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of the Automotive Industry in Developing Countries

Karlovy Vary, CSSR, 24 February - 14 March 1969

SOME PROBLEMS INVOLVED IN THE ESTABLISHMENT OF THE AUTOMOTIVE LIGHTING INDUSTRY

by

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CSSR

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SOME PROBLEMS INVOLVED IN THE ESTABLISHMENT OF THE AUTOMOTIVE LIGHTING INDUSTRY[1]

by

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* This is a summary of a paper issued under the same title as ID/WG.13/17.

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Some Problems Involved in the Establishment of the Automotive Lighting Industry

Within the automotive industry automotive lighting occupies a significant position, which is growingly emphasized by economy requirements. It must ensure fast and safe traffic even under low visibility conditions such as twilight, fog, night, etc.

A variety of lighting devices has been introduced by the industry, to permit suitable observation conditions for all participants in road traffic, and signal the presence of the vehicle or the intentions of its driver in a definite manner without disturbing the smooth flow, or jeopardizing the safety, of the traffic.

Other types of lighting fixtures are used for local illumination either inside or outside the vehicle, or in its close proximity.

It is obvious, that such an extensive assortment of lighting fixtures differs remarkably in both design and lighting properties.

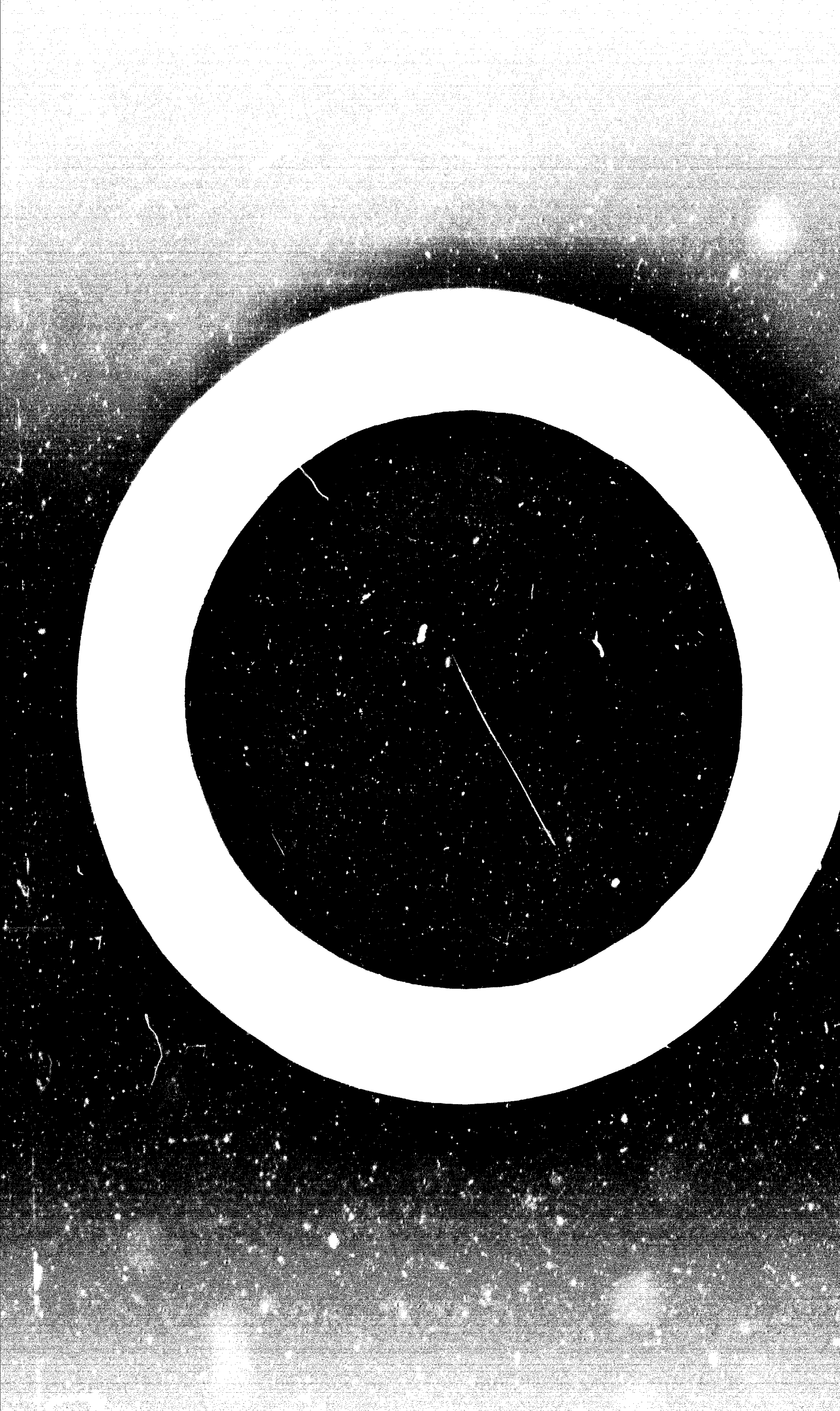
Owing to these facts, this paper is divided into the following sections:

1. Luminous Properties of the Lighting Fixtures analysed from the point of view of photometric quantities /luminous flux, luminous intensity, brightness, luminous emittance, illumination/, qualities of light colority, optical mapping and light utilization.

2. Design Features of individual lighting fixtures, determination of optimum types, especially of the head lights, which require maximum attention due to high technical and service demands. Other types of lighting fixtures and demands specified by Czechoslovak /ČSN/ and ECE standards, as well as special demands imposed upon the lighting fixtures from the point of view of maintaining necessary electric, mechanical-optical and adjustment range are also analysed.

3. Production of Automotive Lighting Fixtures includes a brief description of the manufacture of individual component parts, especially of the headlights /parabolic mirrors, headlight glasses, carrier and rectifying equipment/, as well as their control and assembly.

4. Testing Procedures are divided into four separate paragraphs:



a. Determining the physical properties of the light by means of experimental methods with the aid of photometers, integrators, luxmeters and colorimetric devices;

b. Testing of lighting fixtures /headlights, lamps, refractors/ in the factory, according to the respective recomendations of ECE and ČSN;

c. Testing of lighting fixtures mounted in operating position on the vehicle, according to the respective recomendations of ECE and ČSN, and their correct adjustment;

d. Special testing equipment.

The significance of laboratory testing is emphasized with respect to recent advances in optics. A proposed optimum testing laboratory outfit is added.

5. Tropicalization covers special requirements upon instruments and devices which are used in climates causing unfavourable corrosion of component parts of metals and plastics. The analysis is based on the tentative ČSN standard wherein the properties of metals, alloys, plastics and protecting films for component parts used in the tropics are specified, and testing procedures for such component parts, including their evaluation, are determined.

6. Some aspects of Producing Automotive Lighting in Developing Countries includes:

a. Determination of optimum conditions from the standpoint of the national economy for the establishment of individual plants;

b. Material requirements;

c. Personel demands, qualification of management staff;

d. Necessary cooperation;
- with developed countries;
- among developing countries.

A statement of general considerations concerning the possibilities for manufacturing automotive lighting in developing countries is attached.

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Research Worker

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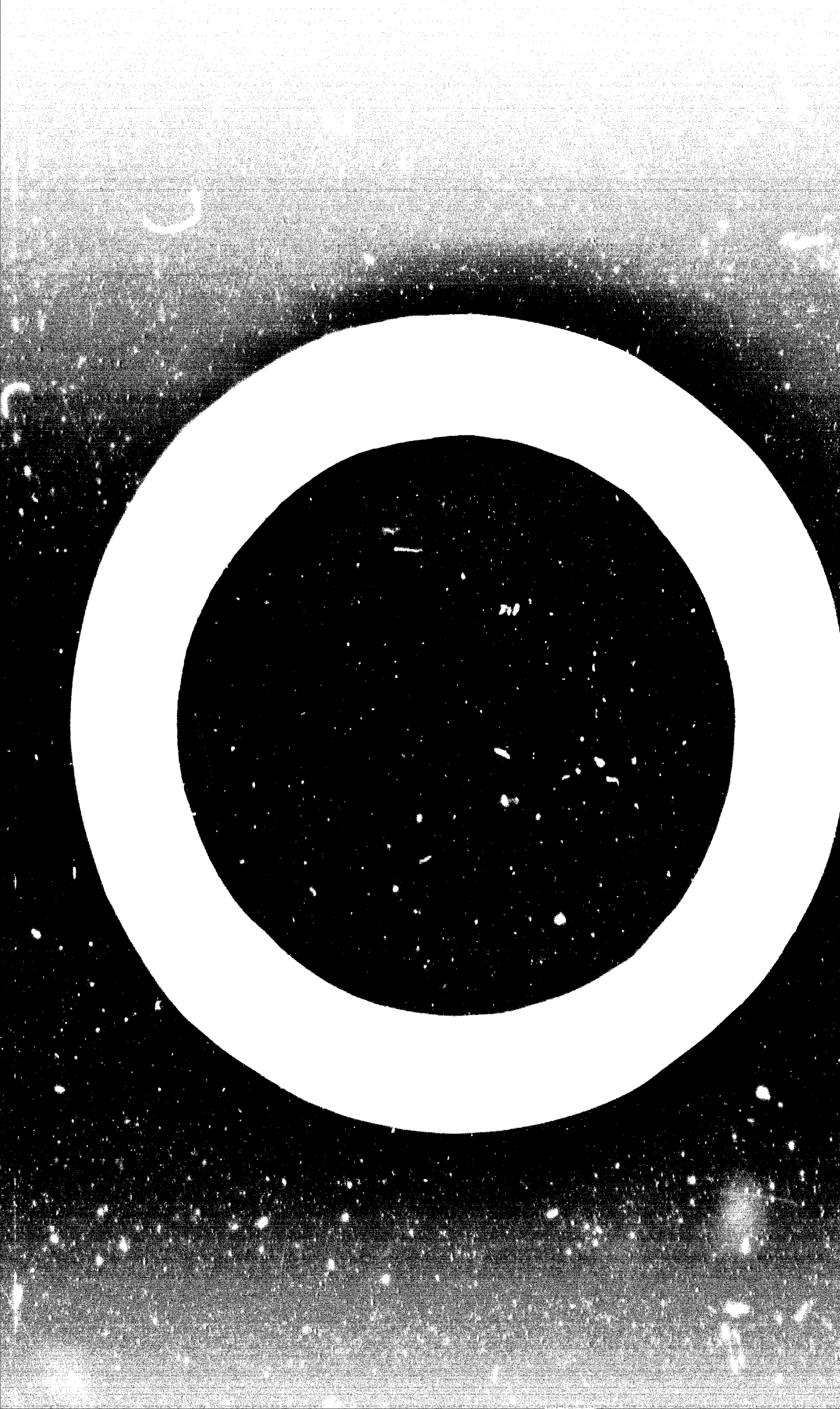

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Introduction

The requirements of a safe and undisturbed traffic on the roads under difficult conditions of visibility /at night, at dusk, during foggy weather et sim./ with high travelling speeds and a heavy traffic which are nowadays as a rule required from the economics point of view, serve as a challenge to the designers of motor vehicle accessories and result in the construction of a series of lighting fittings of various properties and designs.

With respect to their mode of exploitation these lighting fittings may be divided into three basic groups:

a/ lighting fittings which should create on the roads proper observation conditions for all of their users in the vicinity of the motor vehicle with special emphasis to the drivers and thus to contribute to the intensification of their physical disposition in controlling the vehicle. This may be achieved especially by headlights with distance, passing or combined lights, auxiliary headlights /distance, partially distance, adjustable spot and wide angle lights/ and reversing lights ;

b/ lighting fittings which signal the presence of a vehicle on the road under unfavorable traffic conditions as well as the intention of the driver to carry out some manoeuvre with his vehicle. These include indicator lamps / rear, side, stop lights, direction indicator lamps, rear reflex reflectors/;

c/ lighting fittings for local lighting either on the outside of the vehicle - signal lamps /rear number plate lights, parking lights/ or inside the vehicle /ceiling /dome/, seat, panel /dashboard/, runboard lights/.

It is evident that for such a wide assortment of lighting fittings various requirements will be imposed on their lighting properties as well as design.

1 Lighting properties of the lighting fittings

The lighting properties of the lighting fittings depend on the physical properties of light as well as on the mode of exploitation of the light.

The essence of light

In explaining the luminous phenomena and their application on motor vehicle lighting engineering we usually resort to primary geometry optics which in general exploits the concepts and laws of Euclidean geometry. The luminous source is considered as one or more mathematical points and the luminous ray as a mathematical straight line. It is evident that the essence of light described in such a manner is only the first approximation of this explication, the laws of which may be considered as valid only when the wavelength of the employed light may be considered to be neglectable.

The wave characteristics of light /when studying light polarization/ and diffraction phenomena resulting from light interference are considered only in exceptional cases in designing motor vehicle lighting instruments.

In order to understand the activity of the lighting fittings fully, it is necessary to add as well to the geometry optics photometric relations showing the mutual connection of individual optical instrument parameters, especially luminous intensity, luminance, illumination and glare.

Basic photometric quantities

The light source emits radiant energy, the quantity of which per unit of time is called the radiant flux P and evokes in the observer's eye a certain luminous perception F, called the luminous flux. The human eye retine is sensitive to the radiation of wavelengths from 380 $m\mu$ to 760 $m\mu$. However the sensitivity is not the same in the whole extent; maximum sensitivity occurs in the case of yellow-green light of a 555 $m\mu$ wavelength. Further details are included in the Czechoslovak State Standard /ČSN/ No. ČSN 01 1710 where sensitivity values values for cone vision /employed at daylight/ as well as rod vision /observations at night/ are listed. Further study of this standard will show, e.g. that the luminous flux of red light of a proper length 660 $m\mu$ must be more than 16 times larger than the luminous flux of yellow-green light of a wavelength of 555 $m\mu$ for the same facet in order to evoke the same sight sensations.

It should also be mentioned that the sight sensitivity values listed in the above mentioned Czechoslovak State Standard are called as well the relative luminous efficiency of radiation of a given wavelength V_λ. In our case -

$$V_{660\ m\mu} = \frac{1}{16} \quad \text{whereas} \quad V_{555\ m\mu} = 1.$$

The unit of the luminous flux is a lumen /lm/ which is defined as a luminous flux radiated by an absolutely black body at a temperature of 2042° K /i.e. the temperature of solidifying platinum/ of an area of $\frac{1}{60\pi}$ cm^2 = $5{,}305 \times 10^{-3}$ cm^2.

For practical purposes the black radiator is substituted by etalon lamps gauged at a photometric laboratory by measuring on a photometric bench.

In technical practice a multiple of the lumen is employed - the dekalumen /dlm/; 1 dlm = 10 lm.

The quantity of light Q is the product of the luminous flux and time :

$$Q = F \times t .$$

Its unit is the volume of light which the source radiates during the flux of 1 lm per second, i.e. 1 lumen-second /lms/. A greater unit is the lumen-hour /lmh/; 1 lmh = 3600 lms.

The luminous intensity I of a point source is always given in a certain direction; it may be defined as the ratio of the luminous flux dF emitted by a source in a solid angle dΩ, i.e.

$$I = \frac{dF}{d\Omega} .$$

If we consider that the luminous intensity is in all the directions in the given space the same /isotropic radiator/, then -

$$I = \frac{F}{\Omega} .$$

From this formula the following equation may be derived :

$$F = I \times \Omega ,$$

so that the total flux F, radiated by the isotropic radiator of luminous intensity into the whole space is -

$$F = 4\pi \times J .$$

The luminous intensity unit is 1 candela /cd/. A point source of a luminous intensity of 1 lm in a unit solid angle /steradian/ has the intensity of 1 cd. It may be deduced that the luminous intensity of an absolutely black body having an area of 1 cm^2 is in the vertical direction with a temperature of 2042^0K equal to 60 cd.

The relations between the originally employed luminous intensity units and 1 cd, are as follows :

1 SI /international candle/ = 1.02 cd,

1 HK /Hefner's candle/ = o.92 cd.

Luminance

Whereas luminous intensity was related to a point source, luminance is considered with <u>sources of final dimensions</u> and we define it as the ratio of the element luminous intensity of the source luminous surface $\Delta I\alpha$ in the direction α /measured from the element normal to the projection surface ΔS of this element to the plane perpendicular to the direction α, i.e.

$$L\alpha = \frac{\Delta I \alpha}{\Delta S \times \cos\alpha} .$$

If we call the diameter of the luminous surface $S\alpha$ the apparent source surface then it may be said that the <u>luminance is numerically equal to the luminous intensity per surface unit of the apparent source surface</u>.

It may be proved by experiments that in case of homogeneously luminous bodies, the luminous intensity changes according to Lambert's cosine law, i.e.

$$I\alpha = I_n \times \cos\alpha ,$$

where I_n is the luminous intensity in the direction of the normal to the luminous surface /cosine radiator/. The mentioned law shows that the luminous source having a spherical shape appears like a uniformly bright disc.

