The Cooper Hewitt Mercury Vapor Lamp

PART I. THEORY AND OPERATION

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This article is the first of a series of three on the theory and uses of the Cooper Hewitt Mercury Vapor Lamps. The second article, which will appear in the October issue, will illustrate the advantages of these lamps for industrial illumination. The third article will be descriptive of the Cooper Hewitt Quartz Lamp and its characteristics.—Editor.

GENERAL PRINCIPLES OF THE MERCURY ARC

The Cooper Hewitt lamp consists of a tube of glass or of quartz containing mercury, mercury vapor and wires sealed into the ends of the tube to conduct electricity to and from the current carrying vapor. In the manufacturing process all foreign gases are removed and the tube closed vacuum tight. In operation there is a direct current arc from the cathode electrode of mercury to an anode electrode of iron or of tungsten (Fig. 1).

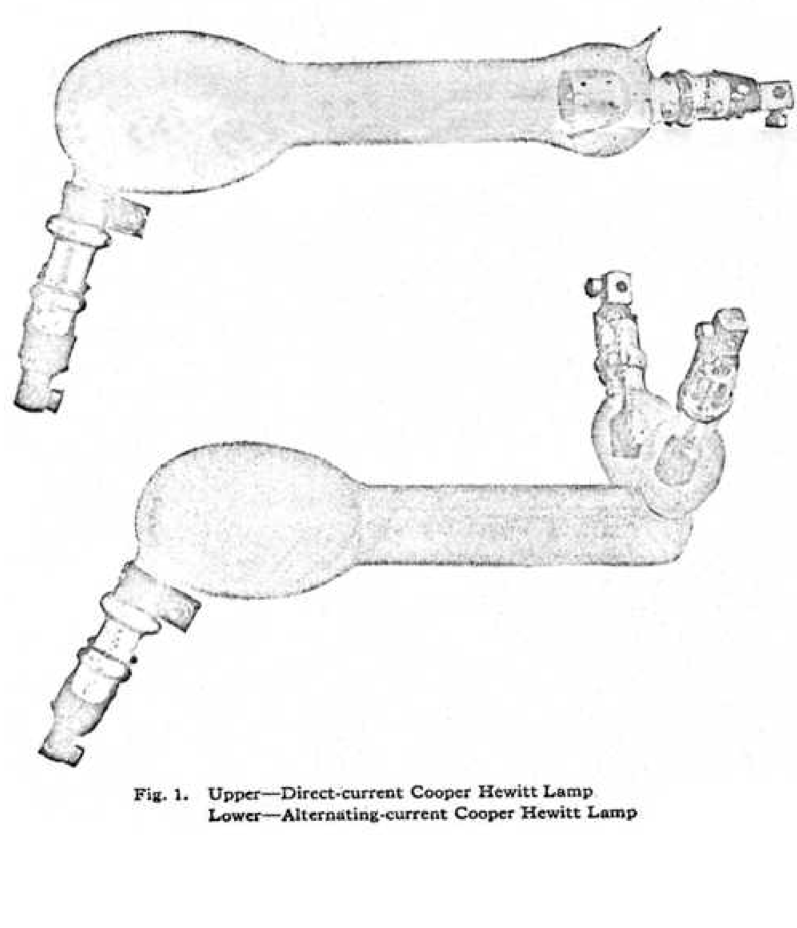


Fig. 1. Upper—Direct-current Cooper Hewitt Lamp
Lower—Alternating-current Cooper Hewitt Lamp

The wattage of a lamp of a given size is limited by the heat resisting quality of the glass used. Two types of lamps have therefore been developed, one of glass to operate at relatively low temperatures, and one of fused quartz to operate at relatively high temperatures. The normal volt-ampere characteristic of a lamp is determined primarily as a very complex function of the mercury vapor pressure and density and of the length and cross section of the tube. With the tube dimensions fixed the vapor pressure is determined largely by the minimum temperature within the tube, while the vapor density varies according to the heat distribution, being in general a minimum along the central axis of the tube. In standard industrial units the normal volt-amperage is then finally determined through the tube temperature by a condensing chamber in the form of a bulb on the cathode end of the lamp tube. A condition of complete equilibrium is reached when the light and heat radiated and conducted from the tube equals the electrical energy input. The effect on the tube voltage and current of the temperature rise during starting is shown in Fig. 2, where they are plotted as functions of time. In the actual design of a lamp these several variables are so balanced as to give at once that critical vapor density at which the light-giving efficiency is

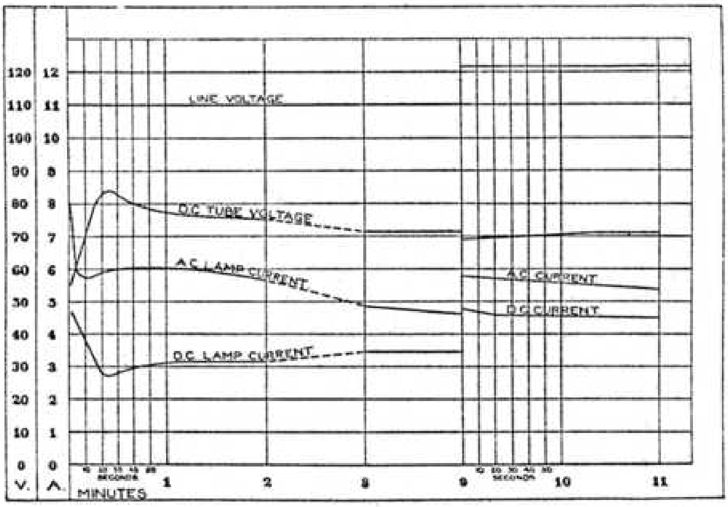


Fig. 2. Volt-ampere Starting Characteristic of Standard Lamps

greatest and a volt-ampere characteristic allowing maximum current regulation with a minimum sacrifice of wattage for that purpose.

