

that using three blades on single-shutter mechanisms did not work out.

Have you experienced this same effect in the three-bladed shutter test that you described?

*Mr. Borberg:* Yes, we do recognize that the ratio between light and dark periods makes a difference in performance on the screen. As you described, the long dark period and short light pulse combination is not as pleasant to look upon as if it were the other way around.

The additional effect that we are detailing is

that with the three-bladed shutter, the extreme buckle excursions during the necessarily high intensity light pulses can also give a sensation resembling flicker. It is not exactly flicker but it is unpleasant to look at and annoying, just as flicker is.

*Merle Chamberlin (M-G-M):* I would like to add one thing to the film-cooling experience that Dr. Daily brought up. It seems from our experiments at M-G-M that little bits of all of these improvements are needed to help out with

focus. The water-cooled back plate has been very advantageous and, as all of you know, there is an attachment available on the open market for water-cooling the back plate of all projection machines. As far as the three-wing shutters are concerned, I'm inclined to agree with Mr. Heacock and Mr. Borberg. Our experiments have taught us that, with the exception of any picture having wide open ocean or bald sky, most people definitely prefer the longer illumination periods of the two-bladed shutter.

## Letter to the Editor: Developmental Possibilities of 16mm Projectors

A few comments are proffered in response to John Maurer's paper "Developmental Possibilities in 16mm Projectors" in the February 1957 *Journal*, which states (p. 50):

"Since we know that the incandescent type of lamp cannot be made to give much more than the 525 lm obtained with the present JAN-Spec projector, we must look to light sources of greater brightness . . ."

I am familiar with most of the studies made of the efficiency of incandescent lamp projection systems, all of which appear to be in agreement with the statement above. Still — I feel that there are considerations which warrant re-examination of the entire problem.

The incandescent lamp has a number of advantages over any of the alternative light sources which have been suggested for 16mm projection. It is simple, it is inexpensive, and it requires no heavy auxiliary equipment for its operation.

The demonstrations of the xenon-short-arc were impressive indeed; but the lamp is expensive, short-lived (in proportion to its cost, at least) and the auxiliary equipment required for its operation is heavy, expensive and complicated.

The zirconium arc, at least in a few experiments which I participated in, did not seem to live up to its preliminary promise as a projector light source. And I have not yet had the opportunity to work with the radio-frequency lamp, but here, again, a large auxiliary is required for operation.

So — let us re-examine the incandescent lamp situation. Incandescent lamps have a luminous efficiency of from 19 to 28 lm/w — say, for easy figuring, an average of 22 lm/w. Thus, a 1000-w lamp has a total light output of 22,000 lm. In the JAN projector, less than 550 lm reach the screen. This is an efficiency of the order of 2½%.

From an engineering standpoint, it is difficult to justify an attitude that the limit of efficiency of a system has been reached at a figure of 2 to 3%, or thereabouts.

If the efficiency of an incandescent system could be raised to only 10% — still comfortably low — the light output of the typical projector would be increased to 2200 lm, which is on a par with the projector using carbon-arc or xenon-arc equipment, and this would not seem to be an unreasonable goal.

I am not questioning the correctness of the statement that 525 lm is about the limit of light output when a projection lamp of the present design is used in connection with conventional optics (that is, the ordinary condensing lens system, with or without a mirror reflector, which in the case of biplane filaments increases the light very little, and is mainly used to improve uniformity of illumination).

What I have in mind is simply this: assume a completely free choice as far as size, shape and filament construction of a hypothetical incandescent lamp is concerned. Assume, too, a free choice of light-gathering elements, of a variety differing from the conventional condenser. It seems to me that with such an approach, we cannot yet write off the incandescent electric lamp as a projector light source, as having reached its maximum efficiency in the area of 2½%.

In short, I think that the problem lies in the area of optical design rather than the need for new and brighter light sources. And I think that the inherent simplicity and economy of the

incandescent light source justify further research in the direction of increased efficiency in its utilization.

This is not entirely a matter of personal feeling. I have seen a few scattered experiments that showed considerable promise along these lines; but these were made many years ago, before the need for high powered 16mm projectors had developed, and before certain improvements in lamp construction had come about. I think this is worth thinking about, to say the least.

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*From John A. Maurer*

I agree with all that Mr. Carroll says about the desirable characteristics of the incandescent lamp. Unfortunately, it does not appear that there is any possibility of a fourfold increase of overall efficiency, or even as much as twofold.

Putting the situation as concisely as I know how to do, the maximum amount of light that any optical system can deliver to any point in an image is determined by the brightness (light flux per unit area) of the source, and by the angular aperture of the lens which forms the final image. If all areas of the projection lens are utilized, this maximum possible image brightness will actually be attained, less, of course, losses by reflection and absorption in the optical system, which seldom amount to as much as 20%.

This condition is very nearly fulfilled in the Jan Spec projector, as may be seen by inserting a pinhole mask in the picture aperture and observing with the help of a ground glass that the image of the lamp filament very nearly fills the aperture of the projection lens with the pinhole in any position within the frame area. Therefore, the only ways in which the light flux can be increased substantially are (1) to increase the brightness of the light source, or (2) to decrease the *f*-number of the projection lens. The first cannot be done with an incandescent lamp without unduly shortening its life. The second can be done only to a limited extent, since lenses of greater aperture than *f* 1.5 tend to give poor definition and, in any case, would be very difficult to keep in focus.

Like Mr. Carroll, I have seen illuminating systems using reflectors instead of condensers which come close to equalling the light output to the screen of the conventional 1000-w lamp and condenser, using lamps of much lower wattage with much smaller filaments. The efficiency of one of these systems is obviously much more than the 2½% cited by Mr. Carroll. It does not follow, however, that we could increase the wattage of the lamp used with such a reflector and thereby obtain more light than is delivered by the Jan Spec machine. The increase of lamp wattage would mean an increase in the size of the filament, and the increased light flux would be lost at the aperture plate of the projector, leaving the light output to the screen substantially the same as is obtained with the smaller lamp.

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