The unit of luminance is 1 <u>nit</u> /nt/, i.e. the luminance of a surface source 1 m^2 large and a luminous intensity of 1 lm in the direction perpendicular to the source plane. A larger unit is 1 <u>stilb</u> /sb/; 1 sb = 10^4 nt.

In order to determine the luminance of perfect diffusers, the following units are employed :

1 apostilb /asb/	1 asb	$= \frac{1}{\pi}$ nt ,
1 lambert /la/	1 la	$= \frac{1}{\pi}$ sb ,
1 footlambert /ftl/	1 ftl	= 3.42 nt .

It is the luminance of a perfect diffuser with a luminous flux of 1 lm per 1 m^2, 1 dm^2 and 1 ft^2.

For better imagination we list examples of some luminance sources:

Sun	2×10^9 nt
Tungsten filament at 2700°K	1×10^7 nt
Fluorescent lamp	6×10^3 nt
Candle flame	5×10^3 nt
Slightly clouded sky	3.2×10^3 nt
Moon	2.9×10^3 nt
Mars	2×10^3 nt
Sunlit white paper	2.5×10^4 nt
Moonlit white paper	3×10^{-3} nt.

Luminous emittance

Luminous emittance H is defined as follows :

$$H = \frac{\Delta F}{\Delta S} ,$$

where ΔS is the source surface element and ΔF the luminous flux emitted by this surface into the entire half-space. Luminous emittance is thus determined - in contrast to luminance - by the luminous flux, emitted by a luminous surface into all directions.

In case of the cosine radiator, the following equation is valid : $H = \pi \times L$.

Thus the luminous emittance π is a multiple of its luminance.

It is evident that from the observer's point of view, luminance is always decisive as it is defined by the luminous intensity which is perceived by sight whereas luminous emittance includes the luminous flux as well which passes the eye into the unseen part of space.

Illumination

Illumination E is the luminous flux density, falling on a considered surface, i. e.

$$E = \frac{d\,F}{d\,S}\ .$$

Thus it is stated by a similar relation as the luminous emittance H with the difference that in case of luminous emittance a luminous flux emitted by a surface element is considered, whereas in the case of illumination a luminous flux falling on the element is envolved.

The unit of illumination is 1 lux / 1 lx/. If a luminous flux of 1 lumen falls on a surface of 1 m^2, the surface illumination is 1 lux. It is also possible to say that the illumination of 1 lx is effected by a luminous intensity source of 1 cd falling perpendicularly on a surface 1 m distant from the source.

The product of illumination and the time of illumination duration is called the quantity of illumination or exposure. Its unit is 1 lux-hour /lxh/ or 1 photo-hour /pht/.

In the Anglo-Saxon countries the following illumination units are employed : 1 foot-candle /fc/ and 1 phot /ph/, i.e. the illumination effected by 1 cd onto a distance of 1 foot or 1 cm /or the surface has an illumination of 1 fc/1 ph/ if a flux of 1 lm falls on 1 ft^2/1 cm^2/ The following equations are valid:

$$1\ fc = 10{,}764\ lx$$

$$1\ ph = 10^4\ lx.$$

Illumination examples :

Starlit sky illumination	0.0003	lx
Full moon illumination	0.15	lx
Street illumination	5 - 20	lx
Comfortable reading illumination	30	lx
Room illumination	20-100	lx
Clouded sky illumination	1000	lx
Sunny - in shadow	2000-10000	lx
Direct noon sunshine	70000-100000	lx.

Basic photometric laws

a/ Light spreads in straight lines so that illumination E of surface elements perpendicular to the direction of the propagation is in an inverse proportion to the square of distance r from the point source :

$$E_1 : E_2 = r_2^2 : r_1^2 .$$

b/ The illumination of a plane element by a beam of parallel rays is in proportion to the cosine of the angle of incidence /Cosine law/ :

$$d E = \frac{d I \times \cos \alpha}{r^2} .$$

c/ The resulting illumination of the surface element by several sources is equal to the sum of illumination by the individual sources /Addition law/ :

$$E = E_1 + E_2 + E_3 + \ldots$$

II Colour radiation

Light colority measuring

When radiant energy passes through a transparent material, e.g. glass, it changes partially into another kind of energy /especially heat/. The radiant flux is thus weakened, absorbed, when passing through the material. In case that this absorption is in the sphere of visible radiation proportionate to the energetic structure of the incident radiation, the observed substances appear in the same colour as that of the incident radiation. On daylight this substance is pellucid, colourless. However if the observed substance absorbs the radiation of some of the wavelengths more expressively, then it is coloured. Thus glass, e.g., absorbing all the radiation except for red, is of a red colour. In the light of another colour, this glass is opaque. Such glasses are employed as monochromatic filters.

However there exist other substances as well that let through lights in a wide colour range and absorb only some of them. In this case the colour of the substance depends not only on their light absorption but on the structure of the incident light. If, e.g. , white light should fall on glass absorbing blue-green light, then the rest of the light that passed through as well as the glass would be of a complementary, i.e. red tone. In the case of visual exploitation we usually do not make any difference between both the types of the colour glasses. However when we test their optical properties with respect to photochemical exploitation, it is necessary to respect the different characteristics.

For lighting engineering purposes we carry out measurings of the glass colourities by means of photometric methods - either visually or by photoelectric tubes on special single purpose apparatuses. Basically two types of such instruments exist: special photometers which obtain monochromatic light by means of prism or grid monochromators and their results may be used in the calculation of colour coordinates and photometers where a set of various coloured filters is employed to achieve monochromatic light. These offer results in a faster but less accurate way. Therefore they are used only for finding out the characteristic curves of glass permeability or for comparing the permeability of substances of a similar colour tone.

Chromatic co-ordinates of light

It may be said that from the point of view of colorimetry each colour radiation may be characterized by two values : colour and intensity. Both values may be expressed by so called chromaticity co-ordinates. We consider the colour of light as a two-dimensional value and intensity as a single-dimensional value. Thus we introduce three co-ordinates, two by means of which the colour is determined and one for determining the colour intensity.

For measuring the colour of light, either natural co-ordinates or trichromatic co-ordinates are employed.

The natural co-ordinates of light are its tone and purity.

The light tone is given by the wavelength of radiation. Light, having the shortest wavelength perceptible to the eye, is of a purple colour $\lambda = 0.38\,\mu$; blue light has a longer wave - length, then follows yellow and the red light has the longest length of visible radiation $\lambda = 0.78\,\mu$. The individual colour tones of these monochromatic lights pass gradually from one to the other and fill up a continuous spectrum. The human eye does not perceive the same intensity of various colours with the same intensity. We say that the photometric structure of light is not identical with its energetic structure. The maximum sensitivity is for cone vision with a wavelength of $\lambda = 0.555\mu$ and for rod vision $\lambda = 0.510\mu$. The minimum is for both peripheral spectral colours. In case of cone vision it is necessary - in order to achieve a luminous flux of 1 lumen - to have a light of a $\lambda = 0.555\mu$ wavelength, 1/683 W, whereas in the other case to have a light of a $\lambda = 0.4358\mu$, 1/12 W, i.e. about 56-times more.

The colour purity of light is expressed by the quantity of monochromatic light in the whole luminous radiation. Thus monochromatic light has a chromaticity with a 100 % purity. Other lights are lights composed of the radiation of at least two wavelengths and the purity of their colours is less than 100 %. Purple light is an exception. Although it is not monochromatic as it is created by the mixing of blue and red light, it may posess a 100 % purity.

In order to state unambiguously the numerical value of the natural co-ordinates of light it was necessary to specify the sight perception which is basically a subjective sensation, by means of certain criteria and to define it precisely :

a/ The observer's eye has a normal visual acuity; cone vision is considered /Czechoslovak State Standard no. ČSN 01 1711/; the image is created on the eye's yellow spot.

b/ Chromatic light is observed directly, isolatedly /on a black or neutrally grey background/.

c/ The eye must be perfectly adapted and not influenced by the effect of the contrast.

4/ The intensity of light must be adequate so that the rod vision would not be evoked /at least 3 nt/.

Trichromatic co-ordinate systems

exploit the knowledge that any light may be obtained by mixing three arbitrary monochromatic lights, under the condition that none of those three lights has such a tone which may be obtained by mixing the remaining two. The International Commission on Illumination /C.I.E./ - further on C.I.E. only - has chosen lights that differ as much as possible by their colours : red R of a $\lambda = 0.700\mu$ wavelength, green G of a $\lambda = 0.5461\mu$ wavelength and blue B of a $\lambda = 0.4358\mu$ wavelength.

In the following explanations the values R, G and B denote the real quantities of the mentioned lights, called as well basic lights. If we mark their unit quantities as r g b , then the following formulae are valid :

$$r = \frac{R}{R+B+G}, \quad g = \frac{G}{R+G+B}, \quad b = \frac{B}{R+B+G},$$

$r + g + b = 1.$

The magnitude of the unit quantities of basic lights was selected in the ratio of 1.000 : 4,5907 : 0,0601 - which corresponds with their photometric effect during visual observation. The energetical volume is however different and is 70,210 : 1,3455 : 1,0000 .

The C.I.E. colorimetric system exploits from the mentioned values for co-ordinate determination purposes only two / r g / as the third / b / may be calculated from the relation $r + g + b = 1 \Rightarrow b = 1 - \; - g$. As the third co-ordinate determining the intensity of light, any of the R,G,B values may be taken as well as their sum. For practical purposes the C.I.E. system uses the G value. If we know this value, we can calculate the entire luminous flux

$$\Phi = R + G + B = \frac{G}{g} .$$

Diagram no. 1 shows the vector OA light composed of basic lights with intensities of R, G, B. The corresponding unit vector is limited by point a. It may be proven that the end points of unit vectors of various lights fill up a plane which intersects the co-ordinate axes in unit distances from the origin O. This plane cuts in the first co-ordinate quadrant the so-called colour /colorimetric/ triangle, each point of which indicates a certain colour of light, i.e. its tone and purity.

Experiments have shown that apart from the three basic spectral colours, determined by the apexes of the colorimetric triangle, all other spectral colours and pure purple colours are depicted outside of the triangle. By joining these points we get a curve showing the colours of pure spectral lights. Inside the curve all possible tones and purities of existing colour lights are depicted. /See table no. 2./

It may be proven that the colorimetric co-ordinates r , g /possibly b/ are determined by the distances of a point, representing a specific light, from the sides of the triangle, if we determine its height as h = 1. The tone of the light is determined by the point of intersection A of the connecting line E a with the curve of the spectral lights, the purity of which is defined by the ratio $s = \frac{Ea}{EA}$. From the table it is evident that the purity value varies between 0 /Point a coalesces with point E/ and 1 /Point a coalesces with point A/.

The trichromatic system /r, g, G/ has certain disadvantages when it comes to practical exploitation: the colour tones are spread unevenly in the colorimetric triangle as the prevalent part is occupied by the blue and green colours whereas colours ranging from red over yellow to green are accumulated on a small area. Further on, colours lying outside of the triangle have one of the co-ordinates negative which often leads to errors in calculations. A further disadvantage lies in the fact that point E, depicting white /colourless, day/light protrudes past the centre of the triangle which is disadvantageous for determining the colour purity. Therefore the C.I.E. elaborated through a proper transformation of the R, G, B or r, g, G systems a new system - the X, Y, Z or x, y, Y in such a manner, so that all the real lights would be depicted by points inside the colour triangle. The point, determining the white colour, would be approximately in the triangle's centroid and the spectral colours would be distributed along the triangle's periphery more evenly. The co-ordinate plane XY is of a zero photometric volume /so-called alychna/ and the co-ordinate Y shows directly the photometric volume of light. By the above mentioned transformation the triangle RGB thus changed into the triangle XYZ. If we mark the unit vectors X, Y, Z, the well-known relations are once again valid :

$$x = \frac{X}{X+Y+Z} \qquad y = \frac{Y}{X+Y+Z} \qquad z = \frac{Z}{X+Y+Z}$$

$x + y + z = 1$.

In this sytem, monochromatic radiation fills up the curve according to table no.3, the general equation of which / X,Y,Z = f/λ/ we may divide up into the following relations:

$$X = f_1 /\lambda/ \qquad Y = f_2 /\lambda/ \qquad Z = f_3 /\lambda/$$

and plot according to table no. 4. /See also table no.2./ The projection of the mentioned curve on the unit plane determines

- after a certain modification - the contour line of the new colour triangle, the sides of which show /as in the first case/ pure, monochromatic lights, whereas impure lights lie inside the triangle. The relative purity of their colours may be determined from lines of a similar purity which run inside the triangle and are marked with the purity percentage.

For calculation purposes we mark the functions X, Y, Z by the following symbols: $\bar{x}\lambda$, $\bar{y}\lambda$, $\bar{z}\lambda$. The coefficient $\bar{y}\lambda$ was selected in such a manner so that it would be in a direct proportion to the relative coefficient of the luminous flux. The final shape of the transformed colour triangle according to tables no. 5 or 6 enables co-ordinates x, y to be read according to the manner, usual in geometry. The tolerance areas for white light and monochromatic lights are specified by the respective Czechoslovak State Standards /ČSN/ or by the ISO/TC 22/Secretariate 71/240 E/ regulations.

Procedure of determining the colour co-ordinates

First of all we carry out a spectral analysis of the luminous radiation normal and find out what the total radiation energy $S\lambda$ divided up to separate wavelengths is. Then we divide up the $S\lambda$ energy into three components in such a manner so that for each wavelength we multiply the $\bar{x}\lambda$, $\bar{y}\lambda$, $\bar{z}\lambda$ coefficients, the magnitude of which is prescribed by the C.I.E. /See table no.1./ Thus we calculate the following terms $S\lambda \times \bar{x}\lambda$, $S\lambda \times \bar{y}\lambda$, $S\lambda \times \bar{z}\lambda$. The total radiation energy $S\lambda$ may be plotted into the curve f /λ/ which we substitute according to the above mentioned directions by three new curves $S\lambda \times \bar{x}\lambda$, $S\lambda \times \bar{y}\lambda$, $S\lambda \times \bar{z}\lambda$. The areas delimited by these curves and the axis, show these totals :

$$A = \Sigma S\lambda \times \bar{x}\lambda$$

$$B = \sum S_\lambda \times \bar{y}_\lambda$$
$$C = \sum S_\lambda \times \bar{z}_\lambda.$$

However in reality the above mentioned calculation is not introduced as in case of the ordinary measurings we use as a rule the standardized light A, /See Note./ for which the listed products may be found in Table no. 2. This table includes values modified in such a way so that the term $B = \sum S_\lambda \times \bar{y}_\lambda$ would be equal to 100, as then the co-ordinate Y, expressing the intensity of light let through by the glass, may be calculated directly from the percentage of the standardized light A intensity. Then we measure by means of a spectral photometer the permeability of the given glass for the individual monochromatic lights /in the range according to Table no.1./ The spectral composition of light is determined by the terms :

$$X = \sum S \times \bar{x}_\lambda T_\lambda \times \Delta \lambda$$
$$Y = \sum S \times \bar{y}_\lambda T_\lambda \times \Delta \lambda$$
$$Z = \sum S \times \bar{z}_\lambda T_\lambda \times \Delta \lambda$$

Then we carry out the products $S_\lambda \times \bar{x}_\lambda \times T_\lambda$, $S_\lambda \times \bar{y}_\lambda \times T_\lambda$, $S_\lambda \times \bar{z}_\lambda \times T_\lambda$ for all the wavelengths and their sums X, Y, Z. At last we determine the chromatic co-ordinates from the relation:

$$x = \frac{X}{X+Y+Z} \qquad y = \frac{Y}{X+Y+Z} = \frac{Y}{100}.$$

Thus calculated co-ordinates are to be plotted into the trichromatic triangle /Table no.6/. Then we make sure, whether the point with the $\underline{x}$, $\underline{y}$ co-ordinates is in the permissible colour zone. The colorimetric purity of light let through the glass will be determined directly by reading the colorimetric triangle /Table no.6/ with the aid of curves of the same purity.

In order to faciliate work it is advisable to use for the records of the measurements and for calculations prepared forms

/e.g. according to Table no.3./

Note

Table no.3 is valid for normal light A, i.e. the light of an ordinary bulb /about 500 W/ with a chromatic temperature of T = 2848° K, the chromatic co-ordinates of which are

x = 0.4476,

y = 0.4075.

Apart from light A, lighting engineering has the following lights standardized :

Light B /the light corresponds with direct sun light/ :

T = 4 800°K, x = 0.3485 , y = 0.3518.

Light C /agrees with diffused day light/ :

T = 6 500°K, x = 0.3101 , y = 0.3163.

Light E /discharge tube light/ :

T = 5 700°K, x = 0.3333 , y = 0.3333.

Table no.1

Table of coefficients $\bar{x}\lambda$, $\bar{y}\lambda$, $\bar{z}\lambda$.

