Application of the Xenon Arc to the Armed Forces 16mm Projector

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This paper describes the problems involved, and their solution, in the incorporation of the xenon-arc lamp into the Armed Forces AQ-2(1) 16mm Sound Motion-Picture Projector. Shutterless synchronized pulsed-light operation and the ballast design are explained.

The Navy AQ-2(1) 16mm Sound Motion-Picture Projector equipped with the Hanovia arc lamp and its associated power supply is shown in Fig. 1. This is the end result of the Navy-sponsored Armed Forces development described hereafter, and at this time we wish to express our appreciation to the Navy for permission to reproduce the data and illustrations herein, which are taken from the Navy progress reports describing the project's history.

The decision reached by the Armed Forces to substitute 16mm film for 35mm film in their entertainment operation has resulted in complete satisfaction where the screen size has been held to a factor consistent with the light output available from the conventional incandescent type of light source. However, in many cases 16mm equipment has been installed as a direct replacement for 35mm in locations where large screen sizes are accompanied by high ambient light levels falling on the screen, thus causing difficulties with respect to adequate picture brightness and contrast.

Incandescent Light Output

In 1944 a target objective was established by JAN P-49 specification of 375 lm for the 16mm Armed Forces projector when using a 1000-incandescent lamp. The equipment finally developed, however, produced 510 screen lm. This is, however, far from the light output available in 35mm arc equipment which is in excess of 2000 to 3000 lm, approximately four times that available from the most efficient of incandescent-equipped projectors.

Recent standards have been established for 16mm projection of 10 ft-L screen brightness. This value would limit 16mm projection to screen sizes of less than 8 ft for optimum viewing. There are cases, however, where pictures of 18-ft width are attempted. Therefore the drop-off in screen brightness is such that a satisfactory viewer result is impossible and re-emphasizes the need for higher projector light output.

There are a few fundamental considerations which any 16mm light source must meet before its acceptance can be general. These are as follows:

16mm Light Source Color Balance. 35mm projection generally has been with the high-intensity carbon arc as the basic projector light source, which has a color temperature of 5400 K. 35mm prints therefore are color balanced to look their best with this light source. Such a light source is very rich in blue, as compared to the incandescent lamp. However, it is the predominant source now in use, and certainly the end result in the theater is most pleasing.

Now in 16mm film the opposite condition with regard to color balance exists, since the bulk of 16mm products is shown with incandescent-equipped projectors. Hence any substitute for the incandescent lamp having a higher light output must closely match its spectral characteristics.

To ascertain their compatibility, matching Technicolor, Ansco color and Kodachrome prints have been screened by simultaneous projection, using incandescent and the xenon arc at the Navy's Brooklyn Motion-Picture Exchange. The general viewer reaction to the xenon arc was most favorable. The spectral characteristics of this arc vary somewhat, dependent upon its method of use. The end result, therefore, is subject somewhat to optical design. At the conclusion of these tests the decision was reached that the xenon arc was satisfactory for projecting incandescent-balanced prints.

Film Damage. The danger of film damage must be considered as the light projected through the film base is increased. Exact data as to the top limit of illumination which the present film light-absorption methods can transmit have not been precisely established. This depends somewhat on the light source spectral energy distribution.

An estimate of 1600 lm has been the general opinion in the past. A postwar arc projector of better quality has extended this to 2500 lm by means of ingenious heat filters and film cooling.

In view of the preceding, a light-source target objective was established at 2000 lm. This value was exceeded by the xenon arc which has developed 2200 lm with a 950-w electrical input. (See Fig. 2 for the typical screen light distribution.)

Unattended Operation. At this time 16mm film conventionally is delivered on 1600-

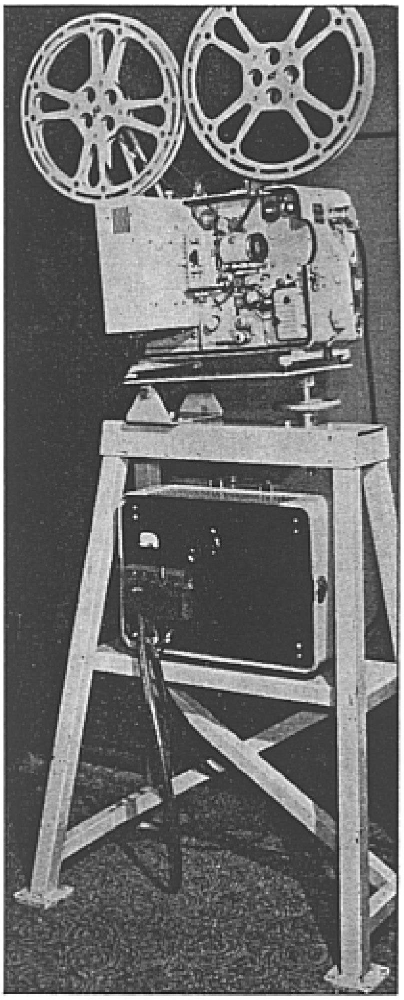

Fig. 1. The Navy AQ-2(1) 16mm Sound Motion Picture Projector equipped with the Hanovia xenon arc lamp conversion mounted on a standard Navy projector mounting base.

This paper was presented on May 5, 1954, at the Society's Convention at Washington, D.C., by Ellis W. D'Arcy (who read the paper) and Anton C. Seda, both formerly of De Vry Corp. Mr. Seda, recently with Bell & Howell Co., is now associated with the senior author in Ellis W. D'Arcy & Associates, 7045 N. Osceola Ave., Chicago 31. The work described in the paper was carried out by the De Vry Corp. under Navy Contract NObs 61644, and this description has been released for publication by the Department of the Navy, Bureau of Ships, after clearance by the Defense Department.
(This paper was first received on May 5, 1954, and in final form on August 6, 1954.)

