INCANDESCENT LAMP DEPARTMENT
GENERAL ELECTRIC COMPANY

LAMP DEVELOPMENT LABORATORY
W. L. ENFIELD, MANAGER

NELA PARK
CLEVELAND, OHIO

Oct. 8, 1935.

Professor R.M. Holmes
University of Vermont
Burlington, Vermont

Dear Professor Holmes:

The operating temperature of tungsten filament lamps increases with the wattage of the lamp. To do what you want would require the operation of lamps at different voltages. The following table gives the temperature of some of our incandescent lamps.

I would imagine that for the purpose you have in mind some of our lamps designed for moving picture work would be quite satisfactory. Thus, if you would pick out the 50, 100, 500 and 1000 watt projection lamps and then set them all at a color temperature of about 3000°K you would probably get the results you are after. I am enclosing a folder that lists some of these projection lamps with the ones I think would be suitable for your purpose checked. I am sending you a paper that gives the temperature of some of these projection lamps.

Very truly yours,

W. E. Forsythe

W. E. Forsythe

WEF:LW

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The Characteristics of Some Lamps Intended for Special Services

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FOR the 115-volt lamps that are used for general lighting purposes, the efficiency (lumens per watt) for a definite life in hours is very important, since these two characteristics largely determine the cost of the light obtained. Economic considerations determine the life of these lamps because light is produced at the least cost when the cost of the lamp is a definite percentage of the cost of the power used to operate it during its life. For many services for which special lamps are constructed, however, the efficiency in lumens per watt is of secondary importance. This is because many of these lamps are used for purposes where the problem is to get as great an amount of light as possible, for the wattage used, through a small opening or onto a certain area. This, in turn, requires that the filaments be concentrated into a very small space. The service is thus at times more important than the life or the efficiency, and the requirement for a great amount of light from a small area is so important that at times this results in some special lamps being operated at a short life.

There are many services that require special lamps; and whenever there is sufficient demand, an attempt is made to develop a lamp for the special service. The characteristics of a number of the lamps developed for special services have been measured. The results are given in the accompanying table; and for reference and comparison, some of the characteristics of three of the lamps used in general lighting service are included. The lamps selected were intended to be representative of the lines of lamps designed for various different services.

CHARACTERISTICS OF A NUMBER OF LAMPS INTENDED FOR SPECIAL SERVICES

Lamp	Volts	Current	Watts	Lumens	Lumens per Watt		Temperature (Deg. K.)
General Lighting Service	115		40	432	10.8		2700
	115		100	1490	14.9		2825
	115		500	9700	19.4		2935
Street Series		6.6		1000	15.7		2860
		6.6		2500	17.0		2885
		6.6		4000	18.3		2915
		6.6		6000	18.5		2920
		15.0		4000	18.6		2950
		20.0		6000	19.6		2995
		20.0		10000	19.7		3000
		20.0		15000	19.8		3000
		20.0		25000	20.1		3010
CX Lamps	115		60		13.6		2840
	115		250		19.0		2970
	115		500		21.3		3025
Airport Lighting	~~115~~ 32		1500		28.0		3250
	~~115~~ 32		3000		28.0		3250
Studio or Airport Floodlighting	115		5000		29.0		3300
	115		10000		29.5		3320
Floodlight	115		500		17.2		2940
	115		1000		19.3		3015
	115		1500		20.2		3050
Spotlight	115		250		16.7		2930
	115		400		19.6		3050
	115		1000		22.0		3145
	115		2000		24.5		3140
Projection (monoplane)	115	82 *	300	7010	24.0	820 †	3230
	115	156 *	500	13280	26.3	1545 †	3265
	30	148 *	900	24570	26.5	2860 †	3290
Projection (biplane)	115	68 *	500	12420	25.0	1700 †	3295
	115	89 *	750	19360	26.0	2670 †	3355
	115	132 *	1000	29160	27.6	4045 †	3360
Photocell Recorder	5.0	6.0					3200
	6.0	9.0					3320
	6.0	18.0					2950
Photocell Exciter	10.0	7.5					3165
	10.0	5.0					3160
	8.5	4.0					3060
Photoflood	115		250	8600			3490
	115		1000	32000			3410
Movieflood	115		2000	67000			3430

* Area light source in square millimeters.
† Candlepower in a direction perpendicular to plane of filament.

