without being necessarily retarded in their action by dash-pots, their feed is positive, and slight frictions in the moving parts introduce no noticeable error; they may be operated at will on direct currents, or on alternating currents of either of the standard frequencies. On alternating currents the power factor of a load of these lamps would be high as compared with a load of lamps having large magnet coils and cores, and in the matter of maintenance there appears to be nothing about such a lamp to suggest repairs, although the replacing of an occasional regulating strip would be much cheaper than the renewing of magnets.

Aside from the economies of enclosed lamps resulting from the increased life of the carbons they possess other advantages peculiar to themselves. As a result of the absolute enclosure they burn quietly, being free from hissing or flaming even though not accurately adjusted, and, as it is impossible for sparks to make their exit, all possible fire risk is eliminated, a feature which meets with the unanimous endorsation of the Boards of Fire Underwriters generally.

By virtue of the long arc which is maintained more perfect distribution of the light over large areas is obtained than is possible with open arc lamps. Direct current lamps of the latter type exert their greatest illuminating effect at an angle of about 45 degrees from the vertical so that a very intense light is noticeable within a radius slightly exceeding the height of the lamps from the ground while beyond this the illumination rapidly falls away. Enclosed lamps on the other hand spread their rays more horizontally, their angle of maximum intensity being about 75 degrees, and as a result the light is more regularly diffused over a large area and does not assume the form of concentric zones of rapidly diminishing intensity.

The economy in maintenance however affords the most striking example of the advantages of enclosed lamps over the open and the gain will be clearly noted by a comparison of the two systems. As an example we may compare the maintenance costs of 450 watt open and enclosed alternating current lamps operating 10 hours per day per year of 365 days, assuming for the former a life of 14 hours per trim of carbons costing $36.00 per 1000, while for the latter a life of 80 hours per trim of carbons costing $30.00 per 1000. In this comparison the matter of interest and depreciation allowance may be dismissed on the assumption that it will be similar in each case and thus there remains to be calculated the cost of carbons and trimming.

As the open lamp requires two new carbons per trim it will in a year therefore, on the above basis of 10-hour runs per day, require some 261 pairs of carbons, costing $18.80; on the other hand the enclosed lamp requires but one new carbon per trim and in a year will consume but 46 carbons, costing $1.38, so that an annual saving of some $17.42 per lamp is effected by the use of the enclosed lamps.

The cost of trimming will depend largely upon local conditions but we may assume that one man at $2 per day can trim one hundred open lamps or one-half as many enclosed lamps, which will make the cost per trim, therefore, 2 cents and 4 cents respectively. On the 10-hour basis the trimming, therefore, will cost approximately $5.62 per open lamp per year, as against $1.84 per enclosed lamp per year, resulting in a further annual saving in favor of the enclosed lamp of $3.78, making the total saving $21.17.

With direct current lamps the saving will be in like ratio, allowances for differences in the life and cost of carbons being necessarily taken into consideration, but whether direct or alternating the advantages of the enclosed lamp are so apparent that before a great period elapses not only will they largely supplant the open arcs, but they will further enter the arena in competition with large incandescent lamps and regenerative gas lamps.

THE PROPER EFFICIENCY OF INCANDESCENT LAMPS FOR CENTRAL STATIONS, INCLUDING A DESCRIPTION OF THE NERNST LAMP.

By E. E. Cary, St. Catharines.

Few questions in the field of electric lighting are of greater importance to central station managers than that of the efficiency of incandescent lamps. This problem of suitable efficiency, many may justly think could be handled more properly by the central station manager than by the manufacturer, but it must be borne in mind that the manufacturer is in close touch with many stations and is thus able to observe the inauguration and development of theories incident to the subject. Few questions seem so thoroughly misunderstood, and yet the fault is not entirely with the central station. In the first place, only the larger companies will invest in the necessary apparatus, and surprisingly few of these will purchase enough apparatus to determine the efficiency of their lamps. The initial outlay, including photometers and instruments will more than pay for itself in the first year. In the absence of the proper outfit, the managers have to depend upon the statements of manufacturers or more often upon those of their representatives, and what is the result? Dissatisfaction. One maker will supply lamps guaranteeing them to be of a stated efficiency, and these lamps will give satisfaction. Should the next order be placed with another company and the same efficiency guaranteed, chances are strongly in favor of the second consignment not giving satisfaction, assuming the specifications call for efficient lamps. Both lots of lamps may consume the same current at the stated voltage and in reality be intrinsically equal, yet one will be thought well of and the other condemned. A situation such as this, upon the face of it, seems incredible, yet such is the daily experience of every lamp manufacturer until, by long and often costly experience he becomes thoroughly acquainted with the actual state of affairs upon the lines of all his customers.