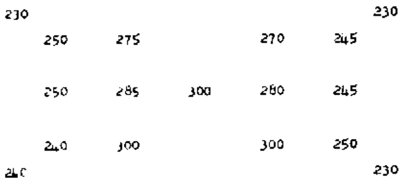

Fig. 2. Typical screen light distribution obtained from the Navy AQ-2(1) 16mm Sound Motion Picture Projector equipped with the Hanovia xenon arc lamp conversion.

ft or 2000-ft reels, with a single projector running time of 55 min. Any light source developed, therefore, would have to take a trim and hold it for 55 min under a very stable operating condition—this in contrast with 35mm practice wherein a 2000-ft reel is standard, having a running time of some 20 min. There are now being manufactured 5000-ft 16mm reels which extend the running time to 2 hr 18 min. In other words, one feature-length film per reel. The xenon arc meets these operational requirements more than adequately, since it can operate in an unattended condition during its life, which is in excess of 300 hr.

Unskilled Operation. Of further concern in the development of a practical type of higher-intensity light source for 16mm projection is the skill of the operator himself. It is a fact that 16mm equipment in the main is operated by a nonprofessional type of operator, one who does not devote his entire time to the operation of projection equipment. There is, however, quite a degree of skill involved in maintaining a carbon arc in optimum operating condition, and aligning it with the mirror type of reflector, which is gained only through complete concentration on the specialty that it is.

The xenon arc on the other hand, once aligned, requires no further operational attention than does an incandescent lamp during its operational life function.

The Hanovia Xenon-Arc Lamp

The xenon-arc lamp has several unique characteristics which, if enhanced and utilized, permit its incorporation into the Navy AQ-2(1) 16mm Sound Motion-Picture Projector in the most efficient manner.

(1) First, the arc being of high intrinsic brightness, makes the Hanovia xenon-arc lamp optically ideal for projection use. The brightness of the portion of the xenon arc used for projection in the Navy AQ-2(1) projector is higher than that of a carbon arc. Further, the Hanovia xenon-arc lamp being an enclosed bulb-type source makes possible an optical system that is closely coupled, and therefore of small size and relatively inexpensive.

(2) Second, the transparency of the arc makes the use of a reflector highly effective. In the Navy AQ-2(1) Sound Motion-Picture Projector the reflector when used with a tungsten incandescent lamp increased projected screen illumination 16 to 18%, while with the xenon-arc lamp the same reflector in the same projector increased projected screen illumination 60 to 70%.

(3) Third, even though the overall light output of the Hanovia xenon-arc lamp has an average color temperature of approximately 5200 K, the center of the arc has a lower color temperature that is entirely compatible with color film processed for the tungsten incandescent lamp.

(4) The fourth characteristic of the Hanovia xenon-arc lamp, and the most novel one, is that the light output from the arc can be pulsed in such a manner that the lamp acts as both light source and shutter. This means that the Hanovia xenon-arc lamp consumes power only when usable light is being projected on the screen and all the xenon-lamp light output reaches the screen. There is no 33 to 50% light loss due to a mechanical shutter blocking the light output from the lamp as in a normal motion-picture projector.

The pulsing of the light in the Hanovia xenon-arc lamp has two other useful effects. First, for the same average electric power into the xenon-arc lamp the higher instantaneous current during each pulse causes the arc to have a higher intrinsic brightness which gives 10 to 15% greater screen brightness for the same power consumed by the xenon-arc lamp. Second, the electrode life is increased and electrode evaporation is reduced because of the "rest period" between pulses.

The xenon lamp shown in Fig. 3 has a center bulb diameter of $1\frac{1}{2}$ in. The total overall length between electrode extremes is $7\frac{3}{8}$ in. The enclosure is made of fused quartz which has the requisite strength at high temperatures.

The operating temperature raises the gas pressure to several times that existing at room temperature. However, the lamphouse affords complete protection from operational hazard. Additionally, the lamphouse door in the Navy AQ-2(1) xenon-lamp conversion is interlocked to prevent operation when

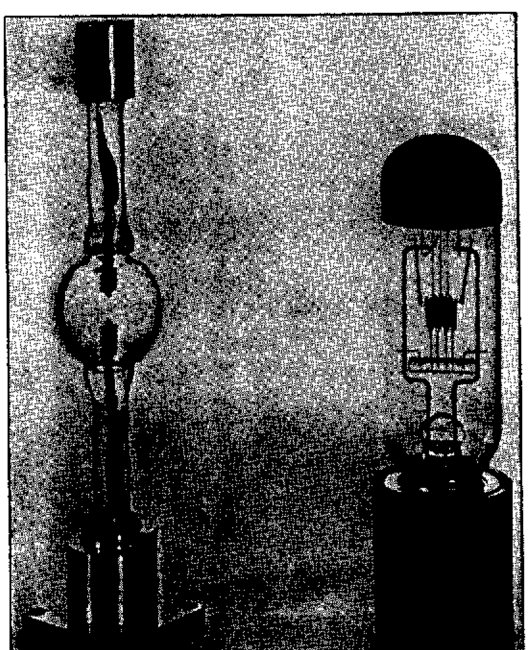

Fig. 3. (Left) The Hanovia xenon arc lamp as used in Navy AQ-2(1) 16mm Sound Motion Picture Projector equipped with the xenon arc lamp conversion, compared to a standard 1,000-watt, 10-hour, tungsten incandescent projection lamp.