λ mμ	$\bar{x}\lambda$	$\bar{y}\lambda$	$\bar{z}\lambda$	λ mμ	$\bar{x}\lambda$	$\bar{y}\lambda$	$\bar{z}\lambda$
380	0,0014	0,000	0,0065	600	1,0622	0,6310	0,0008
390	42	1	201	610	1,0026	5030	2
400	143	4	679	620	0,8544	3810	2
410	435	12	2074	630	6424	2650	
420	1344	40	6456	640	4479	1750	
430	2839	116	1,3856	650	2835	1070	
440	3463	230	1,7471	660	1649	610	
450	3362	380	1,7721	670	874	320	
460	2908	600	1,6692	680	468	170	
470	1954	910	1,2876	690	227	82	
480	956	1390	0,8130	700	114	41	
490	320	2080	4652	710	58	21	
500	49	3230	2720	720	29	10	
510	93	5030	1582	730	14	5	
520	633	7100	782	740	7	3	
530	1655	8620	422	750	3	1	
540	2904	9540	203	760	2	1	
550	4334	9950	87	770	1		
560	5945	9950	39				
570	7621	9520	21	Total	10.68	10.68	10.68
580	9163	8700	17				
590	1,0263	7570	11				

Table no.2

Survey of coefficients $S_\lambda \cdot \bar{x}_\lambda$, $S_\lambda \cdot \bar{y}_\lambda$, $S_\lambda \cdot \bar{z}_\lambda$

for normal light "A"

λ	$S_\lambda \cdot \bar{x}_\lambda$	$S_\lambda \cdot \bar{y}_\lambda$	$S_\lambda \cdot \bar{z}_\lambda$	λ	$S_\lambda \cdot \bar{x}_\lambda$	$S_\lambda \cdot \bar{y}_\lambda$	$S_\lambda \cdot \bar{z}_\lambda$
380	0,001	.	0,006	600	12,704	7,547	0,010
390	5	.	23	610	12,669	6,356	4
400	19	0,001	93	620	11,373	5,071	3
410	71	2	340	630	8,930	3,764	
420	262	8	1,256	640	6,558	2,562	
430	649	27	3,167	650	4,336	1,657	
440	926	61	4,647	660	2,628	0,972	
450	1,031	117	5,435	670	1,446	530	
460	1.019	210	5,581	680	0,804	292	
470	0.776	362	5,116	690	404	146	
480	428	632	3,636	700	209	75	
490	160	1,039	2,374	710	110	40	
500	27	1,792	1,509	720	57	19	
510	57	3,082	0,969	730	28	10	
520	425	4,771	525	740	11	6	
530	1,214	6,322	309	750	6	2	
540	2,313	7,600	162	760	4	2	
550	3,732	8,568	75	770	2	.	
560	5,510	9,222	56				
570	7,571	9,457	21	Total	109,828	109,000	35,547
580	9,719	9,228	18				
590	11,579	8,540	12				

Table no.3

Calculation of chromatic co-ordinates of glass R 2001/1961-2.

Wave-length	Per-mea-bi-lity	Coefficients			Product of data in columns 2 and 3		
		$S_\lambda \cdot \bar{x}_\lambda$	$S_\lambda \cdot \bar{y}_\lambda$	$S_\lambda \cdot \bar{z}_\lambda$	$S_\lambda \cdot X_\lambda$	$S_\lambda \cdot \bar{y}_\lambda$	$S_\lambda \cdot \bar{z}_\lambda$
1.	2.	3a.	3b.	3c.	4a.	4b.	4c.
380	1.15	0,001	.	0.006	0.00115	.	0.0069
390	1.35	5	.	23	675	.	3105
400	0.9	10	0.001	93	1710	0.0009	8370
410	61	71	2	340	4331	122	20740
420	55	262	8	1.256	14441	440	69080
430	55	649	27	3.167	35695	1485	1.74185
440	1.3	926	61	4.647	1.2038	793	6.0411
450	1.2	1.031	117	5.435	1.2372	1404	6.522
460	0.8	1.019	210	5.851	2.0152	1680	4.6808
470	7	0.776	363	5.116	0.5432	4424	3.3812
480	64	428	622	3.636	2702	4043	2.3634
490	61	160	1.039	2.324	976	6338	1.4176
500	0.5	27	1.792	1.509	135	6960	0.7545
510	45	57	3.088	0.969	256	1.3860	43605
520	35	425	4.771	525	14875	1.66985	18375
530	35	1.214	6.322	309	4249	2.2127	10815
540	3	2.313	7.600	168	6939	2.280	4860
550	4	3.732	8.568	75	1.4928	3.4272	3000
560	4	5.510	9.222	36	2.204	3.6888	1440
570	45	7.571	9.457	21	3.4069	4.2556	
580	1.1	9.719	9.228	18	10.6909	10.1508	
590	2.5	11.379	8.540	12	28.9475	21.350	
600	9.0	12.704	7.547	10	114.336	67.923	
610	20	12.[illegible]	6.356	4	253.38	127.120	
620	34	11.373	5.071	3	386.682	172.414	
630	46	8.980	3.705		377.160	155.568	
640	43.9	6.558	2.568		287.986	112.472	
650	44.5	4.336	1.637		192.959	72.846	
660	45	2 28	0.972		118.260	43.740	
670	45	1.448	530		65.16	23.85	
680	45.5	0.804	298		36.582	13.286	
690	45	404	146		18.18	6.57	
700	45	209	75		9.405	3.375	
710	45	110	40		4.95	1.80	
720	44.5	57	19		2.5365	0.8455	
730	44	28	10		1.232	0.44	
740	43.6	11	6		0.4796	2616	
750	42.7	6	8		2562	854	
760	42.5	4	2		170	650	
770	41.3	2			83		

X = 1923.6935   Y = 855.9679   Z = 28.9433

$x = \frac{1923.6935}{2808.6047} = 0.6849$

$y = \frac{855.9679}{2808.6047} = 0.3047$

$z = \frac{28.9433}{2808.6047} = 0.0103$

Check:

0.6849 + 0.3047 + 0.0103 = 0.9999

τ = 8.560 %.

III Motor vehicle lighting fittings

Main headlights

As was mentioned in chapter 1, the headlights are the basic lighting fittings of motor vehicles. From the point of view of construction as well as function, the most complicated are the main headlights.

The main headlights are manufactured either with separate distance and passing lights or they are produced with joined, combined or group lights. /For detailed information, See Czechoslovak State Standards No. CSN 30 4302: Motor vehicle lighting and No. ČSN 30 4303: Motor vehicle headlights./

According to the design, the main headlights are divided into headlights of the European type - marked "E" /according to the European Economic Commission - ECE or ICE/ or of the American, Sealed-Beam type.

The main headlights are composed of headlight inserts and casings. The insert consists of the light source, reflector and protective diffusing glass. The casing includes the setting-up /rectifying/ devices, which enable the turning and tilting of the headlight insert up to such a degree so that it is possible to align the optical axes of both headlights into a position parallel to the longitudinal axis of the vehicle. The setting up device control is outside the vehicle - only in some states the adjustment of the headlights' position may be carried out during driving from the driver's position. In Czechoslovakia, regulations do not permit this.

The "E" headlights are either symmetrical or asymmetrical - where the maximum luminous intensity of the passing lights is shifted to the outside strip of the roadway. With respect to the direction of traffic on the roadway, the asymmetrical passing lights are either right-sided /most frequent case/ or left-sided /in England only/. The American system includes several types. Basically it differs from the "E" system/which has a metal reflector and a removable bulb/ in the fact that it has a glass reflector solidly fused together with the protecting glass. /See further on in the text./ The headlights have either separate or joined lights. The passing lights ensure as well a more intense lighting of the outside strip of the roadway. However this is caused by the fact that the filament of the passing light is properly aligned along the axis whereas in case of the European system the passing light filament is located in the headlight centrically and shifts the maximum of luminous intensity to the outside by means of optics - by the diffraction of the diffusing glass design. The American system offers a more intensive lighting of the roadway especially near the vehicle what however causes on narrow roads a greater danger of glare to the driver coming from the opposite direction.

The American system headlights have the luminous source either sealed into the headlight insert /in the form of two bare electrodes, used especially in the USA and other American states/ or it is formed by a bulb that may be arbitrarily extended /used in England/. Lately a Sealed-beam headlight with a screen was also produced - thus of the European type. It is possible to use it in whole Europe.

Auxiliary headlights

Technically less complicated are the auxiliary headlights, designed as a rule as separate lighting fittings. Most employed are the fog lights, placed in a pair across the vehicle in such a way so that they would not be higher up than the passing lights of the main headlights. Other auxiliary lighting fittings, i.e. the reversing lights, auxiliary distance lights and adjustable spot lights are employed in an arbitrary number and position. For Czechoslovakia the technical and photometric requirements regarding the main and auxiliary headlights are stated in the Czechoslovak State Standard no. ČSN 30 4002 - Motor vehicles' electrical equipment and ČSN 30 4303 - Motor vehicle lighting fittings.

Luminous source

In recent lighting fittings made in Europe, lamps with coiled coil tungsten filaments are employed. Their bulbs are filled with inert gas under pressure. The lamps for the main "E" headlights are of the double filament bulb type. The filament for the distance lights has the form of the letters U or V and it is mounted into the working position in such a way so that the luminous centroid would fall into the headlight reflector focus whereas the passing light filament - straight and parallel with the headlight axis - is mounted in front of the focus and somewhat besides the axis. From the bottom it is covered by a screen for rectifying the passing light which thus forms only a luminous semi-cone, widening away from the headlight where the lamp is mounted. With respect to the position of the filament and in relation to the mirror axis, this semi-cone points somewhat under the horizontal plane and thus illuminates the roadway only and does not glare the drivers in the opposite direction and other users of the roadway.

The shape of the luminous flux may be changed up to a certain degree by the shape of the filament and its position. The passing light filament screen is either flat or double-winged /the wing angle is 195°/. In the first case a straight line boundary /i.e. symmetric light/ occurs between the illuminated space in the direct vicinity of the vehicle and the unlit space above the roadway. In the second case, the boundary line of both parts is shifted to the right or possibly left half of the field of view, obliquely up by 15° /right-sided or possibly left-sided asymmetric light/.

The filaments and screens are mounted on metal /most frequently brass/ bases by two electrodes fused into the bottom of the bulb. Through them the current is conducted from the holder to the lamp. In case of symmetrical lamps, Ba20d bases are used. In case of asymmetrical lamps, supporting rings with two triads of pressed contact faces and centering noses are soldered on the outside of the holders. By this it is possible to mount the lamps accurately into the headlight reflector socket. Instead of contacts three electrodes are mounted on the base, designed for the mounting of the electric current supply connectors. /The bases are of the P 45 t type./

For bifilar lamps for the main headlights with asymmetrical light the following light parameters are valid:

Rated voltage:	6 V	12 V	24 V
Luminous flux -			
Distance light		750 lm	
Passing light		400 lm	
Service life		100 hours	

The increased requirements regarding traffic safety under conditions of worse visibility make the increased luminous intensity of the headlights necessary. This can be attained either by employing reflectors with a larger reflection surface or by more effective luminous sources. The second solution seems to be - from the point of view of operation as well as economics - more advantageous and thus the effort of the technicians concentrated in this direction. With respect to the fact that there has been a great endeavour to find a better material for the production of filaments than tungsten /which is used from the time shortly following the invention of the lamp/, though with minor results, the above mentioned task may be fulfilled only by raising the heating temperature. This leads however to the shortening of the lamps' useful life. Thus various rare gases were added to the inert gas in the bulbs / xenon, krypton/ which have a greater molecular weight than the molecular weight of inert nitrogen, use up less energy for their heating up, so that the filament would not have to be heated up to such a high temperature.

However the decisive progress occured with the invention of the "H" lamps and their application in the motor vehicle industry. These lamps are characteristic due to their considerable raise in the specific /luminous/ output, their increased service life and small size. Basically they are common lamps with tungsten filaments, mounted in bulbs with inert gas and vapours of some halogens, most frequently iodine, possibly bromine /in the meantime for laboratory tests only/, which show certain great advantages of the bromine especially in the respect that no severe chemical purity is required as in the case of iodine and that a purple film does not occur on the bulb as in the case of iodine; the absorptivity may reach up to 5 % of the lamp's luminous flux. However in the case of bromine there is a disadvantage - its aggressiveness. At the present time, tests are carried out in Czechoslovakia exploiting fluorine. The molecules of this gas /iodine/, coming into contact with the filament heated to a temperature exceeding 3000°C break down to atomic iodine, dispersing inside the lamp. At the same time tungsten evaporates and its atoms settle on the relatively cooler wall of the bulb where they combine with the atomic iodine into tungsten diiodide WJ_2. Thus a brown film is created which absorbs a part of the luminous flux and decreases the lamp's luminance.

However if the bulb's temperature is higher than 250°C, the tungsten diiodide remains in a gaseous state, diffuses from the bulb's wall towards the filament and when it reaches the space around the filament having a temperature over 1200°C, it again breaks down into iodine and tungsten. /See Table no. 7./ Tungsten again is deposited on the filament and iodine returns into the regeneration cycle. Thus the following reactions take place : $J_2 \rightleftarrows 2\,J$; $W + 2\,J \rightleftarrows W\,J_2$.

The highest tungsten gas concentration is in the vicinity of the filament whereas in the vicinity of the bulb wall it is the smallest, almost zero. The velocity of the tungsten atoms' diffusion from the filament to the wall depends on the density and temperature of the iodine vapours. Iodine is constantly reconstituted and evaporated tungsten again settles on the filament. In this manner the blackening of the bulb /purple film/ is suppressed and theoretically the lamp attains unlimited service life. At the same time it is possible arbitrarily to raise the filament temperature as well as its luminance. However in reality there are considerable limitations present with respect to the necessary balance between the filament and the bulb wall temperatures and unfavourable influences appear, resulting from the concentration diffusion, thermodiffusion.

The process depends on the exact quantity of iodine under the given conditions which it is very difficult to determine. If there is more iodine present in the bulb than necessary, then it settles on the wall and absorbs the light. Tungsten does not evaporate from all of the parts of the filament evenly and with the same velocity as the filament does not have a uniform temperature along its entire length. At the hottest part the evaporation is the greatest and thus the weakening of the filament is the greatest. Tungsten regeneration, however, is slower so that finally a defect in the lamp's filament occurs.

Hitherto results from the testing of these lamps have however shown that in spite of the above mentioned deficiencies and considerable production difficulties, the "H" lamps show a considerable increase in the specific luminous output as well as life - almost throughout the entire life of the lamp. Further on the stability of the luminous flux is ensured; they have small dimensions which is quite advantageous for the design of the lighting fittings and they have a better colour tone of the light. A disadvantage is the high operation temperature so that for their production it is necessary to employ silica glass and the reflection layers of the reflectors must resist the increased temperature. Finally, it is also necessary to consider the fact that it is impossible /at present/ to mount inside the lamp bulb two filaments at one time as the cold one would be attacked during the operation by iodine and the iodine cycle would be impaired. Thus a number of problems arose which must be considered when solving the motor vehicle headlights. Last but not least it is necessary to consider the higher cost of the iodine lamps.

Standardized types of the "H" lamps:

Recommendation EHK/E/ECE/324; E/ECE/TRANS 505, Reglement no.7 - introduces three types of single filament "H" lamps marked H_1, H_2, H_3. Their rated voltages are 6, 12 and 24 V, input 55, 55 and 70 W and luminous flux 1350, 1550 and 1900 lm./See Table no.8a,b,c./ The lamps are suitable for the design of the main and auxiliary headlights.

Reflector

The task of the reflector is to direct the rays which come from the luminous source located in the focus or its immediate vicinity in such a manner so that they would fall on the diffusing glass at the required place and direction. At the same time the radiant energy losses should be as small as possible.

At the present time, reflectors of a paraboloidal shape are used almost exclusively. However experiments were also carried out with elipsoidal shape reflectors as a number of patents show. The solution rests as a rule in the fact that in one of the elipsoid focuses there is the luminous source whereas in the second an auxiliary optical system is located that transposes the lighting source by means of a diffusing glass to a proper place. In some cases the auxiliary optical system is absent. However, far as we know, reflectors of this type were not introduced anywhere, as from the technological and operation point of view they are rather complicated and they require a multiple face mirror /Difficult assembly and adjusting!/, high production precision of the mirror, highly accurate positioning of the source and then the reflection layer heats up considerably. However the greater exploitation of the luminous flux of the source is very advantageous.

Nowadays paraboloidal reflectors are commonly used, either simple or composed with a circular or rectangular entry opening.

The construction parameters of the simple paraboloidal reflectors /mirrors/ include the focal distance f and the effective diameter D, possibly the f-number, f/D. Basically in the case of these headlights, the principal geometrical rule applies, according to which a beam of rays, originating in the parabola focus F reflects in parallel with the axis whereas the bunch of rays of a beam coming from point A /lying in front of F - See Table no.9/ is directed with a tendency to aim, after the reflection, obliquely down /under the condition that the rays, coming from point A to the space below the axis, are screened/. /See Table no. 9., where $\alpha_n = \alpha_n'$, for n = 1, 2, 3./ It is evident from the table that by shifting point A along the axis or besides it, the obliqueness of the reflected rays may be changed.