Modern theory gives a strikingly graphic picture of the electrical condition in the arc column of the Cooper Hewitt lamp. According to it the tube is filled, during operation, with mercury molecules, mercury ions, and electrons. The ions are molecules which have gained or lost one or more electrons or unit negative charges of electricity, thereby being left charged either negatively or positively as the case may be. These molecules, ions, and electrons move with various characteristic velocities and in individual directions determined by their collisions with their fellows according to the well known kinetic molecular theory of gases. This commotion characteristic of all gas molecules is further complicated by the fact that a constant difference of potential of about one and one third volts per inch of arc length is maintained on the electrodes located in the ends of the tube, and that because of the heat of the cathode and the impact of the electrons, ions and molecules on each other and on the electrodes more electrons and ions are produced than are usually needed to carry the current. The effect of the electromotive force on this gas column is to produce an arc current which may be described as a continuous drift of electrons from the cathode to the anode and a relatively much slower movement of positive ions towards the cathode. The excess of ions and electrons produces the effect of a partial short circuit with a continuous tendency to become a more complete short circuit. The result is a periodic increase of current and fall of potential of a frequency determined by the capacitative and inductive reactance of the arc column and of the supply circuit.

For transient variations of the current this inverse variation of voltage is characteristic of the mercury arc, a cathode phenomenon apparently, for the whole range of practical current values and arc temperatures. It is most pronounced for low currents, but decreases rapidly with increase of normal cur-

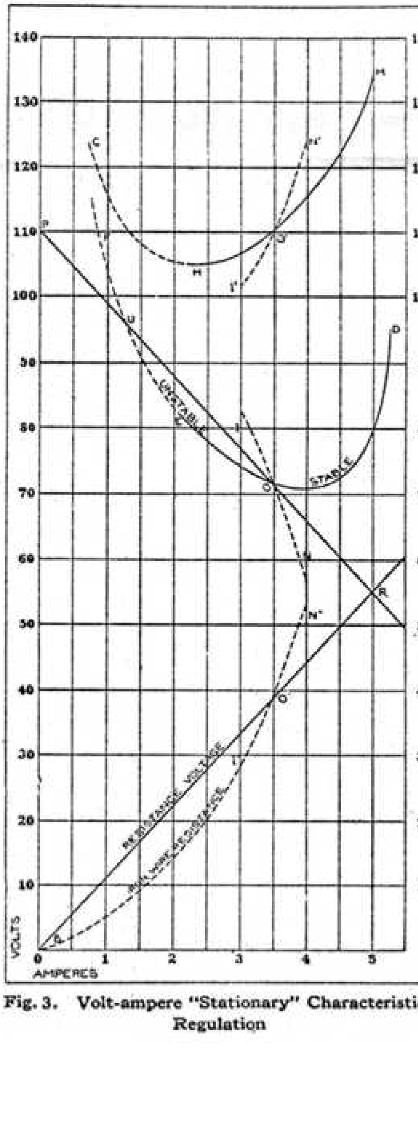


Fig. 3. Volt-ampere "Stationary" Characteristics Regulation

rent. For slow changes of the current this same volt-ampere relationship is characteristic up to a certain critical current value. With further increase of current from this point the tube voltage passes through a minimum and then rises rapidly as shown in Fig. 3. For maximum light efficiency, the Cooper Hewitt lamp is operated at the point of minimum tube voltage, where, if unrestricted, the arc current will fluctuate over a wide range on constant voltage. In order to operate this unstable and essentially constant current device on supposedly constant voltage power lines two forms of regulation are necessary. The current is steadied by an inductance coil, connected in series with the arc and as directly as possible to the cathode so as to oppose every transient action of the current by an instantaneous induced reaction. The falling voltage characteristic of the arc as well as the voltage variations of the line are compensated by an ohmic resistance in series with the inductance coil and the arc as shown in the wiring diagram, Fig. 4. This resistance is so chosen that, for normal operation, with any increase of current the decrease in arc voltage will be less than the increase in resistance potential. In Fig. 3, curve