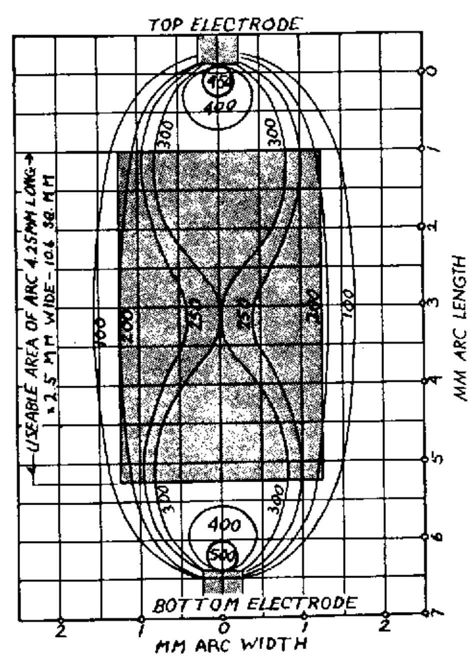

Fig. 4. Light distribution in the arc of the Hanovia xenon arc lamp with the arc image reinforced with an inverted reflected image.

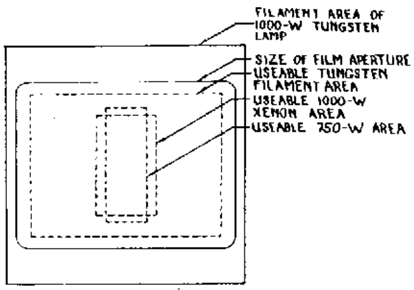

Fig. 5. Relative sizes of the 1,000-watt, 10-hour, tungsten incandescent projection lamp filament and the Hanovia xenon lamp arc as compared to a 16mm film aperture.

open. During experimental development the xenon lamps have been shipped, mounted in the projector, by airplane, train, truck and auto without a single instance of breakage. We have not experienced any instance of lamp explosion with the lamps either hot or cold. The general opinion is that they are not quite as hazardous as television cathode-ray tubes.

The quartz-enclosed electrodes between which the arc occurs are made of exceptionally pure tungsten of adequate section to carry the requisite current.

Light Characteristics of the Xenon Lamp Arc

Figure 4 shows the light distribution in the arc of the Hanovia xenon-arc lamp with the arc image reinforced with a reflector, such as is used in the Navy AQ-2(1) projector optical system. Without the reflection the arc image would be wedge-shaped, with the narrow end of the wedge at the bottom electrode and the broad end of the wedge at the top electrode. The reflector used lays an inverted image of the arc upon itself and makes the arc symmetrical about its horizontal axis. As can be seen, the arc has "hot spots" at each end. The color temperature of these hot spots is upwards of 6000 K.

The shaded area shown on Fig. 4 is the center of the arc that is magnified and elongated horizontally and imaged upon the film aperture by a condenser system. Incidentally the rather peculiar "X"-shaped incidence of the light conduces to very uniform light distribution because it counteracts the normal corner "drop-off" in light on the screen due to lenses. This area of the arc projected upon the aperture and on the screen does not include the hot spots, since their high intrinsic brightness and high color temperature would cause bright bluish bands at the top and bottom of the screen. Further, the electrodes themselves are excluded from the area of the arc chosen for projection because they become incandescent and their light does not follow the pulsed light shape required for shutterless operation. Even though the light given off by the electrodes is minute as compared to the arc, a travel ghost would result. Under actual test, when electrode light was deliberately introduced, a travel ghost was readily seen on black-and-white test film because of its orange-red color rather than because of its intensity.

In the main, 16mm projection will always be predominantly with incandescent as a light source. This makes mandatory a close approximation to the light characteristics of the incandescent lamp in any high light output substitute for it. While the xenon-arc stream, as used in the Navy AQ-2(1) xenon-arc conversion, is higher in color temperature than the incandescent lamp, its light composition does present, because of its continuum with regard to color, an excellent actual compromise result. The Navy, through the facilities of the Brooklyn Motion Picture Exchange, has used it to screen the various color processes and has found a widespread audience reaction that the end result is most acceptable and pleasing. While the blues are somewhat accentuated, the balancing presence of red compensates for this.

Optical Considerations

Figure 5 shows the relative sizes of the tungsten incandescent light and the Hanovia xenon-arc light sources as compared to a 16mm film aperture as used in the Navy AQ-2(1) Sound Motion-Picture Projector.

As can be seen, the usable tungsten incandescent lamp area is of almost the same size as the 16mm film aperture; therefore the condenser system has only to take light from the tungsten incandescent lamp at the maximum useful lens aperture and redirect it on the 16mm film aperture in such a way that the projection lens operates at full aperture for maximum projected light on the screen.

However, the usable area of the xenon arc must be considerably magnified, horizontally more than vertically, in order to fill the film aperture. This was further complicated by the fact that for maximum usefulness the conversion of the Navy AQ-2(1) 16mm Sound Motion-Picture Projector required simplicity and a minimum of replacement parts. Therefore, the reflector for the xenon lamp was to mount in the same holes, the xenon lamp socket was to mount in the same holes in the same adjustable base as the tungsten lamp socket, and the xenon-arc condenser lenses were to be directly replaceable in the same lens holder. Also all existing projection lenses of different focal lengths for the Navy AQ-2(1) projector had to be accommodated at full efficiency.

Figure 6 is a graphical picture of the complete light and optical system for the Hanovia xenon-arc lamp in the Navy AQ-2(1) 16mm Sound Motion-Picture Projector, while Fig. 7 is a photograph of the same. In this photograph the lamp housing and the condenser housing are removed. Also the mechanical shutter is removed for shutterless operation. The lens spacings shown are obtained by replacing the standard Navy AQ-2(1) condenser lenses with the new xenon-lamp condenser lenses, while the Hanovia xenon-arc lamp spacing is obtained by replacing the tungsten incandescent lamp socket with the xenon-lamp socket.

The same reflector is used as in the standard AQ-2(1) projector.

