood Lamps

D.C. HIGH INTENSITY • MIRROR TYPE • COAXIAL TRIM

ARC AMPS	ARC VOLTS	CATALOG NUMBER	"SUPREX" POSITIVE	CATALOG NUMBER	"OROTIP" NEGATIVE
44-46	31	L 0521	7 mm x 12″	L 0563	6 mm x 9″

Table 6. Spot and Flood Lamps

A.C. HIGH INTENSITY • MIRROR TYPE • ANGULAR TRIM

ARC AMPS	ARC VOLTS	CATALOG NUMBER	SIZE	USED IN
60	20	L 0309	7 mm x 14″	Both Holders

Table 7. Stereopticon and Effect Machines

D.C. LOW INTENSITY • INCLINED VERTICAL

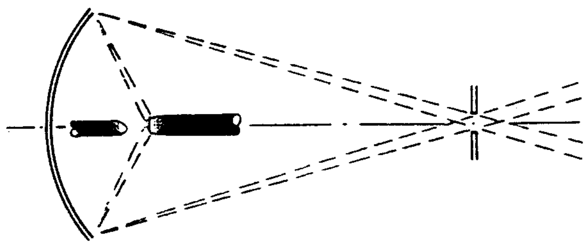
ARC AMPS	ARC VOLTS	CATALOG NUMBER	CORED POSITIVE	CATALOG NUMBER	"OROTIP" CORED NEGATIVE
25-50	51-56	L 1318	5/8″ x 6″	L 1103	5/16″ x 6″
50-65	56-59	L 1324	3/4″ x 6″	L 1112	11/32″ x 6″

Table 8. Stereopticon and Effect Machines

D.C. HIGH INTENSITY • INCLINED VERTICAL

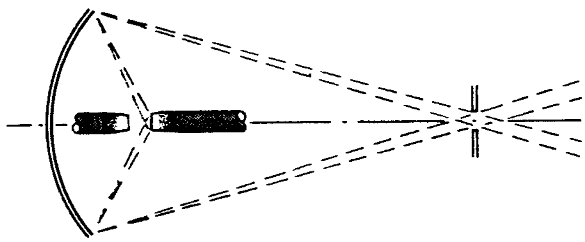
ARC AMPS	ARC VOLTS	CATALOG NUMBER	H. I. POSITIVE	CATALOG NUMBER	"OROTIP" CORED NEGATIVE
60-65	35-40	L 0130	11 mm x 9″	L 1103	5/16″ x 6″
85-90	35-40	L 0133	16 mm x 6″	L 1103	5/16″ x 6″

Dissolving Slide Projectors



D.C. LOW INTENSITY • MIRROR TYPE

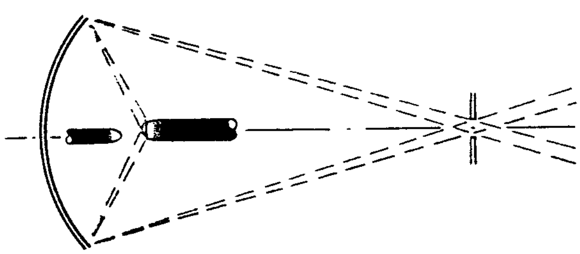
The direct current, low intensity reflector arc principle is used in some dissolving slide projectors. In these lamps the trim is horizontal or coaxial with the positive crater facing a mirror as illustrated at the left and shown in Table 9, right.



A.C. HIGH INTENSITY • MIRROR TYPE

Alternating current, high intensity, reflector type slide projectors use copper coated high intensity spotlight carbons as illustrated at the left and shown in Table 10.

Low Intensity Motion Picture Projection Lamps



D.C. MIRROR TYPE

The low intensity reflector type lamp operating on D.C. current from 16 to 52 amperes, has now been superseded by various types of high intensity lamps. Low intensity lamps produce a relatively poor quality of yellow-white light, rather than the snow white light of the high intensity arc. The low intensity arc also produces comparatively lower crater brightness and, therefore, less light on the screen. Table 11 shows the correct combinations of carbons for use in low intensity reflector arc lamps.

Operating Precautions

Operating precautions for all of the foregoing arc lamps are the same as those for film projection lamps covered in previous bulletins.

for Miscellaneous Lamps (continued)

Table 9. Dissolving Slide Projectors

D.C. LOW INTENSITY • MIRROR TYPE • COAXIAL TRIM

ARC AMPS	ARC VOLTS	CATALOG NUMBER	CORED POSITIVE	CATALOG NUMBER	CORED NEGATIVE
16-20	54-57	L 0921	10 mm x 8″	L 0906	7 mm x 8″
21-32	54-57	L 0924	12 mm x 8″	L 0912	8 mm x 8″
32-42	54-57	L 0927	13 mm x 8″	L 0918	9 mm x 8″

Table 10. Dissolving Slide Projectors

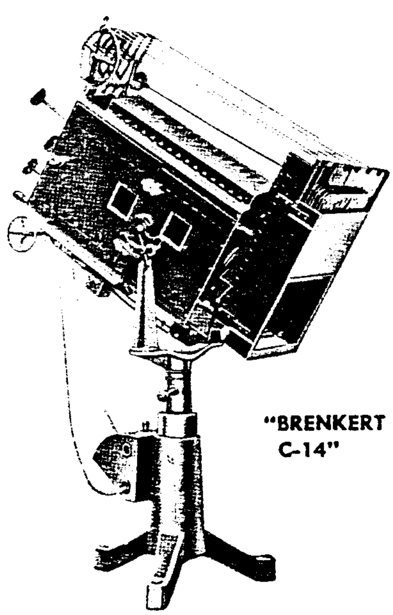
A.C. HIGH INTENSITY • MIRROR TYPE • COAXIAL TRIM

ARC AMPS	ARC VOLTS	CATALOG NUMBER	SIZE	TYPE OF EQUIPMENT
45	21	L 0700	6 mm x 7″	Projector
65	23	L 0307	7 mm x 7″	Projector