In practice, point A is achieved - in the case of passing lights - by means of a filament screened from the bottom by a screen and shifted under the axis. /Table no.10./ Thus in the luminous flux an approximate shadow semi-cone with apex V occurs, spreading from the headlight. Thus there is no direct light above the optical axis, so that the users of the roads are not dazzled.

The reflectors for the American headlights are of a paraboloidal shape as well. The principle of their function is evident from Table no.9. The distance light filament is situated in focus F, the passing light filament under the focus at point A.

Combined reflectors are generally used with a rectangular entry opening. As a representative model of a great number of similar products we mention the Cibié headlight for Citroën AMI 6 motor cars. The leading idea during the construction of this headlight was to equip the vehicle with a highly effective headlight from the lighting point of view without having to enlarge its height dimension as this does not appear - from the esthetic as well as stylistic point of view /especially in the case of modern, low vehicles/ - as favourable. Besides that, the deletion of the upper section of the circular opening theoretically improves the conditions for attaining a good passing light. /It limits the occurance of filament parasitic images above the light-shade boundary./ The Cibié reflector consists of three mirrors /See Table no.11/ of which the largest one /1/ with a rectangular entry opening is a part of the paraboloid, limited by the two planes 2, 2'. In order that the luminous flux which would fall on the 2,2' planes would not be totally lost for lighting, two identical auxiliary mirrors 3,3' of a paraboloidal shape are present, the parameters of which were determined in such a manner, so that they would absorb as much as possible of the luminous flux without disturbing the requirement mentioned in the paragraph above. The 3,3'mirrors are welded to the main /1/ mirror. The advantages of the Cibié headlight are evident especially in the case of the distance lights which have not only a great luminous range but illuminate well the space in front of the vehicle as well. In the case of passing lights, theoretically more advantageous conditions are achieved as well, as -

a/ the horizontal zone of the headlight which - as it was mentioned above - is decisive for the intensity as well as quality of lighting, is quite considerable here /The width of the reflector!/;

b/ the beam of rays on the outside of the roadway is considerably wide which is advantageous especially for driving into turns ;

c/ the parasitic rays, leading upwards, which influence the visibility unfavourably especially when driving in a fog, are here strongly limited.

However, a great disadvantage is the necessity of fulfilling a high degree of precision not only during the production but during assembly and adjusting of the individual mirrors as well. Tests, carried out in Czechoslovakia, showed that only a small percentage of the tested headlights has the presumed properties.

Besides the above mentioned and practically exploited reflectors there are a great many solutions that have not yet been put into wide use, though some of them especially those in connection with the "H" lamps, are patented. Due to the fact that some of them are based on completely new ideas, it seems advisable to offer at least brief information about them. It is presumed that "H" lamps in the form of cylinders are to be exploited. The screens may be used externally only so that with the increased luminance of the source, danger of creating parasitic light spots occurs above the light-shade boundary due to undesirable light reflections on the bulb wall or on some places of the mirror. Special attention must be devoted to this phenomenon when solving the reflectors for the "H" lamps even though - according to the opinion of some specialists - the sharp boundary of light and shade of the passing light tires the eye of the driver more than the gradual transition of light into shade. However, strikingly light places are not permitted.

An older proposal of the Cibié company exploited two identieal incomplete paraboloidal mirrors, symmetrical along the horizontal plane. A cylindrical screen is attached around the filament V in such a manner, so that in the upper half it is mounted from the focus towards the apex and in the lower half contrarywise. It is evident that in both the halves of the mirror some of the rays will pass through the focus./See Table no.12./ However these are reflected in parallel with the axis; all other rays which the screen does not catch will reflect in such a manner that they will be directed down, i.e. under the light-shade boundary. This arrangement enables - in comparison with the classical headlight - the exploitation of the entire reflection surface, however, only with half of the luminous flux. A great advantage is, that in this way a greater working surface is attained and due to this fact also the possibility of supplying under the light-shade boundary an increased illumination. The mentioned solution is interesting especially from the point of view of exploitation in small headlights where it is desirable to have a better lighting output. However it is necessary to consider that this method may be used only in the case of separate headlights with passing lights, i.e. for vehicles with two pairs of main headlights.

The French patent no. 1,318.683, Group B 62 d - F 21 E introduces a multi-part reflector in the form of rotary surfaces with axes BB1 or possibly CC1, the resulting curves 8 and 11 of which /See Table no.13/ are the branches of parabolas with the same focus F on the main axis AA1 of the headlight.

The size of both of the mirrors is limited by two pairs of the planes σ, which pass through the axes of rotation BB1 and CC1 and form angles α, β with the main plane τ, determined by the axes.

The luminous filament 5 is mounted in a grooved screen in such a way so that it is in front of the focus F of the system. Two screens, 6a and 7a are mounted symmetrically to the axis. Their top edges determine the light-shade boundary of the passing light. The angle α is determined in such a manner so that the upper part of the mirror would be omitted as it has an influence on the creation of the parasitic images in the unlit part of the light pattern /α = approximately 66°./

The reflector system is supplemented by two paraboloidal mirrors. The upper mirror 12 - depicted on Table no.13 - is part of the surface, originated by the rotation of the parabola's arch around the axis 13 of the filament 5. The created parabola has the focus 14 located over the filament 5 and a little to the rear /i.e. towards the headlight apex/. The resulting focal line of this mirror has the form of a circular arch. The mirror 12 is supplemented by a screen 12, situated according to Table no.12 above and behind the luminous source in such a way so that the front edge of the screen would lie directly on the focal line 14. The screen 15 is in reality a part of the cylinder surface, arranged in such a manner, so that it would limit the luminous flux falling on the auxiliary mirror 12. Thus it allows passage to those rays only that come out of the headlight along the horizontal plane or below it. Similarly the bottom auxiliary mirror 12', created by the rotation of a part of the parabola with the focus 14' around the axis 13 and supplemented by screen 15', reflects rays again in a horizontal direction or obliquely downwards only. On Table no. 13 the peripheral oblique rays are marked as dashes. Their inclination may be regulated by changing the length of the filament 15 or by changing the parameters of the 12 and 12' parabolas.

It must be stated that the idea of using four mirrors arranged in the above mentioned manner is original and presumes a good knowledge and experiences of the author but its introduction will be even more difficult than in the last case mentioned previously.

In conclusion we wish to show what is the future trend of the idea for exploiting the "H" lamps. Table no.14a shows a headlight of the Balder system where three "H" lamps are mounted in the same casing together with one normal motor car lamp. They are covered by one diffusing glass with four different patterns. The first lamp I is mounted in the rotary paraboloidal mirror with an exit opening of a 75 mm ø. The light, reflected by this mirror, passes through the strongly diffusing pattern in such a manner so that it creates a wide luminous beam, as it is evident from diagram I on Table no.14b. The second "H" lamp II is in the paraboloidal mirror of a 60 mm ø and it creates a concentrated luminous beam by means of a lightly diffusing pattern, as may be seen from diagram II. The third "H" lamp III, mounted in a mirror of a 75 mm ø has a pattern with minor diffusion only. The lighting is shown on diagram III. By combining the luminous beams I and II asymmetrical passing light is obtained,/according to the European code. Diagram A./ By combining II and III, distance light is achieved./Diagram B/.

When switching the distance light to the passing light and vice versa, the beam I always remains in action which ensures a certain continuity in the illumination of the roadway. In the upper part of the headlight an ordinary motor car lamp is mounted, used as a parking light.

Diffusing glass

Originally diffusing glass was used for the protection of extremely delicate reflection layers of the reflectors against mechanical abrasive wear and against the effect of unfavorable atmospheric and chemical conditions as well as for diffusing the light to the sides.

Experiments have shown that even an accurately produced and entirely smooth reflector equipped with a smooth cover glass and a clear glass bulb only, shows a number of various internal reflexes which form on the luminous pattern on the roadway light and dark spots, disturbing observation. Thus grooving of the protecting glass was introduced, possible grooving of the reflector and lamp bulb which would diffuse the light to the sides and thus equalize to a large extent the uneven illumination in the luminous pattern. Besides that, the grooving weakens the excessive concentration of light in the axial direction which is radiated by the common reflector with the source in its focus. The dimensions of the diffusion to the sides may be changed by the depth of the grooving. In older type headlights, slightly mat /satinized/ lamp bulbs were employed as well which aided the more even illumination but at the cost of increasing the luminance and thus glare as well of the headlight when looking from the side.

At present grooving of the reflectors and lamps is no more carried out as it causes an uneven diffusion which makes the observance of quite strict requirements as to the distribution of the lighting intensity in the luminous pattern /as it is the case, e.g. of asymmetrical headlights with passing lights/ impossible. Here the distribution of the illumination is completely asymmetrical and may be achieved only by a precalculated and carefully carried out arrangement of the cover glass. The calculation of the optical elements which have the shape of small prisms, grooves, wedges or aspherical forms, the complex of which we call the protecting glass pattern, requires considerable time. The designing of new headlights with asymmetrical passing lights poses today the most difficult theoretical part of the task, especially with regard to the fact, that the solved pattern must satisfy requirements expected from the passing lights as well as from the distance lights.

As a resumé it is possible to define the task of the pattern on one hand as a complex counterbalancing the luminous intensity irregularities /caused by small deformations of the reflector, internal reflexes in the lamp bulb, on the edges of the parabola et sim./, of the distance as well as the passing lights. On the other hand it may defined as the transmission of light to the space below the oblique light-shade boundary as well as the creation of an asymmetric passing light. In the latter case, the upper part of the mirror in case of the common headlights is exploited only, as the lower part is covered by the lamp screen.

As was mentioned above, the rays pass in the case of passing lights in such a manner, that after the reflection on the reflector they are directed downwards, cross each other and illuminate the space under the headlight's axis. The upper left semi-wave L /in the direction of driving - See Table no.15a/ of the headlight directs the rays to the bottom part P' of the illuminated space /See Table no.15b/ and vice versa. From the drawing it is evident that the concentration of light in space A, where there are the points of maximum lighting R 50, R 75 /defined according to the Czechoslovak State Standard no. CSN 30 4303 or the E/ECE/324; E/ECE Trans 505, Réglement no.1/, may be reached most easily in such a case, when in the space L of the pattern - next to the axis - a field with small prisms will be created, which will condense the luminous intensity in the area P' on the wall at place A'.

At the same time it is impossible to choose an arbitrary shape of the luminous pattern, transposed into place A, as in reality all light coming from the paraboloid, is a summary of an infinite quantity of the passing light lamp filament. All these patterns have the shape of narrow facets /trapezoids/, directed - in the case of the centered filaments - radially towards the headlight's axis. On the test wall it will create at a distance of 25 meters luminous strips of a considerable length which may be limited only by shading the protecting glass, which will decrease the total intensity of the pattern's illumination.

As we require that the light boundary be under the oblique boundary rr', the most advatageous are these parts of the glass which are near the horizontal axis. The higher they are, the less advantageous is the pattern for our purposes. If the concentration of light in the space P' is not sufficient even when exploiting the small prisms mounted in space L, then we use space P near the axis as well, which would normally ensure filament patterns in space L'. However due to the fact that in space P we introduce small prisms having a proper inclination, we transpose the light into a region which is roughly symmetrical with the headlight's axis, i.e. under the right oblique rr' boundary.

It is evident that even in this case it is necessary to use advantageously only those parts of the glass which lie in the vicinity of the horizontal axis. The more we retreat from it, the larger is the danger of surpassing the boundary rr' and illuminating the part of space above it, which should remain unlit, so that the driver coming from the opposite direction would not be dazzled.

When selecting the proper part of the glass for creating the pattern it must be further considered that the effect of a strong diffusion especially at the end of the filament causes a strong flare of the luminous patterns and especially due to aberrations of shape and edges of the pattern during the pressing of the glass, a considerable diffusion of light occurs which can depreciate considerably the theoretically calculated pattern. Practice shows that it is possible to exploit for the passing light pattern only those parts near to the horizontal axis of the glass. From this point of view it is also evident that for intensifying the light intensity of the passing lights, the reflectors with a rectangular shape are especially advantageous.

The calculation proper is carried out by trigonometrical tracing of the rays' tracks when passing through the entire system, further on by determining and adapting the refraction angle of the small prisms /wedges/ in such a manner so that the track would appear on the correct place of the test wall, thus correctly located in the lit up space. The calculation is carried out manually or by means of an automatic computer.

During normal calculations we consider as a rule that the filament is mounted centrically and thus it is quite sufficient to apply the theorems of plane trigonometry. Thus we receive only approximate results which it is necessary to check by means of practical tests and then according to them moderate the final result.

On the other side, results from the automatic computer apply the laws of three-dimensional Euclidean space, i.e. they exploit the Carthesian /orthogonal/ co-ordinate system. A disadvantage of this method lies in the necessity of selecting a large number of rays, so that the characteristic luminous pattern could be secured with a sufficient accuracy over the required test length, i.e. 25 meters.

"H" lamp main headlights' problems

The main parameters of the headlights are the effective opening, the luminous source luminance and the luminous flux - which are at disposal. The luminous range of the headlight, the dimesions and the intensity of the luminous zone depend on them.

The mutual relation of the luminance and luminous flux is determined by the input of the luminous source, i.e. by the lamp. Common motor vehicle lamps having an input of 45 W supply about 550 lm and with a medium luminance of 850 cd/cm^2 they have a real /average/ service life of about 150 hours. If we wish to raise the luminous flux merely by 10 %, the service life would drop by up to 45 %.

However when we use the "H" lamps, the luminance of which is in case of an approximately same lighting area as well as service life about twice larger, the luminance of the whole headlight will be raised proportionally. If only a minor increase in the luminance will be sufficient, e.g. 1·5 times, then it is possible to use a headlight with a smaller effective opening, which from the construction and appearance point of view is frequently quite advantageous.

As it was already mentioned, it is impossible in the meantime to locate in a single bulb of the commercial "H" lamp simultaneously the distance as well as the passing light filaments. Thus it is possible to design the "H" headlight as a separate one only, i.e. separate for the distance light as well as for the passing light, or to employ one of these headlight types with a screen, mounted outside of the lamp bulb, enabling the change over to the second type of light.

Distance lights

The introduction of the "H" lamps in the distance headlights does not practically involve any great technical problems. In case of headlights with an ordinary lamp an illumination of E_{min} = 32 lx is prescribed for the distance of 25 meters /According to the Czechoslovak State Standards or the E.C.E. regulations/. However, in reality it is considerably higher in the case of headlights having a larger effective opening. For example, for a headlight of a 162 mm diameter commonly 60 lx are stated, for headlights of a 200 mm diameter - 100 lx and in the case of rectangular types even more than 100 lx.

In any case it is necessary that the lighting in front of the vehicle be homogenious and so intensive in order to ensure a sufficient lighting even during the maximum speed of the vehicle. Further on it is necessary to respect the necessity that in the case of the transition from distance light to passing light there would not be a great difference in the lighting, especially in the region of points R 75 so that the safety of driving would not be affected. If the "H" lamp will be used, the luminous intensity for a distance of 25 meters - in case of the 135 mm diameter headlight - is increased to about 100 lx; in the case of the 162 mm diameter to 150 lx and in the case of the 200 mm ø up to 200 lx.

Table no.16 shows luminous intensity curves for the Marshal ø 170 headlights with ordinary lamps and for the Marshal ø 130 headlights with iodine lamps. The curves 1, 3 are valid for the right edge of the roadway, curves 2, 4 for the same edge at a height of 0'75 m.

Passing lights

Here the problem is more complicated as a light is involved which even in the case of a considerably increased output must not dazzle more than the present lights equipped with classical lamps. The passing lights of the European type are specified by homologation regulations which prescribe a certain illumination at various places of the test walls at a distance of 25 meters from the tested headlights - as it will be discussed later on. The characteristic points are especially B 50, H, R 75 and R 50. When the passing lights are in operation, the greatest difficulty is the observance of the prescribed values of lighting for the test points H and R 75, i.e. E_H, E_{R75}, as their angle interval is 1° only. At other test places of the passing light the prescribed distribution of the luminous intensity may be achieved by employing a proper pattern of the cover glass. The quality of the passing light is expressed by the luminous coefficient

$$k = \frac{E_{R\ 75}}{E_H} .$$

In the case of the older symmetrical lights, k = 3 - 5, in the case of the present /in average/ 9 - 12. Higher values may be reached only in the case of headlights with a very effective diameter which from the operation point of view is disadvantageous. If we equip the classical headlight with "H" lamps, then the total luminous flux will increase but at the same time the glaring effect will grow as the coefficient will remain the same. /Table no. 4./

Thus in the case of some foreign manufacturers, long-term and costly research work was carried out which ensured the possibility of designing headlights with separate "H" passing lights without necessarily surpassing the lighting at point H, which must not exceed 0.7 lx. At present this problem is also being solved with success in Czechoslovakia.