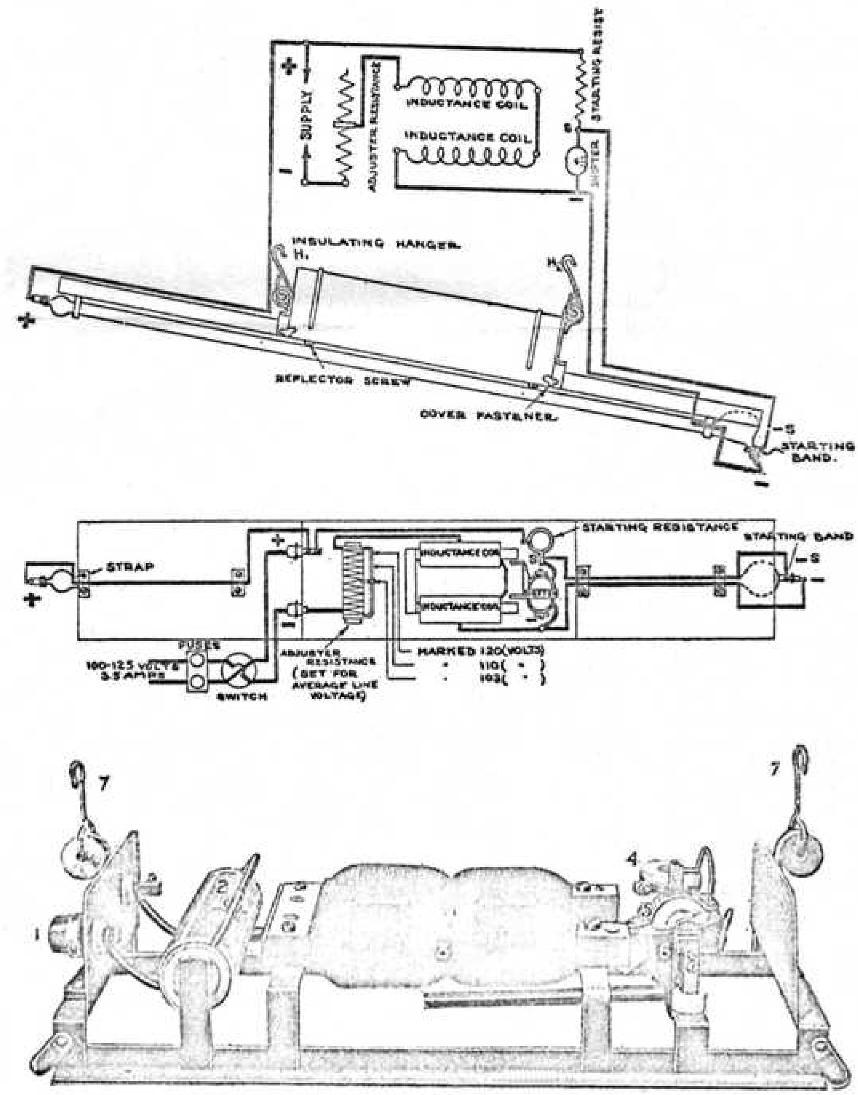
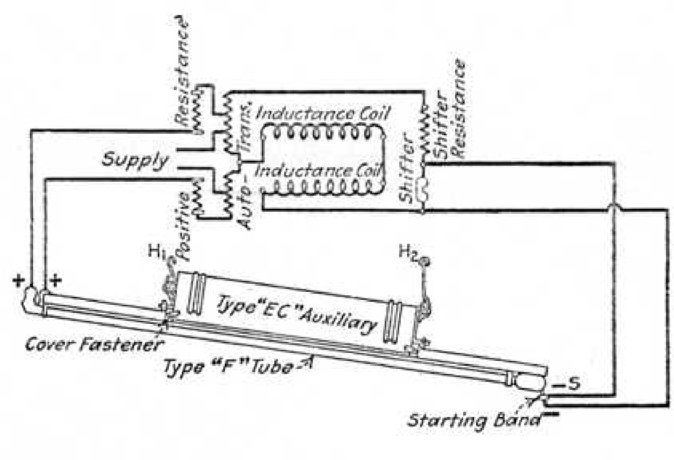


Fig. 4. Wiring Diagrams and the Detail of Direct-current Lamp Auxiliary

$D\ O\ E\ U\ F$ is the volt-ampere characteristic of a Cooper Hewitt arc showing inherent stability above and instability below four amperes. Line $P\ U\ O\ R$ represents the line voltage minus the resistance voltage for various currents, or in other words, the voltage available at any time for arc operation. Point U is, therefore, one of arc instability since any current increase is accelerated by the resulting excess arc voltage. On the other hand, point O is one of stability, a current decrease being opposed by an excess of arc voltage and an increase being limited by the available arc voltage. In this case the regulating series resistance is eleven ohms.

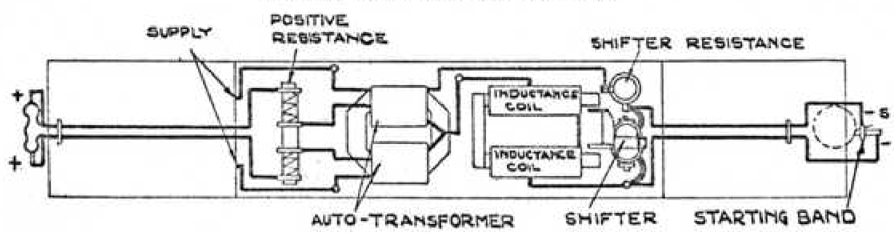
Curve $C\ H\ O''\ M$, the volt-ampere characteristic curve of the whole lighting unit, is the continuous sum of the resistance potentials $B\ O''\ R$ and the arc potentials. Point H therefore represents the minimum maintenance current and voltage of the outfit for the amount of regulation used. The regulation, which is defined as the per cent fluctuation of normal voltage producing a current change from one half ampere below to one half ampere above normal current, is in this case 8 per cent. In the Cooper Hewitt industrial units the series resistance is adjustable to provide for operation on various and on varying voltages.