Table 11. Motion Picture Projection Lamps

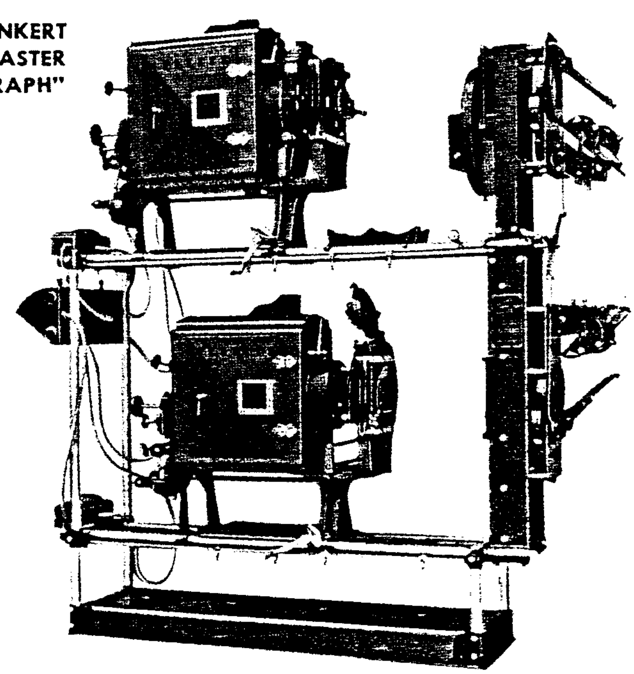
D.C. LOW INTENSITY • MIRROR TYPE • COAXIAL TRIM

ARC AMPS	ARC VOLTS	CATALOG NUMBER	CORED POSITIVE	CATALOG NUMBER	CORED NEGATIVE
16-20	54-57	L 0921	10 mm x 8″	L 0906	7 mm x 8″
21-32	54-57	L 0924	12 mm x 8″	L 0912	8 mm x 8″
32-42	54-57	L 0927	13 mm x 8″	L 0918	9 mm x 8″



"BRENKERT C-14"

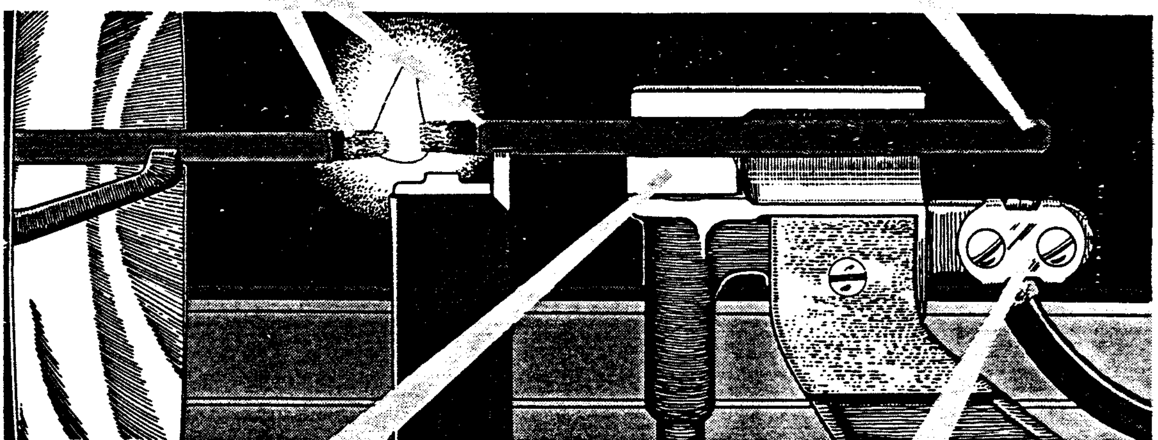
"BRENKERT MASTER BRENOGRAPH"