Table no. 4

European headlights and iodine lamp headlights

Test point		HV	75 R	k
European headlights				
	Diameter in mm	Luminous intensity in lx		E75 : EH
Classical headlight with ordinary lamp	ø 176	0.7	9	13
	ø 137	0.5	5	10
	rectangular	0.7	12	17
Headlights with iodine lamps				
Classical headlight with "H" lamp	ø 176	1.4	18	13
	ø 137	1	10	10
	rectangular	1.4	24	17
Special headlight with "H" lamp	ø 137 with circular focus	0.7	18	25
	rectangular with shift. axis	0.6	22	36

Combined lights

As it was already mentioned above, the problem of producing "H" lamps with two filaments has not yet been reliably solved - though according to information of some of the foreign manufacturers, dating back to 1966, the lamps with two filaments should have been commonly on sale at the beginning of 1968. Therefore the effort of the designers working in the meantime on the headlights


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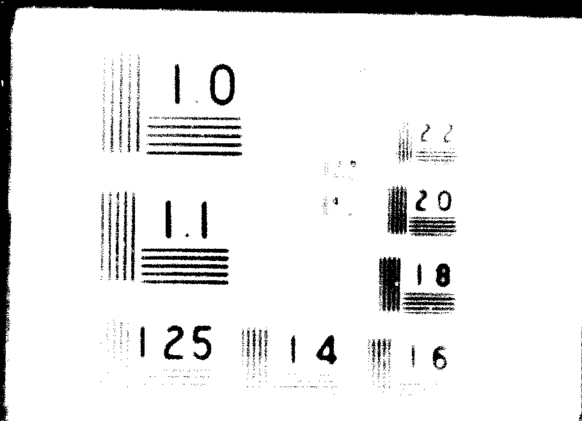


We regret that some of the pages in the microfiche copy of this report may not be up to the proper legibility standards, even though the best possible copy was used for preparing the master fiche with the "H" combined lights concentrated mainly on the exploitation of the "H" lamp with a removable screen for distance as well as passing lights. Further on we shall mention several typical patent documents from which the trend of solving the mentioned problem will be evident, especially with respect to the disclosed items and means as well as similar ways.

The French patent no. 1.[illegible].036 - [illegible]; the English patent no. [illegible] - [illegible]. The invention exploits the axial luminous source, e.g. iodine lamp, which is situated in the focus of a parabolic mirror so that it is quite suitable for distance lights. The passing light is created according to the inventors by means of two rectangular screens 1, controlled by the electromagnet 8, mounted at the rear part of the parabola. When the small screens are closed (pressed to each other with their longer sides), they let almost all the light (distance light) pass through, whereas with the screens open, they screen either the lower part of the flux (they let the convergent beams through) or the upper part of the flux (they let the divergent beams through). This is exploited for the creation of passing lights. The principle is evident from Table no. 17. The main patent requirements are as follows:

a/ The auto headlight containing two lights, equipped with an axial source and devices for the screening of the filament;

b/ these devices are composed at least of one turnable screen which screens a part of the luminous flux;

c/ the motion of the screening device is controlled by a [illegible] or mechanically;

d/ the headlight is equipped with a fixed lamp, mounted possibly besides the focus, further on with optical devices [illegible] that part of the luminous beam which forms the supplement to the distance light. The fixed part of this light creates passing light which is continuously in operation e/ The optical devices mentioned sub d/ may be a part of the diffusing glass;

f/ The mirror may consist of two horizontally against each other shifted semi-paraboloidal mirrors of which one has the focus in the source and the other besides it. The first mirror creates the supplementary part of the distance light, whereas the second light creates the passing light and part of the distance light.

French patent no. 1.376.728 - Marshal

The object of this patent is a headlight with an iodine lamp equipped with a hollow cylinder shaped screen, having several openings adapted in such a manner that the light passing through them will create the passing light. If the headlight should ensure distance light as well, the screen will be shifted by means of an electromagnet along the parabola axis. In this way the passage will be open to all the rays and distance light will be ensured.

French patent no. 1.477.851 - Philips

This patent document states that a headlight, the mirror of which is composed of two identical paraboloids shifted against each other in the horizontal direction and having the filament 1 mounted between the foci of these halves /See Table no.18/, manages to achieve good passing light but is insufficient for the distance light. Therefore the inventor introduces into the focus of the upper half of the mirror across the axis of the headlight a further auxiliary filament 4 and further on next to the exit opening an auxiliary hollow mirror of an elliptical shape, mounted in such a manner so that its foci will correspond with the foci of both the paraboloidal semi-mirrors. In this case the auxiliary filament, located in one focus will figure in the other focus. Both mirrors then give ray beams roughly parallel with the axis, which is exploited for the distance light.

In conclusion it may be said that according to information from abroad as well as technical and patent literature et sim., great interest is devoted to the solution of the headlights with the "H" lamps, especially by motor vehicle manufacturers. The headlights with combined "H" lights are currently on sale. It is expected that once the problem of two-filament "H" lamps will be settled, the headlights of practically all vehicles will be equipped with this lamp.

Auxiliary headlights

From the large group of auxiliary headlights at least the most frequently used fog lights /wide angle lighting fittings/ may be mentioned.

These have a smaller or medium luminous intensity and employ paraboloidal mirrors, including circular or rectangular exit openings. The protecting glasses are usually deeply grooved in the perpendicular direction so that a widely diffused light beam with a limited height but wide side range will be achieved. This is quite desirable as it enables better visibility in a dense fog - at least of the road edges - possibly even the middle part of the roadway.

The fog lights should replace during driving in a fog the main headlights as the luminous cone of the latter is not properly adapted for driving during a bad limpidity of air so that they do not illuminate the roadway sufficiently and on the other hand they create an intensive diffusion reflection on the fog droplets which dazzles the driver and hinders his needed orientation on the roadway. Practical tests have shown that the fog lights assist considerably in improving visibility during a fog only in such a case, when they are properly mounted. During a light fog, the fog lights should be as low as possible and the luminous cone limited in its height, should be directed slightly obliquely downwards. However if the fog is denser, the volume of light diffused in the direction of the driver's vision increases and the luminance of the illuminated fog increases in comparison with the luminance of the roadway. In order to let more light fall on the roadway and less on the fog it is necessary to mount the fog lights somewhat higher and at the same time to tilt the axis of the luminous cone more from the horizontal. During a dense fog the height of the fog light should ensure that the driver's direction of view on near items will not be identical with the fog light luminous cone's axis. However the fog lights must remain sufficiently high as well as sufficiently tilted down.

From what was mentioned above follows that the fog lights should be mounted in an adjustable way. However in practice we neglect the proper position for light fog conditions and mount the fog lights maximally 45 cm above the roadway, with a sufficient inclination. The fog lights must however be located lower than the main headlights.

Signal lighting fittings

The technical requirements regarding signal lighting fittings and the mode of testing their parameters are prescribed by the Czechoslovak State Standard no. CSN 30 4305 /for Czechoslovakia/. They are manufactured with a red light - as rear and stop lights, with an orange light - as front and rear direction indicator lamps or with a white light - as side lights. Lighting lamps, i.e. lighting fittings for the lighting of the number plates, running-boards, ceiling, seat, panel et sim. lighting fittings, have as a rule white lights. The luminous technical properties of the signal lighting fittings are stated on the following Table no. 5:

Signal lighting fitting luminous and technical properties

Type of lighting fitting	Colour of light	Values for 1 level of luminous intensity min.	Values for 1 level of luminous intensity max.	Values for 2 levels of luminous intensity day	Values for 2 levels of luminous intensity night
Rear light	Red	2 cd	12 cd	-	-
Side light	White	4 cd	60 cd	-	-
Stop light	Red	40 cd	160 cd	min.130 cd optim.325cd max.525 cd	min. 30 cd opt. 75 cd max.320 cd
Front direction indicator lamp	Orange	50 cd	700 cd	min.175 cd max.700 cd	min.175 cd max.700 cd
Rear direction indicator lamp	Orange	50 cd	200 cd	min.175 cd max.700 cd	min. 40 cd max.160 cd

The properties of lighting lamps are not stated by regulations. Further on, values of the light chromacity co-ordinates are specified for the red and orange colours. /See the above mentioned Czechoslovak State Standard./ An important property of the lighting fittings is their luminance which however has not yet been stated by any standard. Thus we often see grouped rear lighting fittings which frequently - especially during the night - disturb the sight comfort of the following car's driver as they dazzle him sometimes even to such an extent that an immediate sight indisposition /blinding glare/ may occur which may lead to a traffic accident.

The decisive factor for evoking a sight sensation is the contrast of luminance of the observed object and its surroundings /so-called relative luminance/. Practical tests have shown that with a relative luminance of 1 : 10 a sensitive sight disturbance may occur and with a relative luminance of 1 : 100 even a glare.

With respect to the fact that the maximum bearable luminance for a human eye is about 20 - 30 stilbs, it is recommended that the exit faces of the lighting fittings be sufficiently large, as far as possible plane - without optical effects, possibly grooved, with a shallow profile or it is better to equip them with a scanty dotting which scatters light quite well to the sides and thus decreases considerably the total luminance of the lighting fitting. The reflection surfaces under the individual lamps of the lighting fittings should be moderated in such a manner so that the reflected light would be sufficiently diffused. Thus these surfaces should be finely matted. The mirrors should be with regards to their surface as large as possible and they should have a large radius of curvature.

With respect to photometry it is necessary to require that the lighting fittings' lighting intensity should approach with the prescribed lamp luminous flux the bottom limit boundary of luminous intensity as well as luminance as both values grow with the operation voltage and there is a danger of surpassing the maximum boundary.

IV Production of lighting fittings

Production of reflectors

The basic condition of good functioning of the reflectors is the precision production of the reflection surface, minimum absorption of the light by the reflection layer and the possibility of a correct positioning of the luminous source into the working position. Further on a long service life is expected as well as chemical resistance of the reflection layer even in case of increased temperatures and a resistance against mechanical abrasive wear.

The precision execution of the shape requires not only the strict observance of the geometrical form of the mirroring surface but especially roughness and absolute cleanliness of the surface. It was found out that the greatest influence with respect to the origin of the headlights' incorrect pattern is exerted first of all by the roughness of the surface and especially by the corrugation in the form of concentric circular zones. It was found out that minor deviations of the mirror from the geometrical shape are permissible up to a certain degree if the [illegible] of their [illegible] of origin does not exceed the space, filled up by the respective filament.

Reflectors for European headlights are manufactured by pressing from steel sheets covered then by a reflection layer.

The steel sheets are of the deep-drawing type, cold-rolled. They are [illegible] - [illegible] mm thick. Tensile strength is considered about [illegible] kg / mm², some ductility of about [illegible] %. Further on it is desirable that the supplied sheets have a smooth surface without wrinkles, scratches or rolled-in impurities, an even thickness and roughness with the smallest possible tolerances. The surface must not be corroded. Practical tests have shown that material which has an uneven tensile strength results in bad quality products with respect to precision, as its elasticity is uneven and has a tendency to return to the original form in various directions with a different strength and thus does not accept the correct shape of the pressing tool. The longitudinal fibrillation in the direction of the rolling is the cause of increased ductility of the material in this direction and the resulting pressings have a greater or lesser quality. Further on it is necessary to exert a great care so that the used material would not age fast - that it would not harden before it would be used for pressing.

Pressing

Pressing may be basically done by two methods :

a/ the classical method, consisting of gradual passing of the product from one type of press to another: On the eccentric press a disc is pressed from a steel strip. On the drawing press, prepressing and parabola shaping is carried out. On the friction press the general shape is sized out and on other presses the reflectors are treated.

b/ On modern transfer presses /e.g. the Schuler Co. transfer presses/ the reflector is pressed in several work operations on a single machine. The exploitation of this transfer press in the production presumes great lots of reflectors to be produced with respect to the high cost of acquiring this transfer press.

During all of the work operations it is necessary to [illegible] the cleanliness of the workshops so that the impurities could not be pressed-in and thus the products depreciated.

The pressing tool is a paraboloidal punch and die. The punch is produced by lathe-turning, hardening and manual grinding. The piece is checked against daylight by means of a template.

Far as we know, some foreign manufacturers consider exploiting the technology of pressing the paraboloidal form in a single stroke on a hydraulical press by means of a rubber punch filled with water. The deformation activity during the drawing operation runs in this method almost ideally and thus the shape of the pressing is guaranteed by the die.

After finishing the pressing, the internal surface of the precision reflectors /e.g. for the main headlights/ is ground /polished/ for the coating /finishing/ varnish.

There are several grinding methods. However basically it is required that the direction of grinding be followed as far as possible in planes parallel with the paraboloid's axis as the grinding material takes off material from the top to the edge of the paraboloid, i.e. perpedicularly to the waviness and the roughness grooves, caused by the drawing which - as it was mentioned previously - have a circumferential direction. Thus it is possible to create a good quality surface under the coating varnish layer.

Grinding is carried out in special fixtures with the aid of abrasive discs of a very fine grain and having a proper diameter of curvature, possibly with the aid of elastic discs. Some manufacturers use abrasive band form grinding. The details of operation as well as the employed equipment are held by the manufacturing companies in strict secrecy due to the danger of competition.

After grinding the internal surface of the reflector it is covered by a reflection layer consisting of an undercoat metal paint and possibly a protective coat. The application of the undercoat paint is carried out after perfect degreasing and phosphating of the surface by dipping /spraying/ most frequently in a tunnel line and drying /baking/ at a temperature of 150° - 190° C /according to the type of the varnish/. There are various dipping varnishes. It is required that after the baking it should endure temperatures of about 120°C without cracking or scaling, that bubbles should not occur on the surface and that minor surface irregularities of the ground parabola be removed./In Czechoslovakia high quality surfaces are covered by the Herberts 30714 type varnish, produced by the GDR./ The thickness of the coat reaches about 25μ, in case of double dipping some 30 to 35μ. The undercoat varnish is covered by means of the vacuum steaming method by the reflection proper layer which is either of pure aluminum or more frequently of an alloy of aluminum and 5 % of titanium. Some manufacturers equip such metal coated surfaces by protective coatings applied by the vacuum coating process /glyptal undercoat varnish/ of a small thickness which ensures a long service life of the mirror even in extremely humid regions with a frequent condensation. /The life is prolonged according to some measurements carried out up to five times, with about a 3 % decrease in the reflectivity./

The checking of the ground face surface quality is based on the presumption that the most effective method is evaluating the light-shade boundary of the passing lights' image. The checking in the workshop is carried out visually by observing the image sharpness of the straight edges of the objects' images or images of drawn parallel line sets /grids/ and by comparing them with a model parabola.

Shape deviations will present themselves as local waving and greater roughnesses as line unsharpnesses.

<u>Production of diffusing glasses</u>

Diffusing glasses are manufactured by the pressing of molten glass batch /glass metal/ at a temperature of about 1200°C. The glass batch is a mixture of quartz sand, fluxes /potash or soda/ and limestone which renders the glass resistant against the effects of water. Besides that the glass batch contains a small amount of other substances which ensure the good course of glass plaining and that the glass is colourless. The dosing of the glass is carried out most frequently automatically. Manual dosing is not acceptable as it does not ensure the same batch volume. Due to that the pressed glasses would have various thicknesses, transmittance and different optical effects.

Pressing is carried out on hydraulic presses; cooling in tunnel furnaces.

Cooled glass contains about 70 % of SiO_2 /silicon dioxide/, 16 - 17 % of Na_2O /sodium oxide/, 8.5 % of CaO /calcium oxide/, further on some F_2O_3 /iron trioxide/ and traces of other oxides, the most interesting of which is B_2O_3 /boron trioxide/ which ensures the clarity of glass.

The pressing of glass is carried out by means of two-part moulds /core and counterpiece/, produced from various materials. As the production of the moulds is quite laborious and requires considerable precision, individual metallurgical works develop materials which suit best their experiences as well as tested technological processes. In Czechoslovakia the most frequently used materials are [illegible], having a high consistency even during high operational temperatures. The moulds for glass casting are often equipped with a hard-chromium coating. For example, the [illegible] factory in the Czechoslovak Socialist Republic commonly chrome-plates the moulds to a thickness of about 0.01 mm after previous cleaning of the surface /cleaning with steel brushes, dipping for up to 4 hours in paraffin oil./

The life of a hard-chromium coat is about [illegible] pressings. Then it is necessary to remove the rest of the layer and to carry out the chrome-plating once more.

In some of the foreign metallurgical works, moulds with a nickel lining are employed so that the mould body may be made as well of less particular materials /grey cast iron/. Tests have been carried out with metallization [illegible] of alloyed materials.

The production of the moulds is quite costly. The main problem lies in the manufacture of the punch, into the upper work surface of which /having a concave or convex form - according to the shape of the glass/ it is necessary to mill the design with considerable high precision. For example, in the case of the wedge-form part, designed for the direction of the passing light rays, it is required as a rule to attain for the length values a precision of 0.01 mm and in the case of angle values a precision of 5 - 10 minutes.

It is important that the corners and edges of the pressed glass design be sharp so that the diffusion of light, occurring at these points could be as small as possible. Thus the design of the punches must be finished after milling by manual machining /filing, cutting, engraving, scraping and [illegible] polishing/. This work requires a high personal dexterity and experience of the worker, as the mould is employed in the course of work. The samples are examined, whether they correspond with the requirements regarding the luminous intensity distribution and according to the results of the tests, they are gradually modified.