Starting the Arc

To start the Cooper Hewitt lamp it is only necessary to start and maintain the formation of electrons in a so-called "hot spot" on the surface of the mercury cathode. Collisions with mercury molecules immediately result in the formation of more electrons and ions than are needed to form a current, with the results detailed above. The temperature of this spot, several thousand degrees at least, may be accounted for by the very small cross section of the spot and the fact that some eighteen watts of energy are converted into heat in this small area of liquid

WIRING DIAGRAM EC AUXILIARY



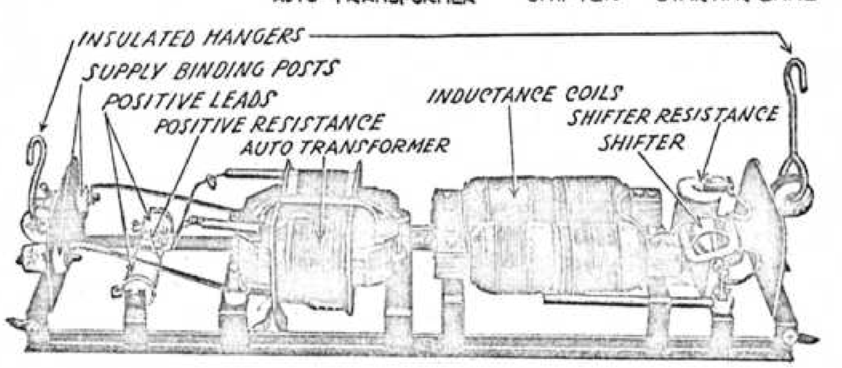


Fig. 5. Wiring Diagrams and the Detail of Alternating-current Lamp Auxiliary

vapor inter-surface, the cathode drop in potential being about 5.3 volts. There is a difference of opinion as to whether ionization at the cathode results from the direct emission of electrons from mercury vapor heated far above its boiling point or whether it results from the impact of positive ions upon hot molecules. In either case the condition is easily produced by bringing the mercury cathode into contact with the anode and then breaking the circuit thus formed, as with the ordinary carbon arc. This tilting method is now used to start the relatively small Cooper Hewitt quartz mercury lamps. An alternative automatic starting method standard for the glass lamps consists in short circuiting a small current through the arc regulating inductance in series with the arc. This current is broken by a mercury switch or "shifter" magnetically operated by the inductance coil itself. The resulting induced high potential is sufficient to start a localized cathode discharge and the arc is formed. A metallic coating placed on the outside of the cathode end of the tube opposite the mercury cathode and connected to the positive side of the supply circuit serves to increase the electrostatic capacity of the cathode and hence to give a greater current density to the induced high potential discharge when it is localized to form an arc. See Fig. 4 for the arrangement of the circuits.

The effectiveness of the "shifter" or mercury switch as a quick acting cut-out switch is worthy of note. It is itself a small glass chamber evacuated except for mercury and mercury vapor and is supplied with leading-in wires for electrical connection. It is made in the same manner as the regular lamps and is itself essentially a small mercury vapor arc. It is so mounted as to be easily rotated by an armature actuated by the magnetic field of the inductance coils. Its operation, in detail, is therefore as follows: At the moment the lamp is connected to its source of electric supply a current is short circuited past the lamp tube, through the arc regulating inductance coils and resistance, through an additional shifter or starting resistance and through the shifter itself (see Fig. 4). The lightly mounted shifter rotates, the mercury pool connecting the two leading-in wires is widely separated, and at the moment of separation an induced electromotive force reaching a very high peak voltage appears on the terminals of the shifter and therefore on the terminals of the arc tube. This voltage is sufficient to start the arc as outlined before, but it will not form an arc in the shifter since the total resistance of the shifter circuit is such as to keep the shifter starting current well below a minimum arc maintenance value. Since the inductance coils used have relatively low self inductance the high induced voltages obtained result from the extremely rapid current decrease when the circuit is broken in the shifter. The effectiveness of this mercury-vacuum switch for this purpose as compared with oil immersed or quick acting circuit breakers is accounted for by the uniquely rapid rate of deionization of cold mercury vapor and the heat dissipating property of volatile contact points. These considerations afford an explanation of the observed fact that the colder the "shifter" the more effective is its operation.

Exhausting the Tubes

In the manufacture of Cooper Hewitt lamps two features are of special interest, the method of evacuation and the treating of the metal anodes. When ready for evacuation the tube containing about twice its final amount of mercury is hung vertically in an upright gas furnace or hot air oven and connected by a tube at the upper end near the anode through a mercury trap to an ordinary vacuum. As the tube heats up to the boiling point of mercury the relatively heavy mercury vapor rises in it, displacing the remaining traces of foreign gases and water vapor. This process is continued until, with the mercury in the tubes boiling vigorously and with the glass walls of the tube nearly at their melting temperature, the tube is acting as a highly efficient mercury diffusion pump to produce its own high vacuum with reference to all volatile substances other than the mercury itself. When this process has resulted in the distillation from the tube of a measured amount of mercury the process is stopped and the bulb sealed off at the tube. Thereafter the "vacuum" of the tube is determined by the vapor pressure of mercury at any given tube temperature.

To free the metal electrodes from occluded gases they are heated to a white hot temperature during the pumping process. This treating is done by operating the lamp on an alternating current at some 4000 to 6000 volts.

The heat of the cathode hot spot is highly localized so that in a glass Cooper Hewitt lamp the arc column temperature varies from some 500 deg. C. in the center to about 125 deg. C. at the surface of the tube. Therefore the vapor pressure seldom rises to over one millimeter. There is a potential drop at the anode of about 5.7 volts and the anode is so designed that its temperature is normally about 350 deg C.