Four Point Guide to Steady Arc Operation

1. Use correct carbon combination for current and voltage available.

2. Align carbons properly.



3. Make certain carbon holders are free from corrosion or pitting.

4. Check that electrical connections are clean and tight.

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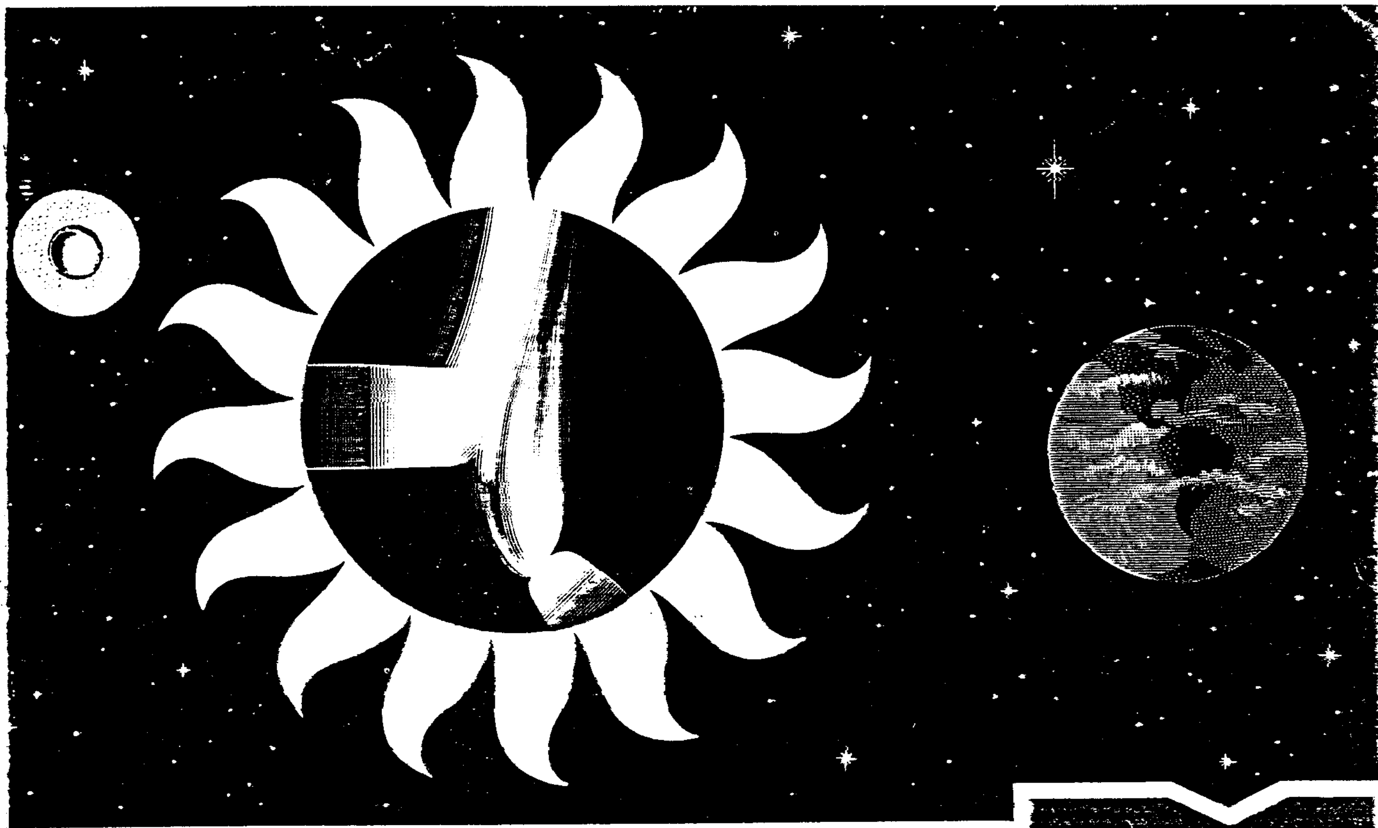


Man-made Sunlight!

14 key steps to arc carbon output at America's Projector Carbon Center, Fostoria, Ohio

NATIONAL
TRADE MARK
10.
Projector Carbons

Over 160 years ago a simple laboratory experiment set the stage for what we like to call "The Fostoria Story."

In the year 1801, Sir Humphry Davy, noted English chemist, formed a brilliant and sustained electric arc between carbon electrodes connected to a Voltaic battery.

Three-quarters-of-a-century passed before this important discovery could come into its own in a broad, commercial way. Opportunity came with the invention of the power-driven dynamo for generating electricity, and the successful efforts of Charles F. Brush to employ the carbon arc in large-scale illumination.

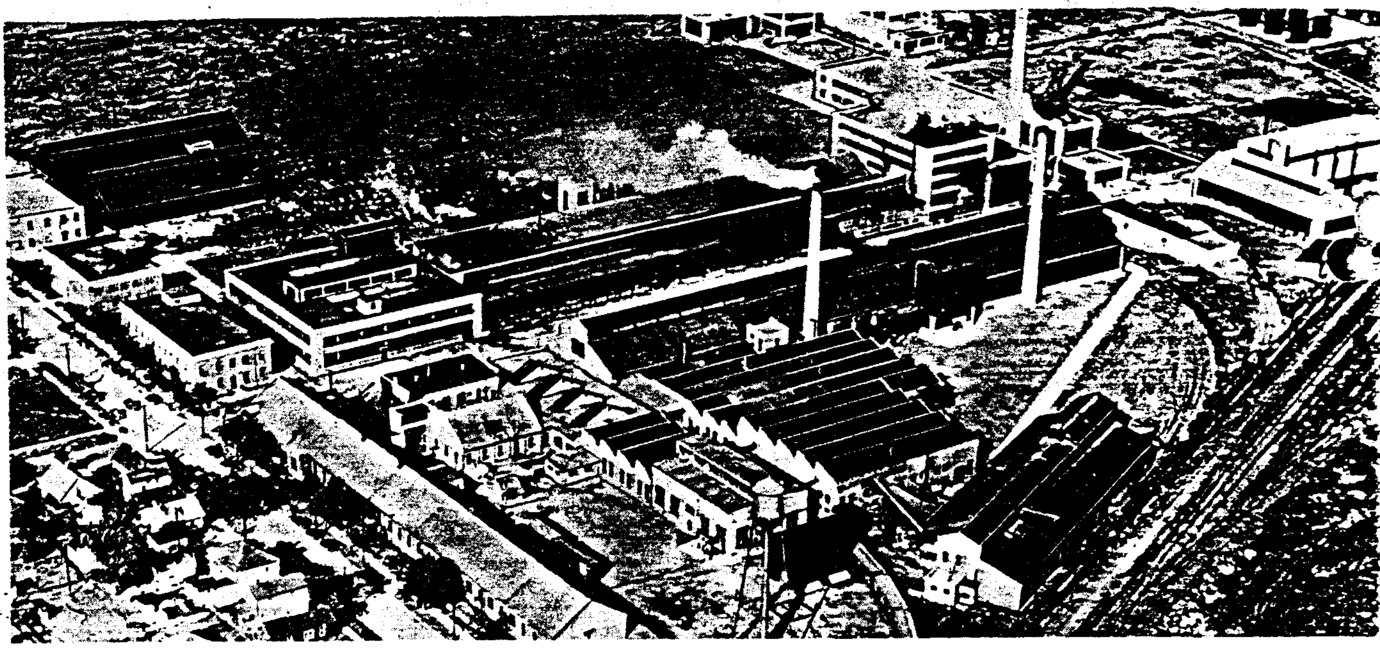
In 1876, Brush demonstrated the first commercial carbon arc light in the public square in Cleveland, Ohio. Some ten years later, in 1886, the original National Carbon Company was formed to produce carbons for the Brush lamp.