Pulsed Light or Shutterless Operation

Figure 8 shows graphically the shape of the light pulses from the Hanovia xenon-arc lamp and how the film pull-downs are accomplished during the xenon-arc "dark-out" periods. A rate of 120 light pulses/sec was chosen because this can be most conveniently ob-

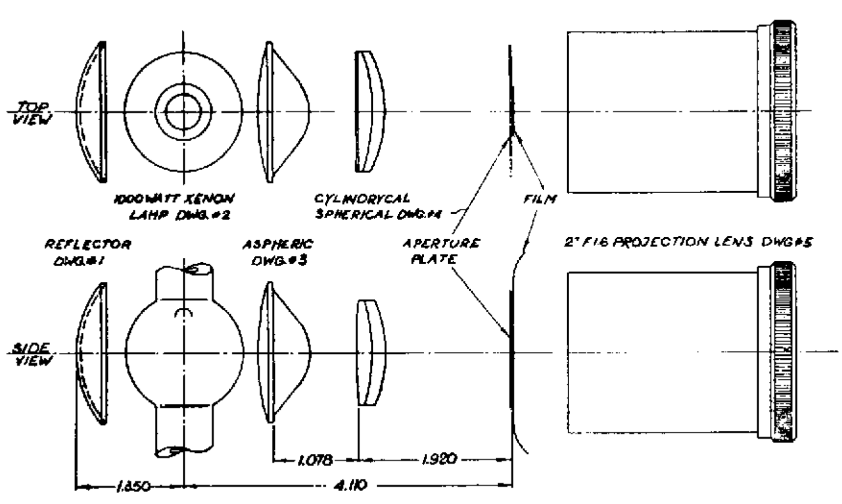

Fig. 6. A pictorial layout of the complete light and optical system of the xenon arc lamp conversion of the Navy AQ-2(1) 16mm Sound Motion Picture Projector.

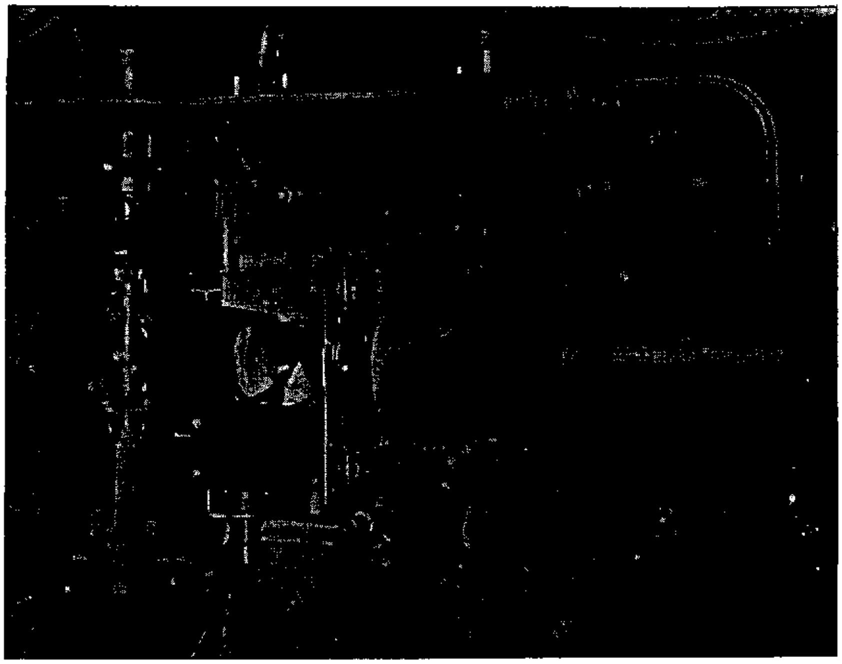

Fig. 7. The light and optical system of the xenon arc lamp conversion of the Navy AQ-2(1) 16mm Sound Motion Picture Projector.

tained directly from a 60-cycle power line and because a synchronous motor driving the projector from the same 60-cycle power line will always synchronize the film pulldowns with the xenon light "dark-out" periods. As can be seen, this gives five light interruptions per frame of 16mm motion-picture film at the sound speed of 24 frames/sec, resulting in completely flicker-free projection.

Figure 9 shows the synchronous motor conversion kit necessary to convert the Navy AQ-2(1) Sound Motion-Picture Projector to Hanovia xenon-arc lamp shutterless operation, while Fig. 10 shows the synchronous motor mounted in the projector replacing the standard AQ-2(1) universal motor.

Ballast

The Hanovia xenon-arc lamp requires a ballast and a starter in order to strike the lamp automatically and to operate it in such a way that a pulsed light output is obtained. As a design objective, every effort was made to design a ballast using only static transformers and condensers. No components of limited life that required periodic replacement were to be used. Further, the use of complex electromechanical devices, for timing or sequencing, was avoided to eliminate adjustment and service requirements. These design objectives were in keeping with the requirements of the Navy for the usage of this equipment.

Naturally, the least possible weight and size of the ballast would be most desirable; however, it was felt that maximum portability and usefulness could be retained if the automatic ballast starter did not exceed the Navy AQ-2(1) 16mm Sound Motion-Picture Projector in size and weight. Due to basic design objectives for operation and safety, which could not be sacrificed, and worthwhile features that should be included for convenience and ease of operation, this was quite difficult to accomplish. However, by designing the transformers for class H insulation and using the best grades of transformer lamination, the weight was brought down to 55 lb, cables included.