The Quartz Lamp

The Cooper Hewitt quartz lamp differs from the glass lamp as follows: The arc temperature is much higher, varying from some 1400 deg. C. in the center to about 450 deg. C. at the surface of the tube. The vapor pressure is therefore an atmosphere and over. The potential drop is about 25 volts per inch. To withstand the higher temperature a tungsten anode is used, which is white hot in normal operation. The quartz burner has no condensing chamber, direct radiation and the construction of the mercury filled cathode providing the required cooling. Fig. 6 shows a cross section of a 220-volt quartz burner in operation. The cathode surface is relatively smaller than in the glass lamp to restrict the fluctuations of the cathode spot. The arc stream is further steadied by deflection from the axis of the tube to the horizontal surface of the mercury. When cold the mercury flows down out of the cathode chamber and a slight tilting of the burner permits starting by the contact of the electrodes. The quartz mercury lamp requires the same regulation as the glass lamp, but a smaller per cent of energy is required for the purpose. The quartz arc column appears to be constricted along the center of the tube in contrast with the uniform appearance of the arc in glass.

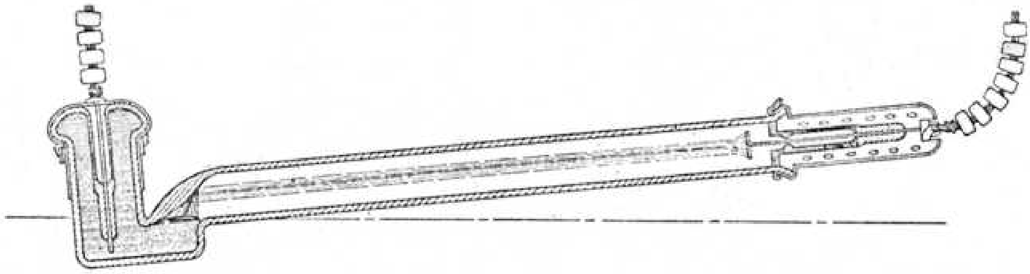


Fig. 6. Cooper Hewitt Quartz Lamp

The Alternating-current Lamp

The Cooper Hewitt alternating-current lamp is a highly specialized form of Cooper Hewitt single-phase constant voltage alternating-current rectifier. As shown in Fig. 1, the construction is identical with that of the direct current lamp except that there are two anode electrodes. The current in the lamp tube is a pulsating direct current of a frequency twice that of the alternating current, as is apparent from the oscillogaph curves of Fig. 7. The mercury arc is essentially a unidirectional conductor because its maintenance is dependent upon the existence and peculiar properties of the so-called cathode "hot-spot." This can be formed and maintained at a low voltage, 5.3 volts at ordinary temperatures only on mercury and certain of its alloys, and once formed is itself only maintained by continuous operation; and even with a mercury cathode this discharge of mercury vapor and electrons can only be started by drawing an arc by contact or by a potential of several thousand volts. These peculiarities of the arc are utilized in the Cooper Hewitt lamp as follows: The cathode of the lamp is connected through inductance to the middle point of the secondary of an auto transformer (see Fig. 5), while the anodes are connected to the terminals. Therefore the cathode is continuously negative with respect to one or the other anode during operation. The arc is started by an induced voltage, the mercury electrode becoming the cathode for the reasons indicated above. Thereafter the cathode functions as continuously negative with respect to one or the other anode. Thus the two halves of the transformer secondary and the anodes connected to them function alternately, the arc shifting from one to the other anode with the alternations of the supply current. The series inductance, in addition to steadying the current for transient variations, has the more important function of sustaining the cathode spot and the arc current during the time of zero voltage, or in other words, of causing the current to a given anode during a half cycle to lag its voltage and overlap the current to the other anode to such an extent that the resultant arc current never falls below the minimum maintenance value. Although the potential between the two anodes is obviously always double that between the active anode and the cathode, there is little or no leakage between them. For an alternating current of a given frequency the minimum sustaining inductance is definitely determined and this also fixes the minimum practical power factor of the outfit.

Regulation such as that provided by series resistance in the case of the direct-current lamp could obviously be provided by inductance or choke coils instead of ohmic resistance at a slight gain in efficiency but with th disadvantage of low power factor, viz., 50 p r cent. In the Cooper Hewitt alternating-current lamp, ohmic resistance is placed in the anode circuits, Fig. 5, and to secure a aximum of regulating effect on fluctuating voltage a special iron wire resistance unit is used. It is so designed that because of the high temperature co-efficient of resistance of iron the voltage absorbed by the resistance varies more rapidly than the current. The volt-ampere characteristic of a certain iron wire resistance is as indicated by the curve $BO''N''$ in contrast with a nearly straight line for an ordinary resistance, Fig. 3; and the effect of using such an iron wire resistance with a direct-current lamp might be as indicated by the dotted lines, I N. In actual practice the series inductance provides part of the regulation, absorbing an appreciable amount of the transformer voltage as shown in Fig. 7, K, and helping to produce a power factor of 85 per cent.