With regards to the fact that light acts as an optical system of precisely defined properties, it is necessary to respect the technological requirements following from the production process, as it was mentioned in the previous paragraphs.

a/ The basic shape of the glass must be arched /convex or concave/ as the pressings with flat surfaces are quite frequently subject to deformations during cooling.

b/ The optical elements of the pattern must have proper dimensions and inclination. In the case of large surfaces, deformation occurs, whereas in the case of very small surfaces, there appears the major effect of the luminous diffusion which occurs in the rounding of the edges of the individual elements. By this, the luminous flux in the desired direction is reduced on one hand, the luminous intensity contrasts are reduced on the other, and at points with the prescribed maximum, flaws usually occur.

The individual above mentioned parts join mutually together either directly or indirectly into a so-called headlight insert. In the case of the European type of headlights, the glass and reflector are most frequently joined mutually by bending the edges and cementing, only in exceptional cases both parts are held together merely by external pressure. Then a rubber sealing ring is inserted between them. The lamp may be freely inserted into the neck of the headlight and held in the working position by means of a resilient spring.

In case of the sealed-beam headlights, the reflector is metalized and it is sealed directly to the glass. The electrodes are sealed directly into the reflector, the insert is evacuated. The exchange of the luminous source is not possible. When the filament is burnt out it is necessary to exchange the whole insert.

Conception of signal lighting fittings

Motor vehicle signal lighting fittings are designed either as separate fittings or as group fittings /there are several separate lighting fittings in the same casing/ or combined fittings /there is one or more luminous sources working under different conditions in the same casing with one protective glass/

Their construction depends often on the aesthetical conception of the car body. However it is always important that the lighting fittings fulfill first of all the functional conditions /specified by the respective regulations - in Czechoslovakia by the Czechoslovak state standard no. [illegible]/.

At present the signal lighting fittings are designed mostly as group fittings which offer certain economical advantages. However, the reduction of their effective surfaces evokes an increased luminance of the lighting fittings and thus the development of the lighting fittings leads back towards separate lighting fittings.

V Testing techniques for motor vehicle lighting fittings

Introduction

Each lighting fitting designed for use on a motor vehicle must comply in respect with its technical and operation properties, possibly even design, with the respective regulations /Czechoslovak State Standards - ČSN/. In case no regulation /ČSN/ stated by the state exists /for some less important lighting fittings/, then the technical and acceptance conditions usually elaborated by the manufacturers in agreement with the customers' companies, are valid.

For the basic lighting fittings - possibly even luminous sources - the European Economic Commission /EEC/ introduced for all of its member states so-called recommendations which correspond to the most recent knowledge, requirements and conventions of the International Lighting Engineering Organization /I.S.O./. /Deviations are carried out only in those cases where it is to the profit of the product's quality and to the safety of traffic./ The product must comply with these regulations, should it be freely saleable in those countries which are members of the E.E.C.

In Czechoslovakia there are no difficulties in sanctioning the E.E.C. recommendations as the Czechoslovak State Standards /ČSN/ are published as a rule after the declaration of the E.E.C. recommendations. For all of the member states of the E.E.C., so-called national testing establishments are authorised to carry out tests of the lighting fittings, prescribed by the E.E.C. recommendations. The Czechoslovak national testing establishment at the EZÚ Company of Prague-Troja, is a member since 1967. The products, approved by this testing establishment are marked by the symbol "E 8". /Symbol "E 1" is reserved for the German Federal Republic, "E 2" for France, "E 3" for the Netherlands, etc./

The so-far issued recommendations of the E.E.C. are valid for asymmetrical headlights /Reglement 1 and 2/, reflex reflectors /Reglement 3/, rear number plate lights /Reglement 4/, Sealed-beam headlights of the European type /Reglement 5/, direction indicator lamps /Reglement 6/, side and stop lights /Reglement 7/ and "H" lamp headlights /Reglement 8/.

Testing techniques

The testing techniques employed for the motor vehicle lighting fittings applied to a wide range of lighting fittings, mentioned in Chapt r 1, are quite diverse. However each lighting fitting is basically subject to tests in a testing establishment and besides that some of the more important lighting fittings are subject to tests with respect to their parameters after mounting and adjusting on the vehicle. The detailed course of the tests is stated in the respective standards.

Basic regulations

The basic regulations for all electrical equipment and installations serving as accessories and equipment of motor vehicles are stated for Czechoslovakia in the Czechoslovak State Standard no. ČSN 30 4002 - Motor vehicle electrical equipment. This standard prescribes conditions for the construction of individual elements of the electrical equipment, its protection and resistance against interfering influences

/including the protection against an unfavourable environment, corrosion, changes in temperature, great temperatures, humidity, dust, vibrations and shocks/. Further on it states the types of tests which it divides up into type, check, piece and acceptance tests.

By type tests a complex of all prescribed partial tests is understood which take place in the case of a new product or a change in the design, material or production technology - if these do have an influence on the change of the products' properties. They take place as well when the production is shifted to another plant or when production is resumed after a temporary stop in production. For type tests, two products are selected at random, approved by the technical inspection of the manufacturer. Should not just one of the products comply with the test specifications, e.g. even merely in one of the partial tests, the whole test must be repeated in the entire extent with two next products.

The check tests are carried out by a special technical product inspection department of the manufacturing plant on random picked products according to such time schedules and with such a number of samples, so that the desired quality of the products would be ensured. It is carried out at least twice a year in the extent of the type test. If only one of the samples does not comply with the specifications during the test, then the test is repeated in a full extent with a double number of samples. The check tests are also carried out by the authorized testing establishment in charge of a permanent inspection of the quality of respective products in the extent necessary for keeping their quality under observation.

The production plant is informed about the results of the tests by the establishment in form of a written statement - the test record.

The piece tests are carried out on each product, usually in the form of a final production check. All the basic properties, dimensions, marks, appearance and basic functional parameters are tested.

The acceptance tests usually have the same extent as the piece tests. Then in doubt, the customer company has the right to submit any product to any test prescribed by the standard /Czechoslovak State Standard no. [illegible] or any related standard.

Tests of the luminous technical properties

The tests of the luminous technical properties of the lighting fittings consist of ascertaining the photometric properties of the lighting fittings, the chromaticity of white lights and possibly ascertaining, whether the lighting fitting does not dazzle the roadway users in an excessive way.

The photometric properties of the lighting fittings are ascertained by measuring the luminous intensity which their light evokes on the testing wall /for main headlights - in Czechoslovakia - Czechoslovak State Standard no. [illegible] applies./. The illumination is measured at certain points which are specified in such a way so that their complex would offer a thorough survey about the distribution of the luminous pattern /luminous track/ on the roadway. Testing lamps are employed, the rated dimensions of which are exactly 1/3 of the tolerance of the same dimensions, permissible for lamps coming from normal production - /for as some regulation does not state otherwise/.

The test luminous figures are as follows.

Main headlights	[illegible] lx in case of distance lights
	[illegible] lx in case of passing lights
(For headlights having an exit diameter of [illegible] mm	[illegible] lx or [illegible] lx)
Fog lights	[illegible] lx
Reversing lights	[illegible] lx
Auxiliary distance headlights	[illegible] lx
Adjustable spot lights	[illegible] lx

For testing the headlights, test walls depicted on Figures no. 19, 20 and 21 are used.

In case of the distance lights (Figure no. 20), the basic requirement is that the luminous pattern projected on the test wall with the horizontal axis of the headlight, be symmetrical as regards the height and width - in the direction towards the center. For checking purposes serves the main point 0 as well as the points 0_{1L}, 0_{1R}, 0_{2L}, 0_{2R}, for which certain luminous values are specified.

The requirements for the passing lights are more strict. In case of symmetrical light (Figure no. 19) it is necessary to heed that Band I and especially Band III (Ranges of dazzling the drivers coming from the opposite direction) must not have a flare, whereas Band IV must show sufficient intensity.

The most strict requirements are imposed on the asymmetrical passing lights. This is why there is a special test wall employed (Figure no. 21), representing a perspective view of the roadway, i.e. wide, in such a manner as it is seen by the

[illegible]

drivers of the vehicle, situated 75 cm above the center of the right half of the roadway /height of the eyes/. The dot and dash line passing to the lower left quadrant of the picture denotes the projection of the eye trace of the driver, coming from the opposite side and along the axis of the roadway's left half. Further on, the edges and the axis of the roadway are depicted on the picture.

The measuring points are as follows: the main point H, i.e. the projection of the headlight's focus on the test wall; points 75 R and 50 R - representing the perspective projections of the point on the right edge of the roadway in a distance of 75 and 50 metres from the headlights;
points 75 R and 75 L - representing the points on the intersection of the test wall with the roadway lying on the beams, deviated from the headlight's axis to the left and right by an angle of 9 °;
point B 50 which represents the projection of the eye of the driver coming from the opposite direction at a distance of 50 m from the headlight.

The entire testing area is divided into 4 test zones, in the same manner as in the case of the symmetrical passing light but the boundary between the bands II and III is in the right half elevated by an angle of 15°. The bands I and IV mark the part of space directly in front of the vehicle which should be illuminated sufficiently for a safe orientation of the drivers upon the meeting of two vehicles. The illumination values /maximum 20 lx, minimum 1.5 lx/ were chosen with respect to retain the ability of differentiation of the driver's eye. In Band III which is achieved by the screening of the luminous cone of the headlight by the lamp's screen, the smallest possible illumination is required, theoretically of a zero value. However, due to the diffusion of light originated by the reflection on the roadway, on dusty particles in the air as well in the headlight proper, a certain illumination occurs here, the intensity of which must not exceed 0.7 lx and 0.3 lx at the test point B 50. In this way, dazzling of persons /vehicles/ coming from the opposite direction should be hindered.

Technically most difficult is the illumination specified for Band II. This is divided by the axis of the roadway into two sections; in the left one the illumination should be about the same as in Band IV, whereas in the right one light is required to concentrate on the edge of the roadway at a distance of 50 - possibly 75 meters. By means of simple calculations it may be determined that these distances correspond with the braking distances of customary vehicles travelling with a speed of 60 - 80 km / hour - nevertheless under the condition of full concentration of the driver /Reaction time; about 0.[illegible] sec./. In reality it is necessary to consider a certain fatigue or lesser concentration of the driver, i.e. a longer reaction time, so that the above mentioned tracks will correspond in practice with considerably lower speeds.

From this it is evident that when we wish to pass vehicles at higher speeds than those mentioned, it is first of all necessary to increase the intensity of lighting of the space between points 50 and 75 m. This can be basically done in two ways: either by using a supplementary light or by introducing more effective headlights.

<u>Additional lights</u>, used till about 19[illegible], i.e. until the time when the intensive exploitation of more effective head-

nous sources was introduced, give a narrow luminous cone intensively lighting up the outside edge of the roadway in a distance of 70 - 100 m and thus extend the effect of the passing lights with classical lamps. In the direction towards the inside of the roadway, the light is screened in such a manner so that it would not dazzle on a straight track the users of the other half of the roadway. Various types of headlights were developed with special lamps /e.g. Novalux - Darklin, Austrian patent/ which do not prove to be competent due to the possibility of dazzling the driver coming from a turn from the opposite direction. /According to Czechoslovak regulations they are not allowed in this country./

The second method of raising the luminous intensity in the vicinity of point 75 R by using new types of headlights with "H" lamps is quite actual nowadays. It was discussed in the preceding chapters.

The photometric properties of the auxiliary headlights are tested on a wall /See Figure no.20./ The measuring is carried out in a similar way as in the case of the main headlights with distance lights./Details are stated in respective regulations./

The photometric properties of lighting fittings are measured in a similar way as in the case of headlights. /According to the Czechoslovak State Standard no. ČSN 30 4305 - The illumination and signal lighting fittings for road motor vehicles./ In this case the test wall has much smaller dimensions and it is used at such a distance where it is possible to apply with a sufficient precision the basic photometric law, expressing the relation between the lighting intensity and the distance of the source. /See Chapter 2./

According to practical experiences it is about ten times the size of the largest dimension of the tested lighting fitting. As the shortest distance usually a distance of 1 m is chosen, for precise measuring 10 meters.

Measuring of the light chromacity

Measuring of the light chromacity is carried out on the basis of the international colorimetric system which presumes that the eye perceives light by means of three organs the sensitivity and colour of which differs and depends on the length of the colour wave. In dependence on the sight sensation, the chromatic co-ordinates of light $\underline{x}$, $\underline{y}$ and $\underline{z}$ are determined. In practice usually the co-ordinates $\underline{x}$ and $\underline{y}$ are stated, as the third one is a supplement to 1.

Chromatic lights are used exclusively in the case of signal fittings. An exception are the yellow lights which are popular especially in France for the main headlights as well as for the fog lights. The advantages which are ascribed to their light, i.e. lesser dazzling effects and better discerning ability, are questionable and were rejected for a long time outside of France.

At present the problem of exploiting yellow lights has again been raised and new measurings are carried out in order to determine the properties of this light with a final validity. So far the results show that especially in the case of the fog lights, there are no theoretical grounds for its use as the luminous diffusion which should be smaller in the case of yellow light than with white light - as some of the practicians believe - is the same for all lights as water droplets, forming the fog have a diameter of micron unit values which is more than the wavelength of visible luminous radiation.

The measuring equipment in motor vehicle lighting engineering is basically of two types :

a/ spectrophotometers, equipped with a monochromator and a measuring photoelectric cell. During the measuring, the intensity of the individual chromatic components of the light in the whole extent of the visible spectrum and from them the chromatic co-ordinates are calculated /according to the method, mentioned above in Chapter 3/.

b/ comparphotometers, where the chromacity of the three basic light components of the tested lamp are compared with etalon lights. The measuring may be performed either objectively by means of the trichromatic colorimeter or subjectively by means of e.g. Pulfricht's photometer.

The trichromatic colorimeter exploits three photo-electric elements with a sensitivity according to Table no. 4. When employing this method elaborate calculation operations may be omitted as the evaluation is carried out directly by the elements. However, it is necessary that the sensitivity of the elements follow quite exactly as the functions $\bar{x}_\lambda$, $\bar{y}_\lambda$, $\bar{z}_\lambda$, especially far as the course of $\bar{x}_\lambda$ is concerned. The realization is always difficult and thus instruments with a precision sensitivity of the elements, modified by proper colour filters, are quite rare. Common instruments of this type always have elements of somewhat different properties than those prescribed. Thus it is necessary to correct the results offered by the instruments, so that they would be at least approximately equal to the C.I.E. co-ordinates. They are rather convenient for fast but less accurate measurings of the light chromacity.

As regards the Pulfrich's photometer, the comparing of colours is done in a simple, visual manner.

<u>Glaring by the headlights</u>

The next property which it is necessary to check in the case of asymmetrical headlights passing lights with respect to the uniform E.C.E., is the glaring by the headlights. This test was introduced due to the fact that the emitted light does not have - in consequence of the luminous reflexes on the lamp screen and on the edges of the pattern of the small prisms - an even luminance. In the field of view intensively shining small surfaces appear which dazzle the observers' eyes in such a way as if they were stricken by a light of a greater luminance than the total headlight luminance.

The testing of this glare is very difficult and so far no reliable testing method is known. In Czechoslovakia a subjective testing method has been proposed according to which the observer compares the glare of his sight by the headlight with a comparison source of a prescribed luminance. A number of measurings was carried out which proved that it would be possible to ascertain the glare by this method. At the same time the observation of several member states of the E.E.C. was verified that the glare test is superfluous, as the headlights which comply with the test on the testing wall mentioned above comply as well with the glare test. In this respect, the Czechoslovak proposal was formulated and then passed on to the Lighting Engineering Commission of the I.S.O. at Brussels. So far no decision was passed on this proposal. For as it is known, a tendency appears abroad towards the introduction of a precision objective method.

[illegible]

Polarization of light

The application of the polarization of light was considered as well in order to reduce the glare. This requires that the headlights be equipped with a polarizer and the driver with an analyzer.

However this solution has an insufficiency - the small luminous intensity of the present luminous sources of lamps and further on the fact that in the polarized light, [illegible] planes of the material [illegible] through which the light passes, /f.e. through the front protecting glass of the car/ as dark spots, possibly due to the depolarization as a highly bright [illegible] which may [illegible] and [illegible] the driver. Further on it was necessary to employ a [illegible] polarized light, the dimming effect of which does not change with the inclination of the roadway. It was necessary to consider what consequences would arise when driving bare lamps with badly adjusted headlights, up to what degree would the depolarization be prejudicial when driving in a fog, rain, etc.

By interchanging [illegible], more effective [illegible], the solution seems to be facilitated but it evokes the necessity of a complete solution of the task from the point of view of technical operation /elimination of the glare for all of the roadway users, harmonizing the street lighting intensity with the auto head-light distance [illegible] lights/ as well as economical /the necessity of simultaneous [illegible] solution in case of all vehicles/. Thus this method is at the present entirely out of question.

Shadowing of the reflecting glasses

The shadowing of the reflecting glasses is a completely special field in lighting engineering testing as [illegible] light is not tested but light reflected /by the bottom surface of the reflecting glass/.