Figure 11 shows the circuit of the automatic ballast, starter and xenon lamp. At the left are the components that go in the separate ballast package; in the center is the interconnecting cable; on the right are the starter components that are fastened on the lamphouse door. Mounting the starter components on the lamphouse door places the rf(radio-frequency) striking voltage directly on the lamp and simplifies shielding for safety from high voltages. The interlock on the lamphouse door will shut off the lamp and kill all high voltages by opening the line contactor in the ballast. The line contactor will also open if the interconnecting cable is disconnected so

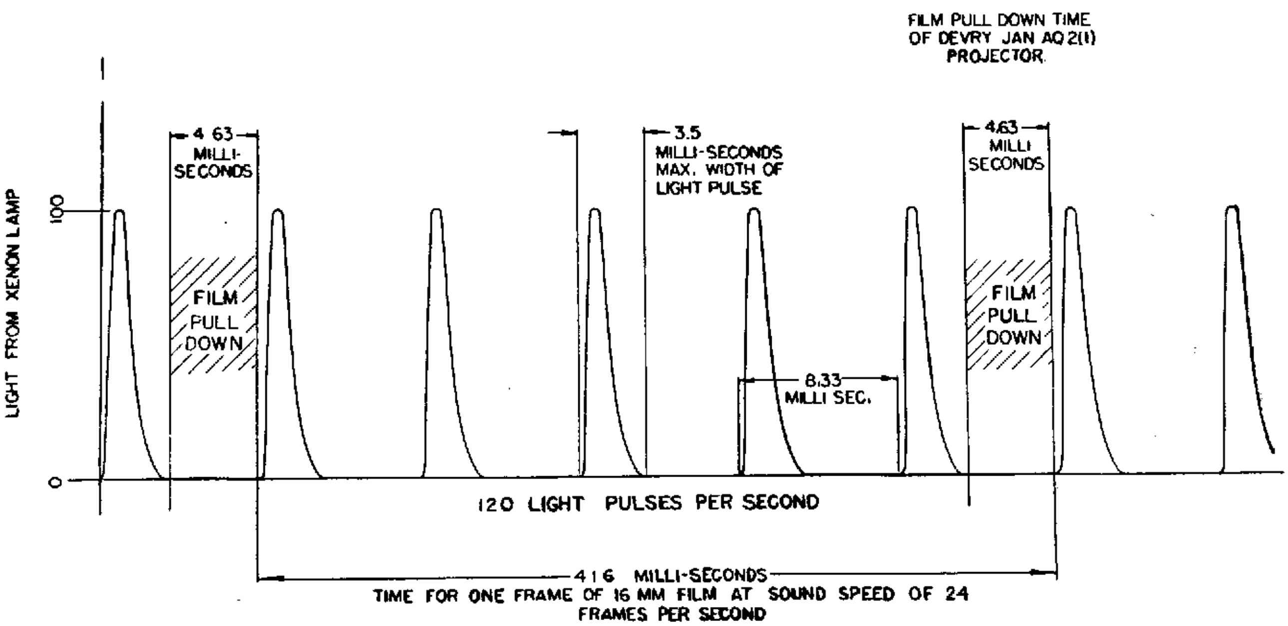

Fig. 8. A graphical representation of the light pulses from the Hanovia xenon arc lamp showing how the film pull-downs are accomplished.

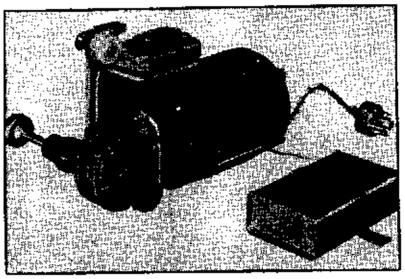

Fig. 9. The synchronous motor conversion kit for the Navy AQ-2(1) 16mm Sound Motion Picture Projector.

that no line plugs or line cable ends can be encountered.

Operation of Ballast

Figure 12 shows the approximate voltages and currents in the ballast starter circuit while the lamp is striking, but before it has struck. Figure 13 shows the approximate operating currents and voltages after the lamp has struck and is operating and giving a pulsed light output.

The "peaking transformer" is a saturated iron-core reactor that distorts the current waveshape such that the Hanovia xenon-arc lamp gives a pulsed light output.

The "ballast and starter transformer" in conjunction with the "striking condenser" supplies the starting currents and voltages and operating currents and voltages at terminals (2) and (3) to complement the electrical characteristics of the Hanovia xenon-arc lamp. Also the "ballast starter transformer," by acting as an autotransformer, reduces the line demand of the ballast. Further, the circuit of "peaking transformer," "ballast and starter transformer," and "striking condenser" tends to regulate the Hanovia xenon-arc lamp current, and consequently light output, for varying line input voltage.

Now before a simplified explanation of the operation of the ballast is made, the striking, starting and operating characteristics and requirements of the Hanovia xenon-arc lamp will be mentioned. The rf striking circuit consisting of "high-voltage transformer," "spark gap," "condenser" and "pulse transformer" will be considered as part of the xenon-arc lamp circuit that the ballast must supply and complement.

Figure 14 shows the starter on the lamphouse door with its cover removed. On top is a small blower that supplies additional cooling to the top of the Hanovia xenon lamp in the lamphouse. In the center is the "pulse transformer," on the bottom is the "spark gap" covered with an insulating housing, and behind the spark gap is the "condenser."

To start the Hanovia xenon lamp requires 150 v of line frequency. With the 150 v available the rf striking circuit is energized and the lamp is struck. However, the lamp when struck will not start unless approximately 900 va(volt-amperes) is available from the 150-v initial voltage to 30-v operating voltage. The higher the volt-amperage available, initially at strike, the quicker the xenon lamp will start. However, to exceed 900 va, which is the operating volt-amperage, at strike may reduce useful lamp life due to electrode evaporation and bulb blackening in the lamp. Therefore, the xenon lamp and rf striking circuit require 150 v at strike, with 900 va available from 150 v strike and start to 30 v operating. At 30 v and 30 amp operating, the rf striking circuit is inoperative because not enough voltage is available from the "high-voltage transformer" to discharge across the "spark gap."

If only the "peaking transformer" and winding No. 1 and winding No. 2 of the "ballast and starter transformer" are connected to the line (see Fig. 12), but the "striking condenser" is not in the circuit, the "peaking transformer" and winding No. 1 and No. 2 of the ballast starter transformer will divide the 115-v line voltage and only a small exciting current will flow. The voltage available at (2) and (3) would be approximately 40 v at no load. With a load across (2) and (3) not more than 350 va could be drawn.