Fig. 7 shows some of the relationships between voltage, current and time in various parts of a standard alternating current lamp. A, the primary voltage, is approximately a sine function as usual, but the current wave form, B, is distorted by the reactance and the arc characteristic of the secondary circuit. D is the e.m.f. between the arc cathode and the active anode, while H is the e.m.f. during the succeeding half cycle when the other anode becomes the active one. C is the anode current corresponding to voltage D, while G is the current in the other anode during the succeeding half cycle. E is the voltage drop in the anode resistance units during their current carrying intervals. I is the superimposed anode currents, while J is the resulting rectified arc current. L shows the superimposed arc voltages and their induced overlap which causes the anode currents to overlap as in I. Curve K showing the voltage drop in the direct-current reactance coils is of unusual interest. The inductive reactance of the arc circuit and the arc characteristics cause the pulsating arc current to rise more slowly than it decreases. The point of anode current overlap also comes during the time of arc current decrease. The bearing of these facts upon the wave form of the direct-current reactance voltage is evident from J and K. Thus points of zero voltage correspond to zero time rate of current change, maxima and minima current or to momentarily constant current; while the

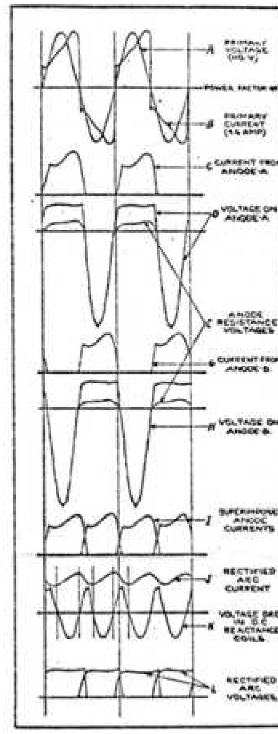


Fig. 7. Oscillograph Record of Alternating-current Lamp Characteristics

points of maximum voltage come when the time rate of current change is a maximum. The effect of the overlap discontinuities of the arc current on the corresponding induced voltage maximum is evident. During the period of current overlay, current flows to each anode and there is during that time no potential difference between them, as shown by a prolonged interval of zero voltage on the approximate sine curve of the voltage between the two anodes. The energy represented by this variation from the full sine curve form of the transformer secondary e.m.f. is momentarily absorbed in the common coils of the transformer which are constructed for high self inductance against each other.

As is evident from B and J, Fig. 7, the tube current fluctuates over a much smaller range than does the usual alternating current. This fact and the lower intrinsic brilliancy account for the success of the lamp for high intensity illumination on alternating currents of frequencies as low as 25 cycles. On the other hand, alternating-current lamps are built for operation on frequencies as high as 133 cycles by modifications in the auto-transformer design.

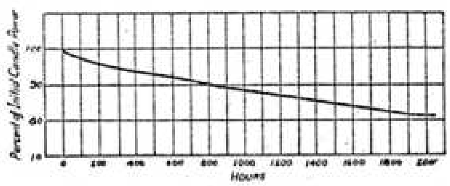


Fig. 8. Candle-power-life Characteristics

While the characteristics of individual lamps vary over a rather wide range, observations for years and on lamps operating under all types of adverse industrial conditions give the basis for a candle-power life of the nature shown in Fig. 8. The regenerative nature of the arc material gives a lamp of theoretically indefinite life, but manufacturing difficulties in the line of impure materials and contamination during the glass-blowing operation seriously complicate the situation. That improved manufacturing methods will produce lamps of even better candle-power life is inevitable.

Luminescence Color Sensations, Visibility and Visual Acuity

The light of the Cooper Hewitt lamp may be thought of as produced by electrical forces acting directly upon the vapor particles in the arc stream. Specifically the phenomenon is thought to be connected with the ionization and deionization of the mercury molecules as outlined above. The result is a relatively cold light since the temperature of the luminescent vapor of a Cooper Hewitt lamp is from 200 deg. C. to 500 deg. C., while that of the filament incandescent lamp is some 2800 deg. C.

The intensity of the light from any artificial source varies for the different wave lengths, being in general greatest for the long wave lengths in the infra-red, as shown on the insert in Fig. 9. These intensities plotted against a wave length scale form a relative spectral