The reflecting glasses have a shape of a very flat cylinder or a triangular prism. On the bottom surface they are equipped with a reflection layer of vacuum-coated aluminium /covered by a coating of varnish/. On the upper surface there is the prismatic design which deflects light falling on the reflecting glass. After the reflection by the bottom surface of the reflecting glass it refracts in such a manner that it is directed in the desired direction.

The measuring of the lighting and technical parameters of the reflecting glass is a rather new line of testing which at the present is in constant development. A recommendation has been passed by the C.I.E., as well as a Czechoslovak State Standard has been issued and the measuring techniques of these properties have been published but still the question remains as up to what degree does it comport with the problems of the task. A very important circumstance is the lack of testing equipment which must have considerably different characteristics than the testing equipment for ascertaining the photometric and colorimetric properties of ordinary lighting fittings. This introduces great difficulties and it may be said that so far it has not been possible to specify optimal conditions for the measuring and determining of /optimal/ measuring methods.

The difficulties of measuring the reflecting glass may be basically divided into two characteristic groups: first it may be stated that very small luminous intensities are measured here which are sometimes of the millicandel order or even less and secondly, the question is still open pertaining to the colorimetry of the reflecting glass for which we do not have not only measuring techniques but also basic specifications of requirements regarding the precision of measuring. In the colorimetry of reflecting glasses it is almost impossible to use the ordinary classical techniques with respect to their minor precision which is limited by the present boundaries of technical possibilities.

Thus it is impossible to state that the present equipment exploited for the measuring of the parameters of the reflecting glasses are fully satisfactory. Usually the properties of the photomultipliers are exploited which are capable - according to the volume of the filament current - of measuring even very weak light intensities. However a major disadvantage is that they require a high constancy of the employed current's voltage and mainly the circumstance that their spectral sensitivity must be adapted to the cone sensitiveness of the human eye. This correction is as a rule rather difficult as the sensitivity of common photomultipliers afflicts most of all the blue radiation regions. The emission current is measured after amplification by means of a galvanometer.

The measuring of the light chromaticity is usually done by means of the comparison visual method.

Adjustment of the lighting fittings on the vehicles

The location of the basic lighting fittings on motor vehicles is usually specified in regulations. /e.g. Czechoslovak State Standard no. ČSN 30 4302/. This means that their position as well as their orientation and angles of geometric visibility are specified. These basic parameters are ensured as a rule by the proper and careful mounting of the lighting fittings on proper places of the vehicle in such a way that after their basic mounting it is not necessary to check them.

An exception are the main headlights as their wrong adjustment dangerously threatens the safety of traffic and quite frequently is the cause of serious accidents.

The adjusting of the headlights of the European type, i.e. introducing their optical axes into a horizontal position parallel with the longitudinal axis of the vehicle is carried out either by aiming at the test wall or by a special adjusting equipment, the so-called reglescopes.

In the first case the passing light boundary is marked at a distance of 10 m on a vertical wall, standing perpendicularly to the longitudinal axis of the vehicle, in such a manner so that the boundary refraction would be lower by so many centimeters than the height of the headlights' centre as is the distance of the wall in metre /thus an inclination of the headlight by 1 %/. Then the coincidence of the passing light is carried out with the indicated boundary. This method requires considerable space and cannot be employed at an open space during the day.

Thus a number of various equipments has been developed, enabling the adjusting of headlights on the vehicle. All of them exploit principally the optical system, either lens or mirrors, by which the luminous pattern created by the headlight on the test wall is depicted in a half scale in a distance of about 1 meter. Some adjusting instruments enable checkup not only of the correct shape and distribution of the luminous pattern of the tested headlight but also finding out the luminous intensity at important points of the distance and passing lights.

The adjusting of the Sealed-beam type headlights is considerably simpler than in the case of the type "E" headlights and it is carried out mechanically at both headlights simultaneously. In principle three contact surfaces are exploited. These surfaces are carried out on the face of each headlight insert by which the plane, vertical to the headlights' axis is determined.

Most of the numerous adjusting equipment which is of various types, enable first the adjusting by means of a mechanism the support bases which come into contact with the contact surfaces of the protecting glass. This adjustment pertains to the axes of the headlights which are introduced into a mutually parallel position and then they are levelled in parallel with the longitudinal axis of the vehicle. The mechanism requires that the exact spacing of both the headlights be known.

Basic laboratory measurings carried out in the lighting engineering testing shop

The average lighting engineering testing shop should be equipped - besides the fore mentioned test wall and instruments for the measuring of the light chromaticity - with equipment enabling the testing of the luminous intensity of the sources, the luminous flux, lighting, luminance, possibly reflectivity and basic parameters of simple optical systems. Therefore the following paragraphs will be devoted to a brief survey of the equipment and methods employed for the measuring of the mentioned values.

Measuring of the luminous intensity

The luminous intensity of the sources and lighting fittings is measured on a photometric bench. This bench consists of a pair of /precisely located/ rails, on which carriages with light sources, screens and measuring instruments may move in such a manner that they are always co-axial. The magnitude of the shift can be read from the scale mounted on the rail, parasitic light is eliminated by means of a screen of a proper size.

The basic measuring involves the luminous intensity normal of a special construction which is used for the gauging of work normals. The laboratory should be equipped with a series of normals different luminous intensities so that by comparing them it could be found out that their luminous intensity did not change. The measuring may be started after the temperatures of the whole lamp settle, i.e. after 3 - 5 minutes. During that time, the luminous intensity will drop for about 4 % .

When measuring the luminous intensity, we presume that we work with a point source. However this presumption is never observed. It is possible to find out that should the fault in measuring not exceed the value of 1 % then it is necessary to measure at a distance which is equal to at least five times the greatest dimension of the lighting fitting's filament. In the case of a ten-fold distance, it is theoretically 0.3 %.

The luminous intensity used to be measured by means of special equipment /Bechstein head, flicker photometer, et sim./. Nowadays mostly objective methods are employed. In objective photometry the measuring organ is the photoelectric cell, so that the eye is completely eliminated from the measuring proper of the light. The normative criterion is the visual capability of an average human eye /average standardised sight/, the properties of which are precisely defined as regards the evaluation of the light. This is also the reason for which we employ for precise measurements principally photoelectric cells which have the sensitivity towards colours /by means of correction filters - glass or gelatine/ adapted in such a manner so that they will evaluate the colours in the same way as a standardised human eye.

The advantage of objective photometry is the promptness, speed and easy reproducibility of the measuring. The disadvantage is the difficulty of a perfect correction so that auxiliary visual measuring is today still frequently used. However it may be presumed that in the future such perfect corrected photoelectric cells will be developed so that subjective measuring will be completely eliminated from the field of photometry.

Nowadays in lighting engineering, photovoltaic cells /Figure no.22/ are employed almost exclusively. They have the shape of a plate and are covered by a layer of selenium with a translucent coat of rare metal /Ag, Au, Pt/ on the outside. Light passing through the selenium evokes on the boundary a certain electric voltage. The second electrode is the basic metal plate. Connection is carried out to the cover. The current is conducted away from the auxiliary metal ring along the periphery of the metal cover layer.

The generated current is measured by a microammeter. the voltage drop is measured on a R microvolt resistor. The volume of the emission current depends on the effective surface of the photoelectric cell, on the illumination and the quality of the sensitive layer. As a rule it is 20 - 40 μA per 1000 lx and 1 cm^2 of the effective surface. As can be seen from figure no.22a, the current is roughly proportionate to the lighting. The precise linear course comes into question only with small lighting values and with a small external resistance.

The advantage of a selenium photoelectric cell lies in the fact that it may be considerably easily adjusted according to the sensitivity of human sight and that it is altogether independent of temperature. However during a greater luminous load, fatigue appears. /After a longer blackout its original properties as a rule return./ We do not usually load the selenium cells with more than 1000 luxes. They are used most of all for rapid operation tests and they do not require an auxiliary source.

In the case of present selenium photoelectric cells a very good correction was attained so that according to some data in the literature, the faults in measuring do not exceed even 3 % . When measuring by the photoelectric cell with correction filters it is necessary to take care that the light falls vertically on the photoelectric cell. If it drops obliquely, the measured value is smaller. The accuracy of the measuring depends as well on the mounting of the photoelectric cell and on the design of the photoelectric cell casing. During practical tests when the luminous beam fell on the photoelectric cell at an angle of 45°, the shown faults in the measuring were in the range of 10 - 20 % .

Besides the photovoltaic cells, photoemissive cells are exploited in lighting engineering. /See Figure no. 23./ These cells have inside a glass bulb, in the middle an anode A and deposited on the wall, the cathode K and for photometric purposes either cesium or potassium /Potassium oxide, silver oxide/. The bulb is vacuumed and filled with gas, argon, neon, helium or their mixture. The light enters into the photoelectric cell by means of an aperture O. In the electric circuit of the photoelectric cell a battery is introduced, as well as measuring instruments and a variable resistance.

Potassium photoelectric cells are more advantageous than the cesium cells as they are better corrected as regards some sensitivity of the human eye and the emission current is approximately directly proportional to the lighting. They are used especially for laboratory tests.

Determination of the luminous intensity curve

The luminous intensity curve /or luminous source curve/ is usually measured in various directions, either continuously, in the range of a complete revolution of 360°, or at intervals, e.g. 5°, 2° or even less. For measuring, goniophotometers are employed, consisting basically of two main parts, the carrier with the source and the photoelectric cells, of which one is always mounted in such a manner so as to enable swivelling. Figure no. 24 shows the principles of the instrument with a revolving arm and a photoelectric cell F and a fixed lighting fitting S. It may be used only in a limited extent and with small lighting fittings, so that the arm would not have to be inconveniently long in order that we could measure with a sufficient accuracy.

Much more convenient is the second construction with the photoelectric cell fixed and the source rotating. /See the following paragraphs of this chapter./

Measuring the luminous flux

For measuring the luminous flux a hollow sphere is used which is white-matted inside and is called an "integrator". /See Figure no. 25./ The measured luminous source is suspended at the centre of the sphere so that the rays coming out of it reflect in a multiple way, so that the inside of the sphere is evenly lit. The lighting is measured by the photometer F which is protected against the direct light from the source by means of a screen S. The illumination of the inside of the sphere is proportionate with a sufficient precision to the luminous flux. The measuring of the lighting is carried out in the previously mentioned manner. For each integrator it is necessary to determine its coefficient which depends on the reflectance of the inside coat. The measured value of lighting is multiplied by the coefficient. In practice it was found out that the coat should be semi-glossy as it is kept clean better than a matt coat. The coat must be neutral with respect to colour and it must not lend to the reflected light any spectral gaps. It is carried out, e.g. by spraying zinc white.

A great influence on the precision of measuring has the screen C which should be equal to about 1/3 of the sphere's diameter and should be located about r/3 from the aperture.

The integrator may serve as well for determining the lighting fitting effectivity, i.e. the ratio of the luminous flux of the lighting fitting to the luminous flux of the source.

Measuring of the lighting

The lighting is measured by means of luxmeters. The luxmeters are portable photometers containing a selenium photoelectric cell and a measuring instrument /microammeter/.

The photoelectric cell is usually equipped with a colour correction filter for the adaptation of the colour sensitivity and a neutral grey filter or reduction screen so that it would be possible to measure high intensities of the illumination.

In motor vehicle lighting engineering, lighting caused by the light of the tested lighting fittings is measured first of all on the test wall /mentioned in the previous paragraphs/ by means of a photoelectric cell with a maximum diameter of the diffusion opening - 60 mm. During the measuring, manual control of the photoelectric cell is necessary. However instruments exist as well which register automatically on chart paper the isoluxes, i.e. curves with the same lighting intensity in the luminous pattern. The Dutch company Philips of Eindhoven designed e. g. an instrument which is turned - by the action of a complicated mechanism with small servomotors having a feedback - in such manner so that the lighting of the photoelectric cell is always of a specific, pre-set magnitude. The turning of the headlight which is done in a horizontal as well as a vertical direction is then transfered to the recorder, plotting directly the above mentioned isoluxes.

Another equipment of a simpler construction faciliates the measuring process on the test wall by automatically turning /according to a pre-set program/ the tested lighting fitting in accordance with the angle distance of the test points and the band on the test wall.

A similar equipment has been developed in Czechoslovakia. Its working distance may be reduced by means of the optical system from the required 25 meters to a mere 4.3 m. By this considerable working space will be saved as well as time and one worker. /See the following paragraphs of Chapter 5./

Measuring the luminance

The measuring of luminance is carried out by finding out the luminous intensity of an accurately limited surface of a known size as well as by special instruments, the so-called luminance-meters. In the first case the lighting intensity is measured from a certain distance and this is converted to a luminous intensity or the source luminance.

The luminance-meters are equipped either for subjective measuring, exploiting the comparative visual methods similarly as in the case of employing visual photometers or for objective measuring, where the source or a certain point of the source is projected on the photoelectric cell or a diffusing filter in front of it.

Special measuring in the motor vehicle lighting engineering testing shop

When testing the luminous properties of the lighting fittings or their individual parts it is often necessary to carry out quite special measurings for which it is necessary to adapt the existing, or to elaborate new measuring techniques and possibly to develop special measuring instruments.

Thus a whole series of measuring and inspection, single-purpose apparatuses was developed for the lighting engineering some of which will be mentioned later on. /We will mention instruments developed and manufactured by the ÚVMV /Motor vehicle research institute/ at Prague, Czechoslovakia./

Practical tests have shown that even the smallest deviations in the position or size of the filament system or the automobile lamp screen, especially in the case of asymmetrical lamps, causes a considerable deterioration of the luminous intensity distribution. Thus it is necessary to use for the verification tests of paraboloidal mirrors or entire headlight inserts only very carefully selected lamps where the dimension tolerances are of the 0.1 mm order. When using these lamps it may be presumed that they do not have a considerable influence on the deterioration of the luminous pattern of the headlight. Thus an apparatus for the selection of the test lamps has been developed, the principle of action of which consists in projecting the lighting system of the tested lamp in a great enlargement on the projection wall and then the respective dimensions are determined by direct measurings on the shadow pattern. In order to determine the mutual relation between the angle values at various places, the lamp holder is turnable and it is equipped with a precision angle scale and a reading-off microscope. By a simple calculation it is possible to determine from the magnitude of the turn and the respective projection on the projection wall the angle parameters of the lamp. The apparatus may be equipped with an attachment for checking the "W" lamps.

/See Figures no. [illegible] and [illegible]./

The measuring of the luminous intensity of the lighting fittings is carried out on the photometric bench or goniophotometer. The first system is exploited primarily for the checking and comparison measurements of the normal and sub-normal of the luminous intensity. A high precision may be achieved by it but it requires considerable more time. Thus for faster technical measurings, possibly supplemented by direct graphic recordings of the luminous intensity curves, far more advantageous are the semi-automatic goniophotometers.

The goniophotometers made by the [illegible] /Motor vehicle Research Institute/ enable the measuring of the luminous intensity of an arbitrary lighting fitting with a luminous source with a feed current of [illegible] - 10 A and a voltage of 6 - 60 V in the entire extent around the perpendicular axis, possibly after manual tilting by 90°, even around the horizontal axis. The instrument is equipped with a recorder which enables a direct recording of the luminous intensity lines and the angle of turning the tested lighting fitting. The recording is carried out automatically on a winding-off chart paper strip with time marks. The winding-off velocity is regulated / 3 - 40 m / hour / according to the desired precision of the measuring.

It is exploited for the measuring of lighting fittings of all kinds and types. /See Figures no. [illegible] and [illegible]./

The testing of the luminous intensity of headlights by measuring the intensiveness of illumination on test walls at a distance of [illegible] meters is often disadvantageous. Thus it was substituted by a semi-automatic equipment by means of which the headlight luminous intensity may be checked and the grada-

[illegible]

[illegible] for the [illegible] of the [illegible] of these head-lights may be [illegible]. The advantage of this equipment lies in the possibility of the application to a [illegible] as the test distance of [illegible] is optically reduced to a length of [illegible]. The equipment is serviced by one worker from one place. The principle of measuring is the same as in the case of the [illegible] system, the necessary time /with respect to the semi-automation/ for carrying out the measuring is considerably reduced.

The equipment consists of a stand, on which the headlight or headlight tester is clamped. It is turned by means of a [illegible] from the control desk. The equipment includes further [illegible] a test wall with photoelectric cells. In the bottom of the stand there is the drive equipment with a gear [illegible] for the automatic turning of the tested lighting fittings to the test points and back, according to the [illegible], [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] for a [illegible] [illegible], [illegible] at intervals of about [illegible], to the individual points of the [illegible] on the test wall /test points/. Their distribution corresponds with the [illegible] in the vertical direction, the [illegible] in the horizontal direction on a surface of [illegible] and with a testing length of [illegible] metres. At the upper part an automatic [illegible], [illegible], is mounted, enabling the reduction of the test distance and a fixing [illegible] for the measured lighting fittings having a [illegible] of approximately [illegible]. The instrument may be [illegible] [illegible] [illegible] the optics for a testing distance of [illegible].