If only the "striking condenser" and winding No. 3 of the "ballast starter transformer" are connected across the line, but the "peaking transformer" is not in the circuit, a heavy current, 7.5 amp, will flow in this series circuit. The impedance of this series circuit consists of only a small inductive reactance, since the capacitive reactance of the "striking condenser" partially cancels the inductive reactance of winding No. 3. However, individually the impedances of the inductive and capacitive reactances are high and the 7.5-amp current causes a voltage drop of approximately 540 v across the condenser and approximately 430 v across the winding No. 3. Now, since winding No. 3 is on the same core as winding No. 2, a voltage of approximately 150 v is induced across winding No. 2 across points (2) and (3).

If the peaking transformer is now put into the circuit, it acts as a high impedance partially isolating point (1) from the line such that the voltage at winding No. 2, points (2) and (3), is determined by the voltage across winding No. 3 rather than by the line. With the higher voltages across windings No. 2, No. 1 and the peaking transformer, a somewhat higher exciting current is drawn through these windings.

Now, with 150 v across points (2) and (3), the rf starter strikes the xenon lamp and the lamp starts to draw 900 va. This volt-amperage, while the lamp current is low and the lamp voltage high, is mostly supplied by the series circuit of "striking condenser" and winding No. 3, and partially by increased exciting current through the peaking transformer as the lamp load across winding No. 2, points (2) and (3), lowers the impedance of winding No. 2. As the lamp heats up, its impedance drops and an increased current flows through it, caus-

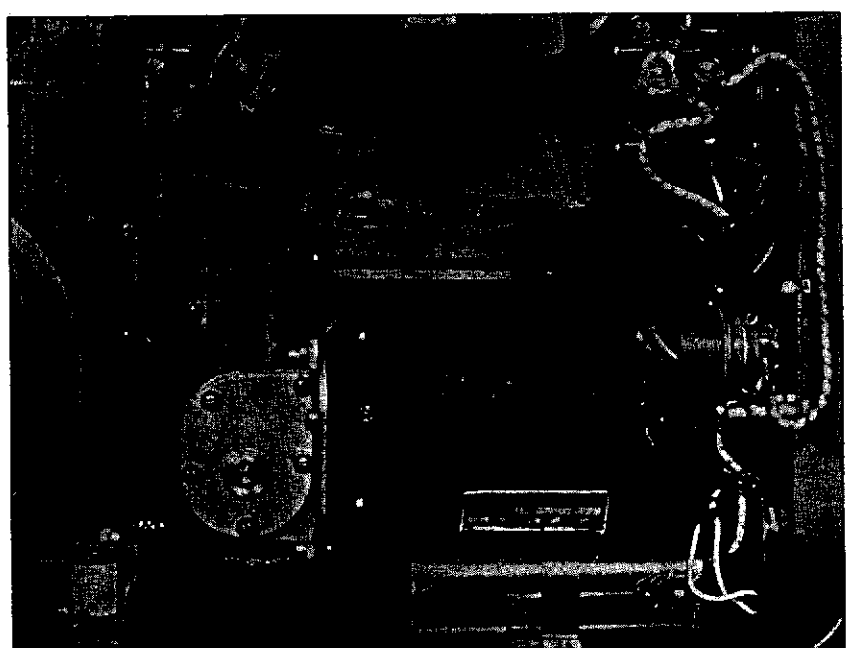

Fig. 10. The synchronous motor mounted in the Navy AQ-2(1) 16mm Sound Motion Picture Projector.

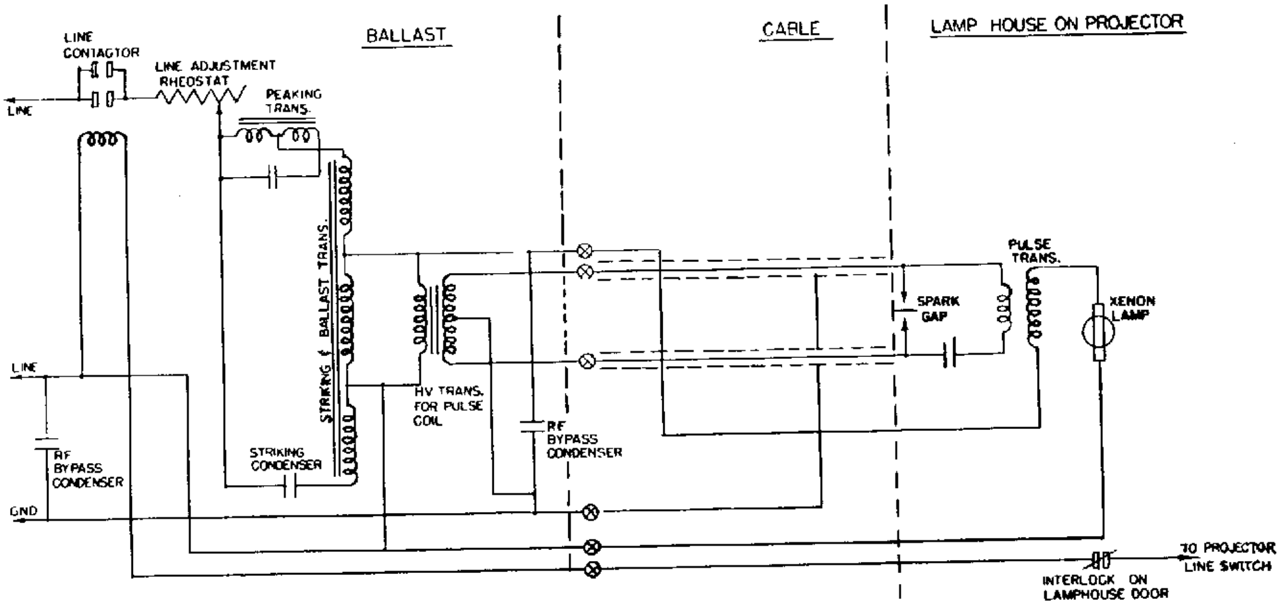

Fig. 11. Wiring diagram of the automatic ballast, the starter and the Hanovia xenon arc lamp.