For many years generators, and later transformers, have been rated in light capacity upon the basis of fifty watt lamps. Multiples of fifty are convenient quantities to handle mentally, though, when this unit of capacity was adopted, everyone felt confident of the universal adoption of fifty watt lamps.

It has been unfortunate that 3.1 watt lamps have become such a household term, as their use has often proven very costly to companies before experience made them alter first ideas.

Everyone will probably agree that it is desirable to use the most efficient lamps possible, consistent with fair life where current is supplied upon the meter basis. Two questions immediately arise: what should be considered fair life, and at what efficiency under conditions existing upon the lines can this life be most economically obtained. Hardly two managers will agree upon the first question, and very few have at hand the necessary information to answer the second.

Every lamp maker, however worthy of the name, has on record the results of many tests showing the average life to be expected of lamps of different efficiencies when operated at normal or at voltages other than normal. Below in table 1, will be found the efficiency and average life of lamps at various voltages. Though these results are in one sense approximate only, yet they are the average results of many tests.

Before discussing the table, it is well to state that the efficiency of an incandescent lamp is generally given in watts per candle. A lamp radiating sixteen candles when operating at fifty volts, and one ampere of current, consumes fifty watts, and has therefore an efficiency of 3.1 watt per candle. When lamps are tested for efficiency, one grievous error is generally made. The voltage is taken carefully as labelled on the lamp instead of being taken at the point of the lines where the lamp will be used. For example any lamp, whatever its normal efficiency may be, can, and often is operated at a much higher efficiency. For instance a four watt lamp is often burned at three watts, and a three and a half watt often burns at two and a half watts. This is simply to show that when a manager talks of using more efficient lamps, he may be operating at that very time, lamps at a higher efficiency than he contemplates using.

EFFICIENCY AND AVERAGE LIFE OF LAMPS AT VARIOUS VOLTAGES.

Efficiency in Watts per C.P. at Normal Voltage.	Average Life at Constant E.M.F.	98 per cent. of Normal Voltage.		99 per cent. of Normal Voltage.		100 per cent. of Normal Voltage.		101 per cent. of Normal Voltage.		102 per cent. of Normal Voltage.		103 per cent. of Normal Voltage		104 per cent. of Normal Voltage.		105 per cent of Normal Voltage		106 per cent. of Normal Voltage.	
		Actual Watts per C.P.	Actual Life in Hours.	Actual Watts per C.P.	Actual Life in Hours.	Actual Watts per C.P.	Actual Life in Hours.	Actual Watts per C.P.	Actual Life in Hours.	Actual Watts per C.P.	Actual Life in Hours.	Actual Watts per C.P.	Actual Life in Hours.	Actual Watts per C.P.	Actual Life in Hours	Actual Watts per C.P.	Actual Life in Hours.	Actual Watts per C.P.	Actual Life in Hours.
4.5	2400	4.85	3500	4.68	2900	4.5	2400	4.34	2060	4.21	1830	4.06	1600	3.92	1400	3.8	1240	3.7	1120
4.	1500	4.31	2000	4.16	1750	4.	1500	3.86	1330	3.74	1160	3.62	1020	3.48	880	3.38	800	3.28	710
3.5	900	3.77	1200	3.64	1040	3.5	900	3.38	800	3.27	700	3.16	620	3.05	550	2.96	490	2.87	440
3.1	580	3.34	760	3.22	660	3.1	580	2.99	500	2.9	460	2.8	400	2.7	360	2.62	320	2.54	280
2.5	260	2.69	350	2.6	310	2.5	260	2.41	230	2.34	210	2.26	190	2.18	170	2.11	150	2.05	140