The lighting of streets is a good example of a special service that was found important enough to justify the development of lamps for that particular problem. This resulted in a line of series lamps for several reasons, one important reason being the existing series distribution formerly laid out in various cities for the purpose of operating the old arc lamps. The availability of these high-voltage circuits makes it possible to use, in series, lamps of low voltages and relatively high currents, which is fortunate, for a lamp of small wattage with high current can be made to have a higher efficiency than is possible using a lamp of high voltage and low current. This is because a high-current lamp has a filament of larger diameter than the lamp of small current and the efficiency of a gas-filled tungsten lamp increases rapidly with an increase in the filament diameter up to a filament of about the diameter of that of the ordinary 115-volt 500-watt lamp. Constant-current operation, however, results in a slight sacrifice of initial efficiency, since constant-current lamps do not live as long as constant-voltage lamps of the same size and initial rating. These lamps are made in a number of sizes to satisfy the demand for different amounts of light on different streets. Since street lighting is generally sold on the basis of a definite illumination, these lamps are rated in lumens.

A line of lamps called CX lamps has been developed for the production of intense infra-red radiation combined with mild ultra-violet. The life of these lamps has been shortened to take advantage of the increased radiation due to the higher temperature for the shorter life. These lamps are manufactured with a special glass bulb which has a high transmission in the ultra-violet down to wavelengths about 2900Å and transmits some energy down to wavelengths of about 2600 to 2700Å. Thus, the mild ultra-violet radiated by the tungsten filament at the higher temperature at which it is operated in this lamp is transmitted.

Another service for which special lamps have been developed is the floodlighting of studios and airports. Both these services require very high intensities, and since high wattage can be used, 5000- and 10,000-watt lamps have been developed for this illumination. Some lamps of lower wattage are also used for airport floodlighting. Lamps have also been developed for the floodlighting of buildings and certain important displays. These floodlight lamps are generally used in reflectors which require the filament to be specially placed to produce the best results.

Another line of lamps somewhat similar to the floodlight lamps and intended for a similar service is the line of spotlight lamps. These lamps are also used with reflectors or lenses so the filaments must be arranged in such a position as to give the best source for this purpose. Spotlighting lamps are used for throwing a spot of light of high intensity on some displays and stage settings. These lamps are designed for a short life since the wattage is somewhat limited and high intensity is necessary.

The projection of moving pictures, either with the small home movie projection machine or with the larger machines used to project regular pictures, requires a special lamp. This service is quite varied and thus requires lamps varying in size from about a 100-watt lamp for the small moving picture machine to lamps of 1000-watt rating or larger for the larger projection machines. For this service, the problem is to get as much light as possible, for the wattage used, through the projection machine onto the screen; and for this reason the filaments are concentrated and the lamps designed for a life of 25 to 100 hours, since the amount of light from a given filament increases very rapidly as the life is shortened. The question here is how much light is radiated in a definite direction within a definite cone—and that too from a light source of definite small size. Many of these lamps have their filaments arranged in two planes, with the coils in one plane immediately behind the space between the coils of the plane in front, thus giving a source of small area almost filled with the light source. This very greatly increases the amount of light that can be sent through the projection instrument. These biplane projection lamps have a somewhat lower lumen-per-watt rating than the monoplane lamps, but they have a much more uniform light source. The light source area and the candlepower in a direction perpendicular to the plane of the filament are given in the table. ✓

When taking and projecting sound motion pictures, the very special illumination for both making the sound record and for reproduction requires a high-intensity lamp with a filament of very special dimensions. A line of photocell exciter and recorder lamps have been developed for this service.

Another line of lamps for special purposes are the photoflood and movieflood lamps intended for taking regular, home movie, and color pictures. For these purposes a great amount of light is necessary, and it should be of as high color-temperature as possible, since light of a high color-temperature is more effective photographically than light of low color-temperature. Since it is so important to have a great amount of light at not too high wattage and also to obtain a high color-temperature of the source, these lamps are operated at the very short life of from 2 to 15 hours, depending upon the size of the lamp. A comparison of the temperature and lumen output of the 250-watt photoflood and the ordinary 500-watt lamp will show what has been gained both in color-temperature and amount of light output by designing the photoflood for the very short life. This increase in color-temperature is very important, since the photographic effect of a source for the same amount of ~~light~~ is increased by a factor of about 30 to 40 per cent for a 100-deg. increase in temperature at 3000 deg. K. Thus, the increase in temperature of the 250-watt photoflood lamp results in an increase in photographic effectiveness of the lamp by a factor of three or four.

wattage

Emissivity of Aged Tungsten Filaments at Various True Temperatures in C°.
International Critical Tables Vol 5 p. 243 $\lambda = 665$ mμ