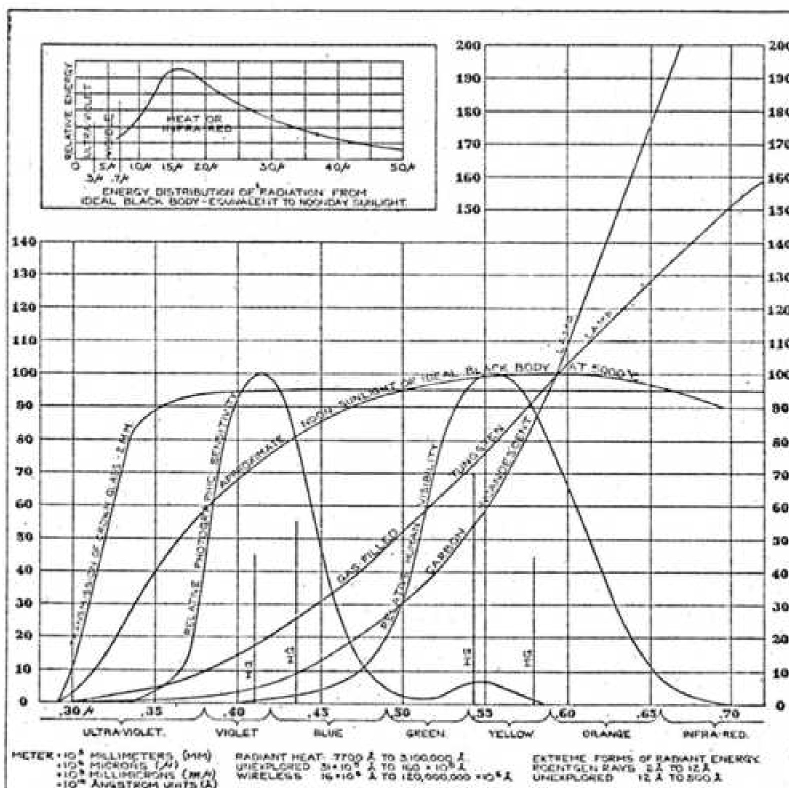


Fig. 9. Energy Distribution in Various Illuminants

distribution curve for any given light source. With increase in the temperature of the source this maximum in the infra-red moves towards the visible part of the spectrum. In so far as this change is not according to Wein's displacement law for a perfect radiator the radiation is said to be selective, favorably so if producing greater visibility.

For the discontinuous spectrum of luminescent light the energy distribution may be located by lines and bands along the wave length scale and the corresponding intensity by their height, as for mercury in Figs. 9 and 10. The spectral distribution of pure luminescence is completely selective and has not as yet been shown to be a function of temperature.

Light of each distinct wave length produces its own characteristic effect of visibility, color, visual acuity, photographic effect and psychologic reaction. All these effects differ in quality and intensity with the nature of the light waves. Some of these complicated relationships may be shown graphically by plotting the relative intensities of these effects against a wave length scale, as in Figs. 9 and 10. These effects also vary with different eyes, photographic plates, and nervous temperaments. The human visibility curve represents the average of a large number of eyes studied by the Bureau of Standards. The photographic sensitivity curve represents approximately the effect of white light on an ordinary photographic plate.

Visible light of any given wave length produces the sensation of a single color—monochromatic light. Light of all wave lengths and uniform intensity utilized in the proportions indicated by the visibility curve produces the sensation of white light. Color or white light produced by any other than these natural means is described as subjective. White light may be produced by the proper mixture of a series of complementary hues, such as orange with blue, yellow with blue-violet, or yellow-green with violet-purple. The whiteness of the Cooper Hewitt light is due to the combination of the nearly complementary hues of the yellow-green lines with the blue and violet lines. The difference between such a subjective white and true white light is only apparent when examining objects of colors other than those making up the former, since colored objects have their color by virtue of the colored light they are able to reflect. One method of studying

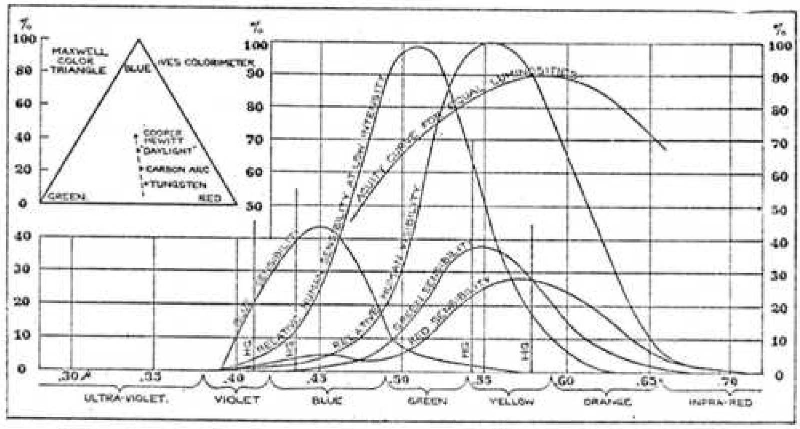


Fig. 10. Color Sensibility Curves

light considers it as made up of combinations of three primary colors, red, green and blue. Ives has found that on the basis that white light is one third each of red, green and blue the mercury arc light gives the effect of being 29 per cent red, 30 per cent green and 41 per cent blue. Green and red produce the sensation of yellow; therefore the mercury arc light may be said to be 59 per cent yellow and 41 per cent blue, there being an excess of 9 per cent green and 12 per cent of blue light more than needed to produce the sensation of pure white.

Analyzed in terms of hue and saturation the light of the Cooper Hewitt lamp may be described as apparently of dominant hue 0.49 or blue with an admixture of 70 per cent of white light. Other lights analyzed on the same basis are:

	PER CENT	
	White	Hue
Sunlight	100	0
Cooper Hewitt light	70	.490μ
Average clear sky	60	.472
Mazda C	53	.584
Carbon glow lamp 3.8 w.p.c.	25	.592
Neon tube	6	.605

Transparent and solid objects are seen as colored only when they select and absorb from the light illuminating them all but some characteristic color or colors which they either transmit or reflect. Therefore any change in the color of an illuminant by means of colored glass globes or reflectors involves a decrease in luminosity since the color is produced by a process of subtraction from the original light. When the Cooper Hewitt light is produced in a glass tube of true spectral red color the glass absorbs nearly all the light and transmits little or none since there is no objective red in the Cooper Hewitt light. Similarly dull dark red objects may appear nearly black because of maximum absorption and minimum reflection.

As has already been said, the most unique property of the Cooper Hewitt light is that while it produces the sensation of white light the independent investigations of Luckiesh and Bell show that it is essentially a monochromatic light giving a visual acuity some 50 per cent higher than white light. It is of interest to note also that for equal illumination by monochromatic lights of various colors visual acuity is a maximum for yellow light of wave length 58 microns, which is also nearly the color of maximum visibility (Fig. 9). High monochromatic visual acuity and a white light containing a full range of spectral colors are mutually exclusive.