Fostoria, Ohio, inaugurated its long history as a manufacturing center for carbon rods in 1892. Seven years later, National Carbon—now the Carbon Products Division of Union Carbide Corporation—purchased a 50 per cent interest in the local carbon plant, then later assumed full control. Thus, for more than six decades the craftsmen and technical people of the Carbon Products Division have been consistently adding new and interesting chapters to "The Fostoria Story."

Grew up with motion pictures

From the beginning of the commercial history of the motion picture in 1894, light sources and the projectionists have played vital parts in its progress.

The pioneer projectionists had to contend with a combination of gas, oxygen, and a block of calcite to illuminate their



America's Projector Carbon Center, Fostoria, Ohio.

screens. Then came a major breakthrough in the form of the low-intensity carbon arc. This carbon arc was also used as the prime light source for studio stages.

As early as 1917, NATIONAL projector carbons became the standard for quality screen illumination. Later, during World War I, NATIONAL arc carbons served in many areas on land and sea, particularly in giant searchlights used to spotlight the enemy for anti-aircraft gunners.

Many projectionists will remember the Victory carbon, developed to overcome War Production Board restrictions during World War II, and the important role it played in meeting the great need for civilian motion pictures for morale building, industrial training, and entertainment. In the armed forces, arc carbons played a vital part in searchlights and other high-intensity lighting applications, in making blueprints, and in helping to heal the wounded with therapeutic lamps.

America's Projector Carbon Center

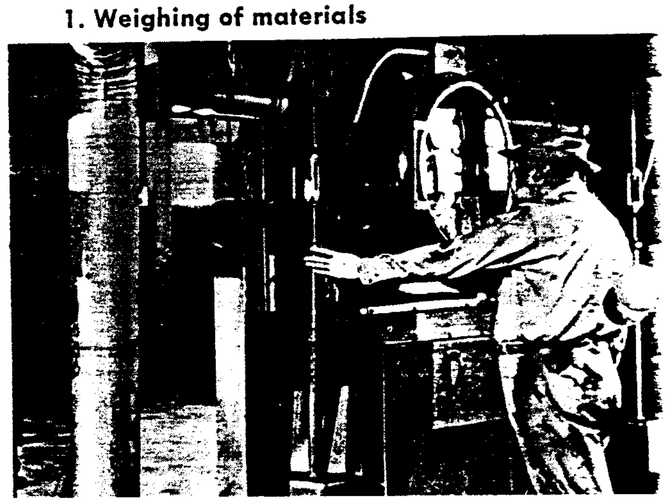
Today, Fostoria continues to serve the motion picture industry from production to exhibition. The high-intensity carbon arc is used to light studio sets and even to boost the sun on outdoor filming. In thousands of theatres across the nation the carbon arc provides unexcelled screen illumination. For these applications, light from the carbon arc and sunlight are considered identical.

Without the aid of the carbon arc the motion picture industry would never have reached and could not maintain its present high plane. The large screens, long throws, and high level of screen illumination in modern theatres and drive-ins require a light intensity that only the carbon arc can supply—a crater brilliance millions of times the brilliancy of the screen.

What goes into a projector carbon?

The modern projector carbon is not exciting in its ready-to-use form, but when you look inside and take it apart you can see one of the most fascinating examples

1. Weighing of materials



of meticulous and endless research and rigid quality-control manufacturing in American industry.

As is true of any quality product, the manufacture of arc carbons begins with careful selection and preparation of raw materials. In general, their principal ingredients are: petroleum coke derived from the refining process, lamp black, graphite, and rare-earth compounds that provide the special qualities of the light. Pitch materials are used to bond the particles together.

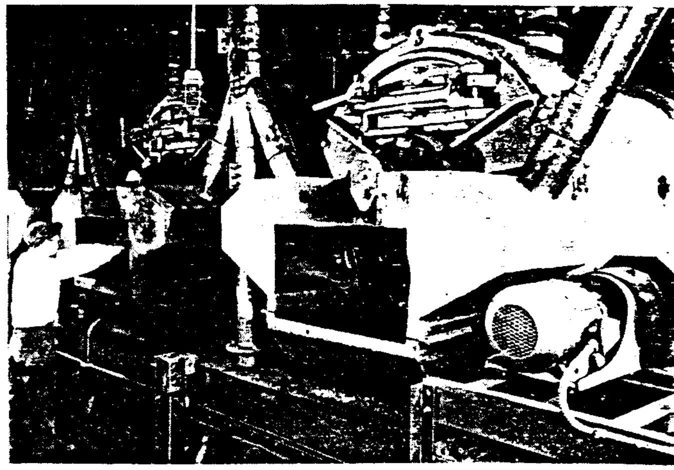
In the following 14 steps and their accompanying illustrations you are shown the major production phases each and every NATIONAL projector carbon must pass through before it is ready for packaging and shipment from Fostoria:

1. Following a series of milling and screening operations, petroleum coke is reduced to the particle size required for a given grade of carbon. This dry material is then conveyed to storage bins from which exact amounts are drawn into hoppers accurately weighed on automatic scales.

