THE INTERNATIONAL UNIT OF LIGHT

Department of Commerce and Labor
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In order to determine as accurately as possible the relations between the photometric units of America, France, Germany, and Great Britain, comparisons have been made at different times during the past few years between the unit of light maintained at the Bureau of Standards, Washington; at the Laboratoire Central d'Électricité, Paris; at the Physikalisch-Technische Reichsanstalt, Berlin, and at the National Physical Laboratory, London.

The unit of light at the Bureau of Standards has been maintained through the medium of a series of incandescent electric lamps, the values of which were originally intended to be in agreement with the British unit, being made 100/88 times the Hefner unit.

The unit of light at the Laboratoire Central is the bougie decimale, which is taken as 0.104 of the Carcel lamp.

The unit of light at the Physikalisch-Technische Reichsanstalt is that given by the Hefner lamp burning at normal barometric pressure (76 cm) in an atmosphere containing 8.8 liters of water vapor per cubic meter.

The unit of light at the National Physical Laboratory is that given by the 10-candle-power Harcourt pentane lamp burning at normal barometric pressure (76 cm) in an atmosphere containing 8 liters of water vapor per cubic meter.

In addition to the direct intercomparison of flame standards carried out recently by the national laboratories in Europe, one comparison was made in 1906 and two in 1908 between the American and European units by means of carefully seasoned carbon filament electric standards, and as a result of all the comparisons the following relationships are established between the above units:

The *pentane unit* has the same value within the errors of experiment as the bougie decimale. It is 1.6 per cent less than the *standard candle* of the United States of America, and 11 per cent greater than the *Hefner unit.*

In order to come into agreement with Great Britain and France, the Bureau of Standards of America proposed to reduce their standard candle by 1.6 per cent, provided that France and Great Britain would unite with America in maintaining the common value constant, and would agree to call it *the International Candle.* The National Physical Laboratory, London, and the Laboratoire Central d'Électricité, Paris, have assented to this proposal, and the date agreed upon for the adoption of the term "international candle" and the change of unit in America is April 1, 1909.

The following simple relations will therefore hold after that date: 1 international candle = 1 pentane candle = 1 bougie decimale = 1 American candle = 1.11 Hefner unit = 0.104 Carcel unit. Therefore 1 Hefner = 0.90 international candle.

The pentane and other photometric standards in use in America will hereafter be standardized by the Bureau of Standards in terms of the new *international candle.* This, within the limits of experimental error, will bring the photometric units for both gas and electrical industries in America, France, and Great Britain to a single value, and the Hefner candle will be in the simple ratio of 9/10 to this international unit.

The above announcement is being made simultaneously in America, France, and Great Britain, and marks an important step forward in the history of photometric measurements. For many years the British parliamentary candle was the unit recognized in this country, but the lack of precision in practical photometry did not permit its value to be very accurately expressed or reproduced. In recent years the gas industry has employed either the 1-candlepower sperm candle, the Hefner lamp, or the 10-candlepower Harcourt pentane lamp, while the electrical industry has employed incandescent electric lamps certified by the Bureau of Standards. The unit of the Bureau has been maintained very constant, as shown by frequent comparisons with the standards of France, Germany, and Great Britain, but differed appreciably from the British unit and hence from the unit employed by the gas companies in America which employ the pentane lamp as a standard.

The Bureau of Standards took the initiative several years ago in bringing about international uniformity in the unit of light by sending its representatives abroad with copies of its standards to determine more accurately the relative values of the units of the several European countries, and to urge the adoption of an international unit. In this country the Illuminating Engineering Society, the American Institute of Electrical Engineers, and the American Gas Institute have acted together in support of the Bureau, and have voted in advance to recognize the new international unit of candlepower.

In England the National Physical Laboratory has secured the indorsement of the London Gas Referees and the Institution of Gas Engineers.

The union of the three national standardizing institutions of America, France, and Great Britain in maintaining the international candle, and the cooperation of the German Reichsanstalt in redetermining, from time to time, the ratio of the Hefner unit to the international candle, assures the highest attainable constancy for the new unit of light.

Unfortunately there is no primary photometric standard that is sufficiently constant and reproducible to be generally accepted as an international standard. France, Germany, and Great Britain each have their own primary flame standard, and a great deal of effort has been expended in attempting to determine accurately the relations between them. Until the flame standards themselves are better understood, however, and the atmospheric and other conditions more perfectly controlled, the unit of light can not be preserved as accurately by primary flame standards as by incandescent electric secondary standards. The latter, when well made, properly seasoned, and carefully measured, permit comparisons to be made (using the means of settings on several lamps) with excellent precision, the lamps themselves being constant enough and the precision of measurement high enough to fix the final values to about one or two tenths of 1 per cent. There is good reason to believe that in this way the international unit of light can be preserved so nearly constant that any inevitable drift occurring one way or the other would be too small to detect with certainty by any of our present flame standards in a lifetime. The Bureau of Standards will continue to standardize flame standards by the electric standards and will also carefully investigate the flame standards. Similar tests and investigations will also be made in Europe, and if any appreciable drift does occur it will sooner or later be detected.

The effect of this change of 1.6 per cent in the unit of the Bureau, which is in general use for electric lighting throughout the country, is to raise the candlepower rating and decrease slightly the watts per candle of electric lamps. A 16-candlepower lamp will give 16.2 candles in the new unit, or a 16-candlepower carbon filament lamp burning at 110 volts will give 16 candles on the new basis at 109.69 volts. The change, though small, is important in the photometry and rating of lamps.

The new international candle being in agreement with the present English unit as represented by a 10-candlepower standard pentane lamp, there will be no change in the

unit of light now employed by those gas companies which use pentane lamps which are in agreement with the English standard. But as pentane lamps may differ slightly from one another, even when burned under the same conditions, it is desirable to have them standardized in terms of the international candle. These variations, amounting to from 1 to 5 per cent, are generally in the same direction; that is, the lamps if not correct give less than 10 international candles under standard conditions when burning in a pure atmosphere at a normal barometric pressure of 76 cm of mercury, and an atmospheric humidity of 8 liters of water vapor per cubic meter.

Gas standards will be certified after April 1, 1909, in terms of the international candle. Electric standards will be certified in terms of the old unit until July 1, 1909, unless otherwise requested. After July 1 only the new unit will be recognized by the Bureau of Standards and by the Government in the certification of standards and in the inspection and testing of lamps.

It is hoped that the adoption of the international candle will tend to reduce the use of the Hefner unit in American practice. For a time the full expression "international candle" may advantageously be used, but the term "candle" in the sense of a unit will very soon be understood to mean the international candle without ambiguity.

Further information with regard to change of photometric unit or to the testing of gas and electric standards will be given on request.

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Approved:
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