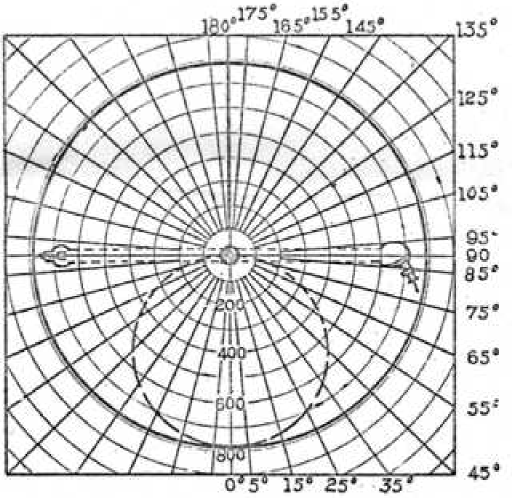


Fig. 11. Candle-power Distribution About a Bare Lamp

While it is claimed by some that subjective white light and colors should not be compared with ordinary white light and the spectral colors, yet there is no basis for defining the difference, which appears to be one of degree only. In fact, according to the most widely accepted theory of color vision, all colors are subjective in the sense that we never actually see the true primary colors which are themselves excited not by narrow ranges of wave lengths of light but in varying degree by wide ranges of light vibrations. Koenig's hue sensation curves for true primary red, green and blue are analogous to the visibility curve for the human eye (Fig. 10). Therefore the yellow Cooper Hewitt light excites moderately the sensations of primary red and green, and feebly the blue, producing the subjective sensation of yellow. The green Cooper Hewitt light excites strongly the primary green, moderately the primary red, and feebly the blue, producing the subjective sensation of green. The blue light excites strongly the primary blue and but slightly the other two, producing a subjective sensation of blue. The human eye apparently integrates these three primary color sensations as white—light visibility. The data for the insert in Fig. 10 were obtained by Ives by methods based on such a three color theory.

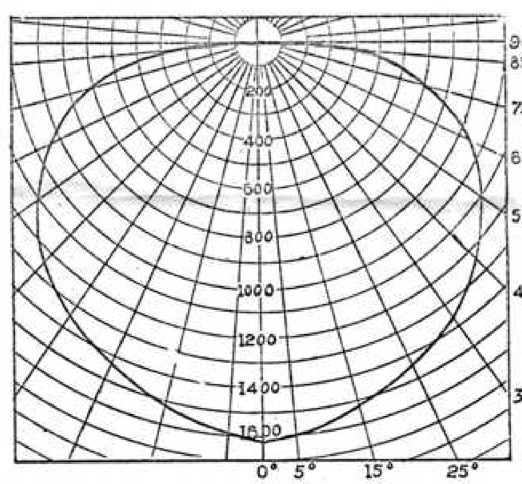


Fig. 12. Representative Light Distribution with a Standard Reflector

Photometery

The physical evaluation of the Cooper Hewitt light has been a perplexing problem for years. Added to the well known difficulties of heterochromatic photometry is the questionable process of comparing a light of discontinuous spectrum with a standard light of continuous spectrum. As yet direct comparisons with and without color corrective screens have failed to give thoroughly consistent results, nor does the flicker photometer seem to solve the problem for all its effectiveness in general heterochromatic photometry. Integrating spheres and hemispheres are limited by the marked effect of a diffuse reflecting surface in increasing the selectivity, by reflection, of a selective light.

Direct comparison with calibrated color filters to reduce the color difference on the comparison field seems as yet to most nearly approximate a physical valuation of use to the illuminating engineer and the candlepower data of Table I were obtained by this method. As the common form of Cooper Hewitt lamp is distinctly a source of finite area, and especially of finite length, the lamp is photometered at such a distance as to reduce this error to less than one per cent while in calculating the mean spherical candlepower the usual spherical reduction factor is used. The approximate distribution curve of a bare lamp, Fig. 11, is characteristic of any line source. A standard reflector widely used for industrial installations is so designed as to give identical distribution curves, in planes both parallel and perpendicular to the tube, of the type shown in Fig. 12. In the layout of an industrial installation these curves and accompanying data are used according to the principles fundamental in all illuminating engineering practice.

TABLE I

Current	Length of luminous tube in inches	Terminal Volts	Amperes	Power Factor	Watts	Mean Spher. C. P. Bare	Lumens per Watt Bare	Universal Reflector M.H. C.P.	Watts per Candle	Lumens per Watt	
Direct	50	110	3.5		385	550	17.9	875	.44	14.2	Photograph Illumination
Direct	2–50	220	3.5		770	940	15.4	1500	.52	12.2	Photograph Illumination
Alternating	50	110 or 220	3.8	85	430	615	17.9	975	.44	14.2	Photograph Illumination
Direct*	67	110	7.		770						Blue Printing
Direct*	67	110	15.		1650						Blue Printing
Direct	3	110	4.		440						Quartz Arc
Direct	6	220	3.5		770						Quartz Arc

*Made also for alternating current. Variations in length and shapes of above lamps provide some 25 standard lamp tubes.

Table I is a tabulation of some of the characteristics of standard types of Cooper Hewitt lamps. The larger tubes are used in blue printing machines rather than for lighting, and illumination data are therefore omitted. These straight tubes are modified into specialized forms by variations in length and by bending the standard 50 in. tubes into U and M shapes for photographic enlarging outfits.