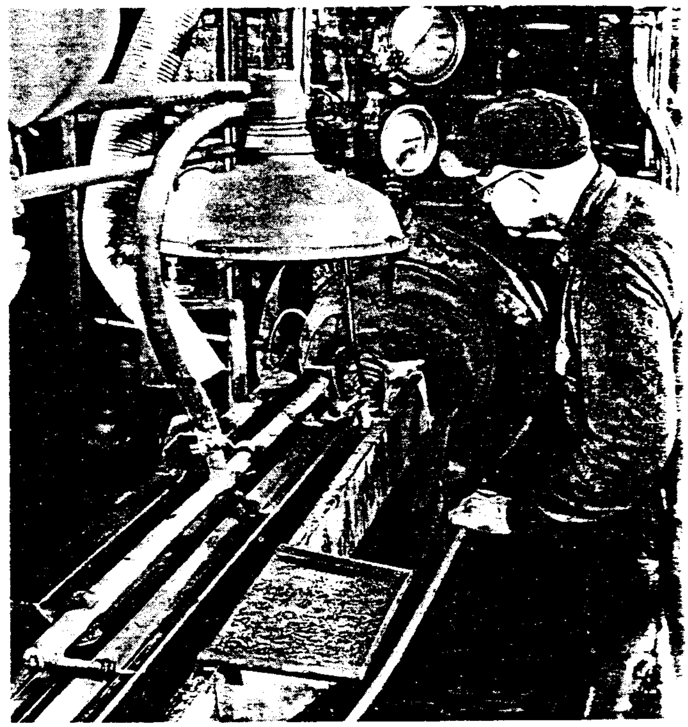
2. Pitch materials in a dry condition are also weighed automatically. Whatever the grade of carbon being produced, its precise formula in the quantity required flows by gravity to steam-heated mixers for thorough blending.

3. With the carbon materials and pitches thoroughly mixed and heated to a fluid state, the final material is fed into the cylinder of an extrusion press. Like toothpaste from a tube, the material is squeezed through a die by the pressure of an hydraulic ram.

4. The hollow carbon rods are cut to prescribed lengths and carefully checked for size. This is but one of approximately 60 quality control inspections and tests arc carbons undergo on their way through the total manufacturing process.

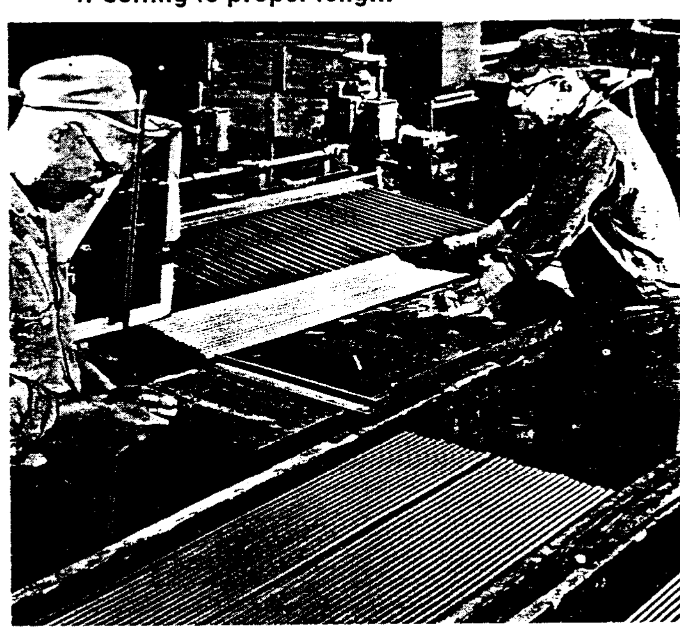


2. Blending of materials



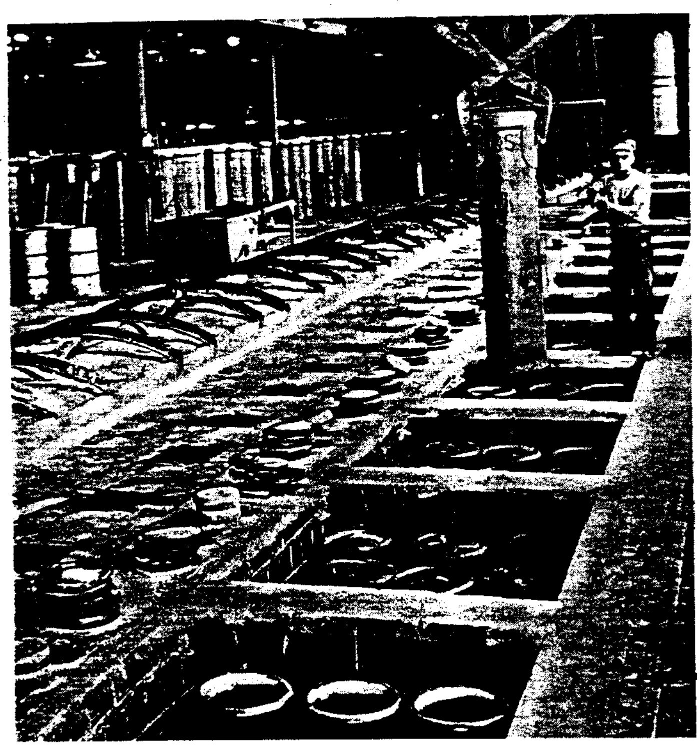
3. Extrusion of hollow carbons

4. Cutting to proper length



5. Readying for baking in saggers

6. Cooling after baking at 1800° F.



7. Straightness test is vital

5. After cutting, carbons are positioned by hand and packed closely with a special coke flour that supports the carbons during oven-baking.