ing the voltage across winding No. 2 to drop. At this point both the line through the "peaking transformer" and the series circuit of "striking condenser" and winding No. 3 are supplying power to the xenon lamp. With increased current through the lamp, the current through the "peaking transformer" causes a higher voltage drop across it, which reduces the voltage of winding No. 2. The higher current through winding No. 1 and No. 2 causes a bucking current in winding No. 3 that reduces the current through the series circuit of "striking condenser" and winding No. 3, that reduces the voltage across winding No. 3, that reduces the voltage induced into winding No. 2. This bucking current through winding No. 3 finally increases to a point where it is greater and there is a reversal of current through the series "striking condenser," winding No. 3 circuit. Due to the parameters of the circuit, this action continues until a stable point is reached where the lamp operates at 30 v and 30 amp.

The bucking current through winding No. 3 circulates through the peaking transformers, windings No. 1, No. 2, No. 3 and the striking condenser (see Fig. 13). This bucking current increases the saturation of the peaking transformer and raises the voltage across the peaking transformer. With the peaking transformer at a higher voltage, separated by the turns ratio of winding No. 1 and No. 2, the effect of line variation on lamp voltage and current is minimized. Further, the circulating bucking current opposes current change in the circuit. Thus, fairly good lamp-current regulation is achieved.

This explanation of the automatic starter ballast is only approximate due to its high harmonic content. The

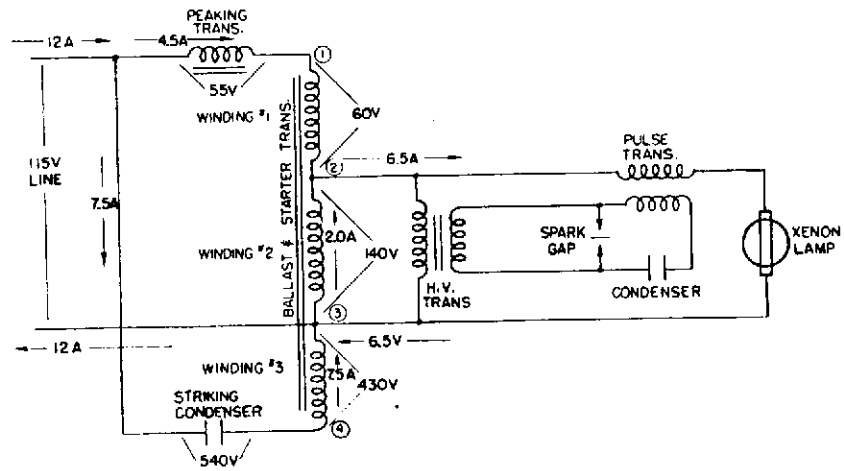

Fig. 12. Approximate voltages and currents in the ballast-starter circuit while the Hanovia xenon arc is striking, but before it has struck.

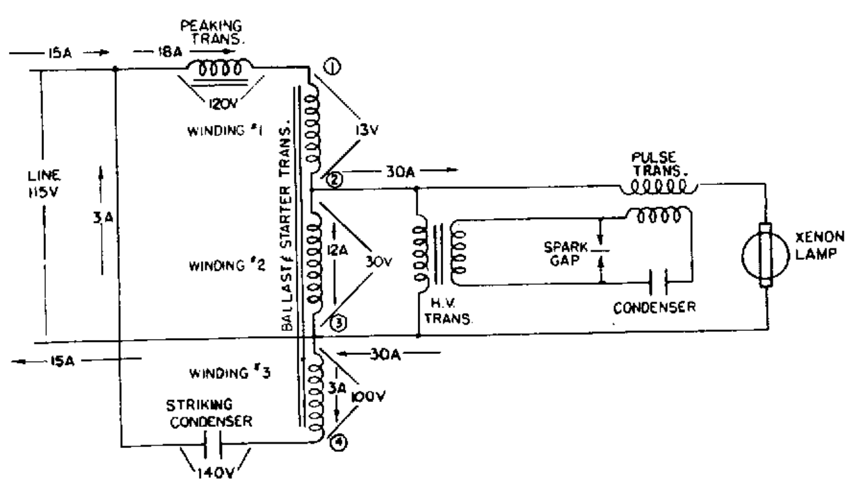

Fig. 13. Approximate operating currents and voltages after the lamp has struck and is operating with pulsed light output.

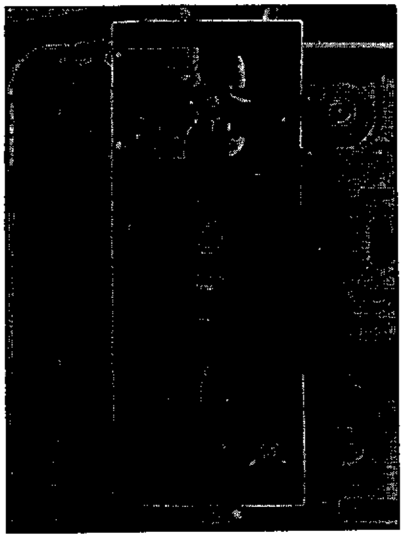

Fig. 14. The starter, with cover removed, mounted on the lamp house door of the Hanovia xenon arc lamp conversion of the Navy AQ-2(1) 16mm Sound Motion Picture Projector.

values of current and voltage shown on Fig. 12 and particularly on Fig. 13 are approximations for this reason.