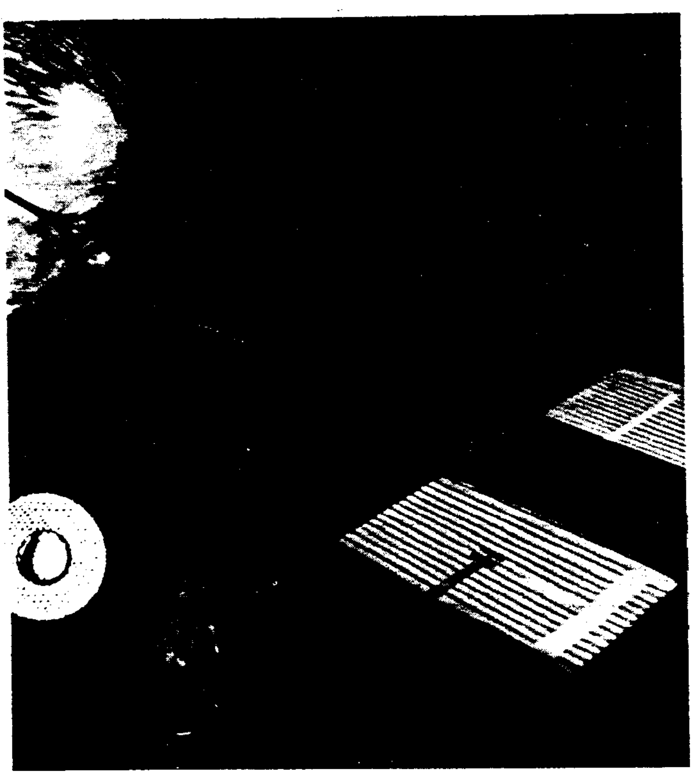
6. Loaded saggers are next placed in huge gas-fired ovens and baked over a long period at temperatures exceeding 1800° F. This operation sets the binder and leaves a completely carbonaceous rod.

7. After the longer lengths of carbons are cut to more nearly their finished size, numerous inspections are made, including visual checks and measurements of diameter and straightness of each carbon. Any carbon out of alignment more than a few thousandths is rejected. This inspection is vital for the reason that only straight carbons burn with correct cratering, resulting in the maximum light on the screen. Actually, we pay our inspectors a premium to detect and discard carbons that cannot pass our rigid tests for straightness.

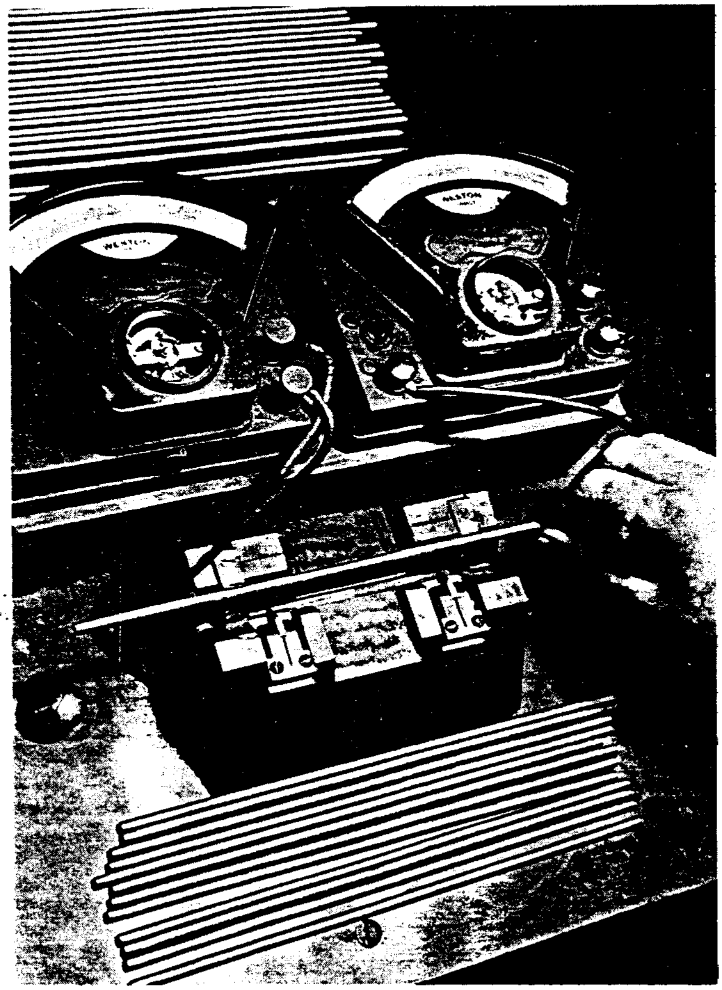
8. In the next important production step, cores of positive carbons are filled with a special mixture of rare earths and carbon to provide the spectral qualities of light required. Cores of negative carbons are filled with a special mix to help support the arc and make it more stable. All positive carbons pass through a darkened x-ray room for detection of voids or breaks in their rare-earth cores—the key to uninterrupted burning and maximum light quality. To keep keen and alert, the operators of this equipment change off every 30 minutes. As an extra safeguard, our x-ray inspectors are paid a premium for every imperfect carbon they reject.

9. Carbons are coated with copper, not for eye appeal, but for the all-important purpose of assuring more dependable screen illumination. The coating helps conduct current from the jaws of the lamp to the arc. For maximum light efficiency the copper coating must be of precision thickness—no more, no less.

8. X-ray check for core flaws



9. Coating carbons with copper

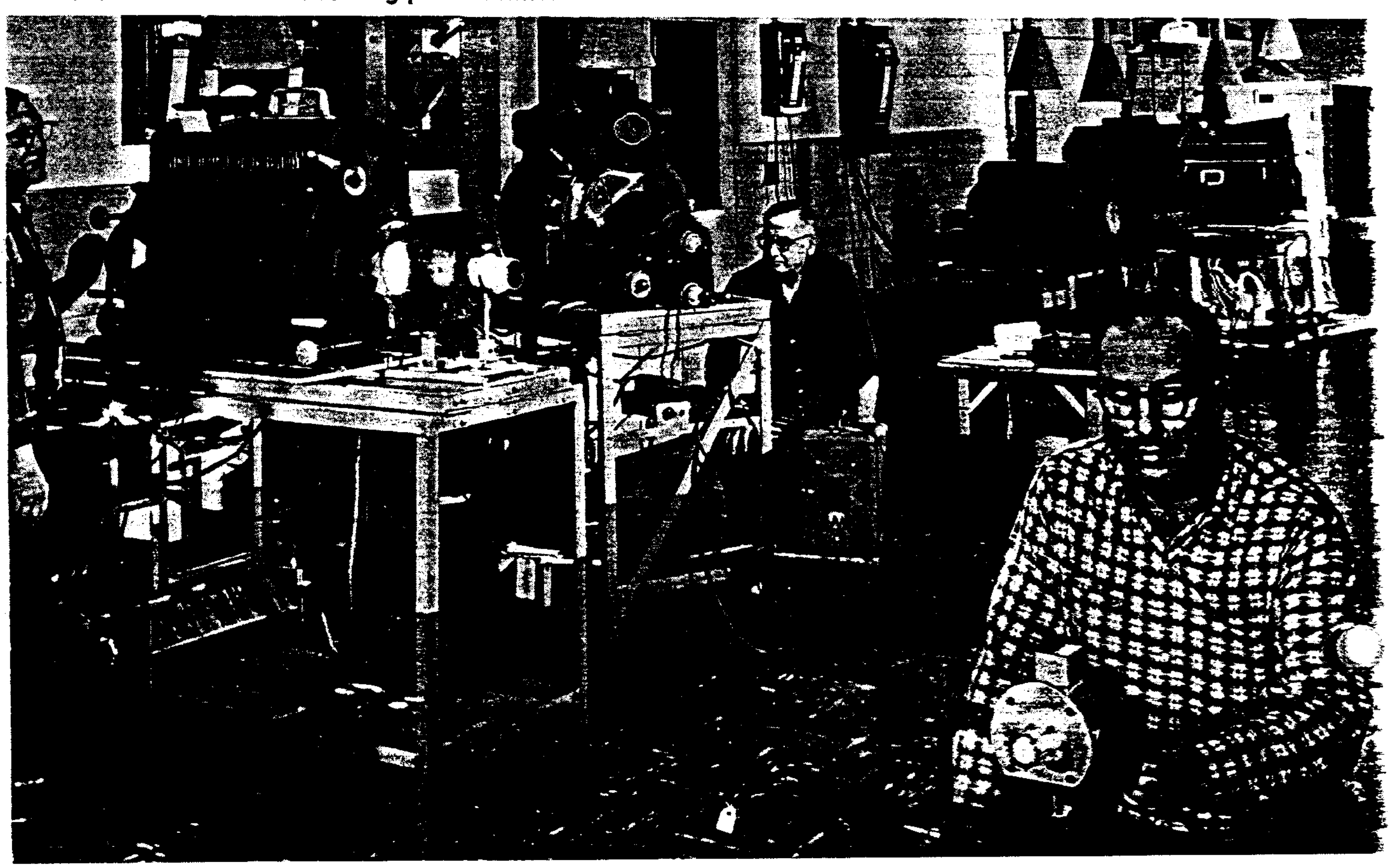


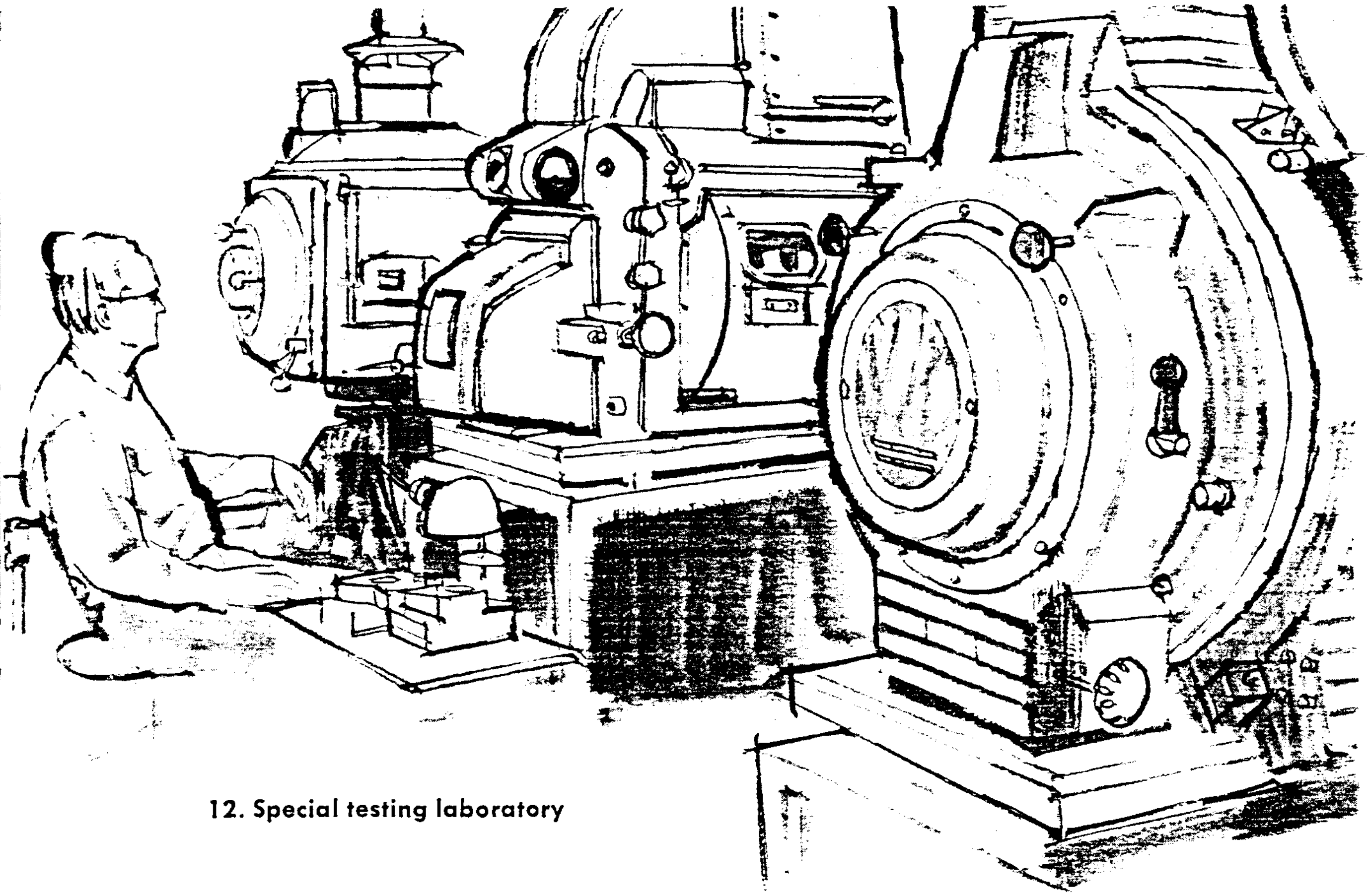
10. Coating measured in ohms-per-inch

10. After being copper-coated, carbons are cut to standard lengths and polished. The thickness of the coating is carefully checked. If the coating is too thin, the carbon might spindle back to the holder, resulting in freezing and a possible lamp shutdown. If too thick, it might produce copper dripping and cause the arc to wander. Carbons not falling within closely-held limits of electrical resistance are rejected.

11. Randomly-selected carbons from every production lot are sent to the fully-equipped "burn room" for a variety of tests on light output and distribution, consumption rate, and other factors important to close quality control. Lamps of many types are used. As part of its continuing technical service to motion picture exhibitors, Fostoria also evaluates other light sources that are introduced from time to time and reports its findings.

11. "Burn room" for testing performance





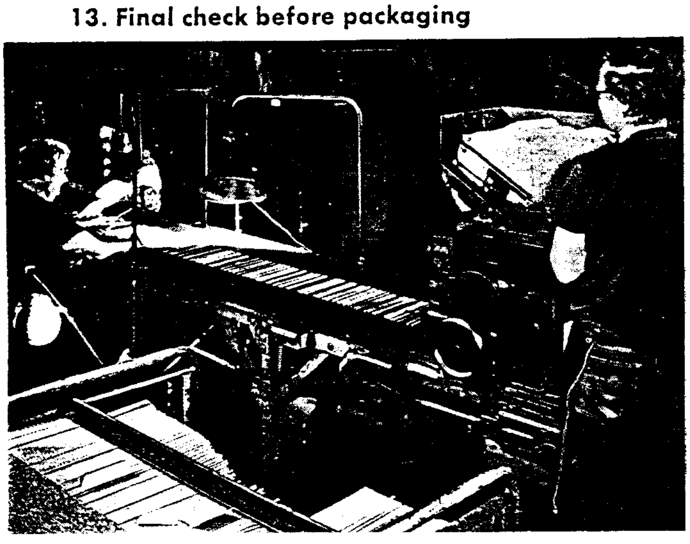
12. Special testing laboratory

12. In addition to specific tests in the "burn room," a special projection laboratory housing modern projection lamps is maintained for evaluating arc carbons under actual theatre conditions. This specialized quality control not only pays dividends to the theatre owner in carbon economy, but assures movie patrons the finest lighting for indoor or outdoor presentations. Continuing studies show that the carbon arc outperforms all other sources of screen illumination, and still holds the greatest promise as the most brilliant light source of the future.

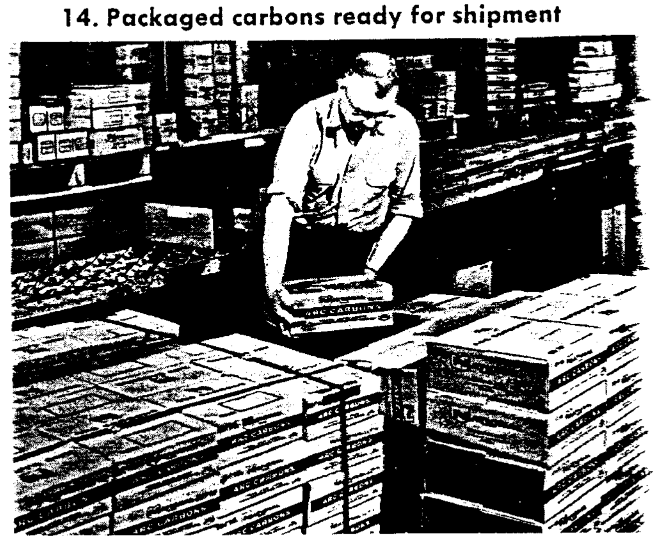