Other Applications of the Xenon-Arc Projector

The pulsed light output from the xenon-arc lamp conversion of the Navy AQ-2(1) projector having a frequency of 120 light pulses, or fields, per second immediately suggested itself for television use, where 60 light fields, lace and interlace, per second give 30 pictures per second. As it happened, a vidicon television camera was in use for 16mm motion-picture pickup in the same projection room where the xenon-arc lamp projector was being tested; therefore, the xenon-arc lamp projector was simply substituted for the special 16mm, mechanically shuttered, 60 light fields/sec, television film projector. At the time it was a surprise that the xenon-arc lamp projector, with its 120 light pulses/sec, or two light pulses per television field, produced a television picture having uniform light distribution. Further, all the difficulties of poor television picture light distribution and application bar that had been encountered with the mechanically shuttered television projector were eliminated, since the poor television picture light distribution was due to the transit time of the mechanical shutter and due to imaging behind the motion-picture film upon the shutter blades, because of increased depth of focus of the projector and television camera optical systems, and the application bar was due to minute imperfections in shutter blade width and spacing.

These results led to further tests on television pickup of 16mm motion-picture projection with both image-orthicon and vidicon television cameras. It was found that the image persistence of both cameras was great enough so that having two separate light pulses per television field was not detrimental to picture light uniformity.

One interesting feature was brought out when the xenon-arc lamp projector was used with a rear-projection screen for television stage backgrounds. The general foreground stage lighting could be increased and even directed upon the rear-projection screen until the image of the xenon-arc lamp projector picture was washed out. However, the image persistence of the television camera retained the peak intensity of the xenon-arc lamp pulses. Therefore, the television picture showed the background rear-projection image at full contrast, while the eye seeing the average light from xenon-arc lamp pulses saw the rear-projection image on the stage washed out by the foreground lighting.

The xenon-arc projector was also excellent for television color film pickup, because of the abundance of light, the television color-separation process being exceedingly wasteful of light. Further, the continuous color spectrum of the xenon-arc lamp made color balancing of the three color images easy to accomplish.

At this time we want to thank Philip M. Cowett of the Navy Bureau of Ship, who first recognized the possibilities of the xenon-arc lamp for 16mm motion-picture projection and for all the help and suggestions he gave us on this Navy project; Dr. W. T. Anderson, Jr., Director of Research, and J. F. Postell, of the Hanovia Chemical and Mfg. Co., for their cooperation in the development of the lamp that made the success of this Navy project possible; and Walter A. Lotz for the optimistic assistance he gave the authors in the field of optics and the many others who contributed their efforts and encouragement in this project.

It is our feeling that the xenon-arc lamp as a new light source with its many novel and unique characteristics has possibilities not only in the motion-picture field but in all fields where a color-balanced light is required. The high-pressure xenon-gas quartz lamp may usher in a new era of high-efficiency light output devices. It has been a privilege to the authors to contribute in some small degree to this basically new art.

Discussion

L. L. Behrmann (Army Medical Service): What is the possibility of using this lamp in a television system?

Mr. D'Arcy: We've had very good success with this light source in television. We've had no shutter-bar. It surprised me how effectively the lamp functioned. In the case of television, of course, everything is limited by the 60-cycle light source, giving two pulses per field. You might expect that one would get a little frame dark spot at the top and bottom of each field and a bright spot in the center. However, we have not encountered these. Apparently there is sufficient storage capacity in the present camera tubes, both the image orthicon and the vidicon, to make this a very practical way of doing the job.

Mr. Behrmann: Is it possible to obtain this lamp in a smaller wattage?

Mr. D'Arcy: Definitely.

Walter I. Kisner (Eastman Kodak Co.): Have you made any measurements with respect to the heat at the aperture when this lamp is used, relative to that when a tungsten lamp of equivalent wattage is used?

Dr. Anderson: Not as yet. The xenon lamp does not produce as much heat as the Mazda Lamp operating at the same power. It is cooler. I think it produces about 80% of the temperature.

Anon: On smaller screens is there an adjustment for operating at less than 2000 lumens?

Dr. Anderson: Yes, you can reduce the power input to the lamp. I understand that the color temperature decreases somewhat, which is rather favorable if you are going to consider the fact that prints may have been matched to the color of Mazda and not that for the xenon source.

Mr. D'Arcy: The color temperature doesn't change radically. In other words, when Dr. Anderson spoke of color temperature dropping with lower current, I don't think it is a very drastic change — a few hundred degrees at the most.

R. T. Van Niman (Radio Corp. of America): What is the weight of the power supply? I can see that it is rather small but is it very heavy?

Mr. D'Arcy: The power supply weighs 55 lb. The weight of the projector itself is increased an additional four pounds by the weight of the lamp and the coil and spark starting mechanism.

R. A. White (General Precision Laboratory): I notice in Mr. D'Arcy's lantern slide illustrating the timing cycle that the film pulldown takes place between the light pulses. I presume that the projector used in the demonstration was performing in this manner. Did you have to increase the speed of pulldown on the standard projector to accomplish this?

Mr. D'Arcy: Our projector has a 40° pulldown

Mr. White: 40°?

Mr. D'Arcy: That's correct. And that's adequate to do the job. Mr. Seda had quite a bit of romance in shaping the pulse. That's a different story. It's not only the pulldown, but it's also the electrical shaping of the pulse which makes this job possible.

Mr. White: I was thinking in terms of television projection which you mentioned.

George Lewin (Signal Corps Pictorial Center): I noticed that it seemed to take a little time to start the arc. Is that typical or can this be resolved?

Mr. D'Arcy: I think we can make improvements in the starter. This is not the ultimate in starters as yet and for some reason, this being a time when it would act up a little bit, it isn't doing the job the way it normally does. Normally the arc should start immediately after the first starting pulse. You can understand my unwillingness to delve into the equipment at this time to improve the performance.