13. All carbons that successfully pass the approximately 60 tests and inspections for quality are given a final carbon-by-carbon visual check for the most minute flaws. Any finished carbon not worthy of being stamped with the company trademark is immediately discarded.

14. To assure full quantity in every package of NATIONAL projector carbons, special electrically-triggered jigs count out a carton-full of carbons. Cartons are carefully boxed, and the boxes strapped into pallets for shipment to warehouses.

13. Final check before packaging



14. Packaged carbons ready for shipment



Supplement to "The Fostoria Story"

The Parma Research Laboratory of Carbon Products Division

With one exception, "The Fostoria Story" has presented a comprehensive picture of the craftsmanship required in the production of NATIONAL projector carbons at America's Projector Carbon Center.

This exception is the vital role played by the Parma Research Laboratory of Carbon Products Division, located in the Cleveland area.

At Parma, research and development of the carbon arc for motion picture projection have produced vast improvements in color quality—from the early yellowish light of low intensity to the present snow-white light of high intensity.

The volume of projected screen light has been increased from several hundred to many thousands of lumens. In brightness, the carbon arc has multiplied eleven-fold since the early days of low intensity. Operating economy, in terms of lumens-per-dollar, has improved ten times in the same period.

Without these advancements in the carbon arc it would be impossible for the industry to have quality color pictures, wide-screen projection, and drive-ins.

Thus far, the carbon arc has fulfilled all demands of the motion picture art—from set-lighting to projection. As new requirements arise they will be met by the continuing program of scientific studies at the Parma Research Laboratory of Carbon Products Division.

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