[illegible] intensity measuring is carried out by a photoelectric cell, corrected to the sensitivity of the human eye. The originating emission current is subtracted on the scale of the measuring apparatus. Besides that the apparatus is equipped with three auxiliary photoelectric cells for a fast check of the luminous intensity at points B 50, 75 R and 50 R with a single setting of the headlight insert in the measuring position /point B/. The precision of the setting of the apparatus during the automatic shifting is as follows : in the region of the central part of the screen ± 0.5 cm, in the peripheral region of the screen ± 1 cm /for a distance of 0.3 metres./ See Figures no. 30 and 31./

VI Tropicalization

Definition of basic terms

The tropicalization of products is a line engaged in the technology and design of technical equipment resisting difficult climatic conditions, especially conditions of a tropical climate. Further on, we may mention tropical products, which are products specially designed and technologically modified in such a manner so that they would resist the influences of the tropical climate in contradistinction to tropicalized products which are normal products, specially modified to withstand conditions of a tropical climate.

Definition of the climatic regions

As the motor car industry products are noted for their high mobility and a large action radius of operation, it is impossible and even unnecessary to specify in detail, in what kind of a climate the vehicle and thus its lighting equipment will be moving.

It is possible to define the basic climatic regions only roughly as follows :

a/ mild climate,

temperature in winter rarely below -35°C,
in summer over 35°C,
average temperature in winter -5 - +5°C,
average temperature in summer +15 - +25°C.
Simultaneous occurrence of a higher temperature with a high relative humidity does not come into question.
Regions: Europe, part of North America, part of South America, major part of Central Asia and southern

part of Australia.

b/ tropical climate:

ba/ climate tropically humid:

characterized by a simultaneous occurrence of a high relative humidity /above 80 %/ and an increased temperature exceeding +[illegible]°C. It is characterized as well by strong rains /10 cm of precipitation even in 1 minute/, the influence of biological factors, sun radiation, possibly dust as well.

Regions: Central America, northern part of South America, southern tip of North America, southeastern Asia, northern part of Australia.

From the technical point of view this climate is harmful as it causes partial condensation of water vapours, e.g. on the lighting fitting reflectors.

bb/ climate tropically dry:

these regions are characterized by high temperatures /up to 55°C/ with a low relative humidity, high sun radiation intensity, great changes in temperature /day - night/ and a high contents of sand and dust in the air.

Regions: northern part of Africa, western tip of South America, part of Central Asia and Australia.

c/ cold climate:

This region is characterized by low temperatures. The average monthly temperature is in the range of -[illegible]°C to + [illegible]°C. In the winter months, temperatures below -[illegible]°C frequently occur.

Regions: predominantly regions above the [illegible] parallel of the north latitude.

[illegible]/ High mountain climate :

This climate can be found practically all over the world. It is characterized by a low pressure of the air. Otherwise it is similar in its /climatic/ effects to the cold climate.

[illegible]/ Seaside climate :

By its effects this region may be included in the tropically humid climate. However great humidity appears to be especially corrosive there as well as salt spray.

Classification of the atmosphere with respect to corrosiveness

It is not advisable to take into account in the production of all the motor vehicle parts the region and its climatic conditions, to which the vehicle is to be exported. The considerable diversity of production of many types does not make mostly such possible. Thus it is necessary from the economical as well as from the commercial point of view to manufacture only one basic universal type, resisting all of the types of atmospheres and regions. According to the purpose and function it is necessary in some cases to choose a compromise. Otherwise it is advisable to use for the evaluation of the influences of various factors on motor vehicles, their parts - especially the metal parts, a classification and evaluation system according to the corrosion groups - characteristic deleterious effects. /For Czechoslovakia the specification included in the Czechoslovak State standard no. [illegible] is valid./

operation of the vehicle or its part from the functional point of view. In such a case we prefer selecting good quality material and a good quality surface treatment.

When introducing a new material, especially when the climatic resistance is not known, it is necessary to check the climatic stability by a series of natural or laboratory /accelerative/ tests.

/The following paragraphs discuss materials most frequently employed for the production of the lighting engineering equipment./

Metals

In the case of metals we discern these types of corrosions: atmospheric, chemical, electrochemical and intercrystalline. The atmospheric corrosion is influenced by the humidity of the air /the critical relative humidity is 60 - 70 %/, contamination of the air by solid particles, dew and rain precipitation, increased temperature of the environment.

The chemical corrosion occurs directly due to a chemical reaction between the metal and the environment /as its contamination by gases/.

The electrochemical corrosion occurs on the places of contact of two different metals in the presence of an electrolyte /e.g. in humid tropical regions a galvanic cell thus originates easily/. If the difference in the electrochemical potencials of both the present metals excedes 0.5 V, an electrochemical corrosion of a dangerous extent occurs, especially dangerous in humid tropical regions. The mutual influence of different metals is evident from the following table.

The intercrystalline corrosion is an uneven corrosion of

Table no. 6 :

Classification according to the deleterious effects

Group:	Conditions defining the corrosion group:
VL	Effects of the internal atmosphere in closed, heated rooms, where during the day and throughout the years considerable fluctuations in the temperature and relative humidity do not occur and the dew point is not reached /i.e. water vapour condensation does not occur/.
L	Effects of the internal atmosphere in rooms, where due to the influence of temperature variations during the day and throughout the year condensation of water vapour may occur.
S	Effects of the external atmosphere, i.e. humidity, rain, dust, mud, air and salt content as well as sun radiation.
T	Severe deleterious effects of the external atmosphere having a salt content, contamination by chimney gas, chemical fumes and especially hard conditions, e.g. strong mechanical wear.

Note: If the part is subject to considerable mechanical strain, abrasive wear by hands, sweat, it is necessary to choose the nearest class. For the motor vehicle external parts, group T comes into question, for the internal parts under the car body group S and for parts inside individual groups and minor parts of the measuring instruments et sim. group L. The VL group is assigned for specially protected and closed groups, protected by oil evaporations et sim.

Basic requirements regarding the universal design

As it was already mentioned, it is required that the vehicle together with all of its accessories be resistant against the influences of various types of climates, i.e. that it be from the climatic point of view universal. However it must be considered that the motor vehicle has a shorter service life /approximately five years/ than most of the other products. With respect to the evaluation of the deleterious effects of the atmosphere /the vehicles travel through various regions - T, S, L./ the average influence is that of the "S" class. This circumstance and the production conditions as well /lot production/ justify fully the requirement that the most advantageous and practically only possible modification in the whole world around - universal modification, differing in the supplementary outfitting. The production of a motor vehicle absolutely resistant against the climatic conditions is complicated by the economic requirement of manufacturing cheaply, in such a manner, so that the product can withstand /price/ competition.

Thus it is necessary to choose a compromise when solving some of the tropicalisation problems and thus to ensure economical production of one universal type, or to evaluate whether it is more economical to choose a tropicalised product or a normally produced product with the perspective that during exploitation, the product will be exchanged in the case.

From the point of view of tropicalisation it is necessary to pay attention always to two factors :

a/ factors with corrosion.

b/ factors with changing functional parameters.

Table no. 6 :

Classification according to the deleterious effects

Groups	Conditions defining the corrosion group:
VI	Effects of the internal atmosphere in closed, heated rooms, where during the day and throughout the years considerable fluctuations in the temperature and relative humidity do not occur and the dew point is not reached /i.e. water vapour condensation does not occur/.
5	Effects of the internal atmosphere in rooms, where due to the influence of temperature variations during the day and throughout the year condensation of water vapour may occur.
6	Effects of the external atmosphere, i.e. humidity, rain, dust, mud, air and salt content as well as sun radiation.
7	Severe deleterious effects of the external atmosphere having a salt content, contamination by chimney gas, chemical fumes and especially hard conditions, e.g. strong mechanical wear.

Note: If the part is subject to considerable mechanical strain, abrasive wear by hands, sweat, it is necessary to choose the nearest class. For the motor vehicle external parts, group 7 comes into question, for the internal parts under the car body group 6 and for parts inside individual groups and minor parts of the measuring instruments et sim. group 5. The VI group is assigned for specially protected and closed groups, protected by oil evaporations et sim.

Basic requirements regarding the universal design

As it was already mentioned, it is required that the vehicle together with all of its accessories be resistant against the influences of various types of climates, i.e. that it be from the climatic point of view universal. However it must be considered that the motor vehicle has a shorter service life /approximately five years/ than most of the other products. With respect to the evaluation of the deleterious effects of the atmosphere /the vehicles travel through various regions - T, S, L./ the average influence is that of the "M" class. This circumstance and the production conditions as well /lot production/ justify fully the requirement that the most advantageous and practically only possible modification in the whole world around - universal modification, differing in the supplementary outfitting. The production of a motor vehicle absolutely resistant against the climatic conditions is complicated by the economical requirement of manufacturing cheaply, in such a manner, so that the product can withstand /price/ competition.

Thus it is necessary to choose a compromise when solving some of the tropicalisation problems and thus to ensure economical production of one universal type, or to evaluate whether it is more economical to choose a tropicalised product or a normally produced product with the perspective that during exploitation, the product will be exchanged in the case.

From the point of view of tropicalisation it is necessary to pay attention always to two factors :

a/ factors with corrosion,

b/ factors with changing functional parameters.

When we elaborate on these two points it is possible to state from the point of view of climatotechnology that the parts and the accessories as well as the motor vehicles themselves must ensure :

a/ the operation of the motor vehicles without faults and under difficult climatic and operational conditions;
b/ a long-term exploitation of the motor vehicles under difficult climatic conditions /about 5 years/;
c/ a sufficient resistance of the materials /choice of materials, choice of a proper surface treatment, anti-corrosion precautions, hindering degradation processes/;
d/ safeguarding against the effects of dust and sand;
e/ safeguarding against the effects of moulds, fungi and other biological factors.

Proper material for the universal version

When selecting the material /This is also valid for the surface treatment!/ for difficult climatic conditions it is important that the designer collaborates closely with the technologist. It is necessary to consider the requirements regarding the condition of the product and thus the requirements regarding the material as well. The following possibilities come into consideration :

1/ To select a material with a high resistance and good quality surface without noticeable changes.
2/ To select a material without special specifications regarding the condition of the surface, with minor requirements regarding the resistance against corrosion /in lighting engineering this does not practically come under consideration/.
3/ To respect requirements, ensuring smooth, faultless

Table no. [illegible]

[illegible]

Notes: [illegible] - The contact [illegible] not influence the corrosion [illegible]
[illegible] - The contact influences the corrosion [illegible]
[illegible] - [illegible] influences the corrosion [illegible]
[illegible] - In industrial regions the influence on corrosion is [illegible] acid).
[illegible] - Combination of [illegible]
[illegible] - Combination of [illegible]
[illegible] - Carbon and low-alloy steels and cast iron (without surface treatment).
[illegible]

cathode running along the boundaries of the crystal into the depth of the material.

Nickel and nickel alloys

The velocity of atmospheric corrosion of nickel and its alloys is very low. It is maximally 1 μ per year. It is a suitable construction material for products with a continuously conductive surface. In a dry or humid environment, no corrosion products occur. In industrial environments the badly polluted air with sulphur contents causes corrosion. The corrosion products are non-conducting, however. Nickel is a suitable material for electrolytical surface treatment.

Zinc and its alloys

In dry atmosphere almost no products occur, in humid warm regions voluminous corrosion products occur. The corrosion velocity is the highest in the case of seaside regions and it reaches up to 20 μ/year. In the industrial regions the atmospheric corrosion is even higher. Zinc may be used for surface protection /galvanic, metallisation/, however it is necessary to protect it by a galvanic layer of copper and nickel or to carry out chromate surface coating.

Cadmium

Cadmium and its alloys is not used as a construction material, however it is used for electroplating. The corrosion products do not occur almost at all in a dry atmosphere. Humid tropical regions support the generation of corrosion products but cadmium plating may be employed with the provision that there are no major requirements as to the condition of the surface or the conductivity and that chromate treatment will be carried out. In industrial regions cadmium has a small conditions, it produces voluminous corrosion products but it is possible to say that for seaside regions it is suitable.

Copper and its alloys

The resistance of copper is suitable. In clean, non-industrial atmospheres the corrosion speed amounts to 1μ to 2μ/year, in the seaside regions up to 10 μ/year and in industrial regions up to [illegible]μ/year.

The resistance of brass with a content lesser than 63 % of Cu is much lower. In seaside regions with a humid environment great danger is the "dezincification" of brass articles /so-called selective corrosion/.

Alloys with nickel have a better resistance and may be used without surface protection. For the surface protection of copper, nickel is employed as well /coated electrolytically or [illegible]/.

Aluminium and its alloys

Due to a small velocity of corrosion under difficult climatic conditions, aluminium is suitable for tropical regions as by atmospheric oxidation a thin layer /0.01 μ/ of oxide originates on the surface of aluminium and thus creates a natural protective layer. Greatest corrosion appears in the seaside regions and in industrial regions where it reaches 12 μ/year. Aluminium alloys with other metals except for manganese decrease the resistance.

Aluminium is protected by anodic oxidation or chromate treatment together with a paint coat. When requiring a lasting glossy surface it is necessary to protect aluminium by a galvanic surface protection of copper and nickel. Aluminium may be used as well for metallization surface protection in these cases these surface quality requirements are not so strict. In case of aluminum conductors it is necessary to pay attention to a suitable protection against contact corrosion /to protect the contacts by cadmium, chromium or nickel/ and to limit mechanical stress especially upon clamping due to the very small modulus of aluminum elasticity. When connecting aluminum conductors to brass accessories a strong corrosion of the oxidized spot and its vicinity may be expected. A special position in this chapter may be occupied by aluminum, used as a reflection layer of the paraboloidal reflectors. Usually extremely pure aluminum is required /99.9 %/ which is coated on the reflector in the vacuum process to a thickness lower than 1μ. During operation, the reflection layer is affected - among other mentioned influences - also by a considerably high temperature of the luminous source. The layer must reflect perfectly the luminous flux /aluminum reflectivity is 88 - 90%/. Whatever atmospheric corrosion aggression decreases the reflectivity, in other words it gradually deteriorates the product from the point of view of its function. It is practically impossible to protect the layer. The only possible protection are recommended thin layers of glyptal varnish which increase the service life of the reflection layer some 4 times but simultaneously decreases the reflectivity by some 3 %. Another solution lies in employing an alloy of aluminum with 5 % of titanium where the service life of the layer increases up to twice. The reflection layer may be also protected indirectly by a perfect sealing of the headlight insert and the case with the frame.

Silver

Silver is resistant in all of the climatic regions except for regions with an atmosphere polluted by sulphur and strong reagents /industrial regions, combustion products, exhaust gases, decay products, et cetera/. The originating silver sulphide is non-conducting /results in electrical contacts/ and has a blackish colour. /The protective reflection blacken so that silver is scarcely or rarely used for that purpose./ For the contacts it is better to use rhodium, together as possibly a combination, e.g. surface treatment by rhodium of a silver plated contact.

Stainless steel, carbon and low-alloy steels

Stainless steel - with a minimum contents of 18 % of Cr - is suitable for all types of atmospheres. The corrosion products originate only in exceptional cases. Thus it is not necessary to protect its surface. The corrosion velocity of carbon and low-alloy steel and cast-iron reaches in the industrial regions and in regions next to the seaside up to 200 µm/year. The corrosion products originate quite rapidly. The material is suitable only as construction material which it is necessary to protect. The suitable surface treatment techniques include zinc plating, cadmium plating, phosphatisation, followed by coating; zinc plating and cadmium plating followed by passivating, a triple coating and chrome plating. For other purposes it is necessary to apply galvanic plating Cu - Ni - Cr /with a minimum thickness of 30 - 15 - 0.8 for the [illegible] environment/.

Non-metallic materials

Plastics

There are a great many kinds of plastics used on motor vehicles. Of plastics used in lighting engineering for the lighting fittings and direction indicator lamps /those functional items/, polystyrene and methyl methacrylate materials stand in the first place.

a/ The polystyrenes soften at temperatures of 80 - 100° C. They resist humidity and water and they are not attacked by mould. In case of an elevated temperature, sun and UV radiation, they are attacked by oxygen from the air and ozone /life endurance 1 - 2 years/. Their chromatic constancy is considerably low as well /they fade/, especially in the case of yellow colours. It is necessary to protect them by materials that absorb and reflect ultra-violet radiation and to add anti-oxidation compounds, pigments /life endurance 6 years/.

b/ The polymethylmethacrylate materials soften at temperatures over 70°C, they resist the biological factor, humidity and water. They are also resistant against the effects of oxygen and ozone. Through the sun and UV radiation activity they loose their optical properties and grow milky dim. Nevertheless they are more constant in colours than the polystyrenes. Quite frequently they deform due to temperatures. For the tropical regions they are not exactly suitable.

Laminated materials

Laminated bakelised paper and textile fabrics have a tendency towards hygroscopicity, especially at the place of their cutting. These areas must be well protected by revarnishing by a transparent lacquer. It is also proper to protect products made of bakelised paper by dipping, spraying, impregnation and always to cure such a film.

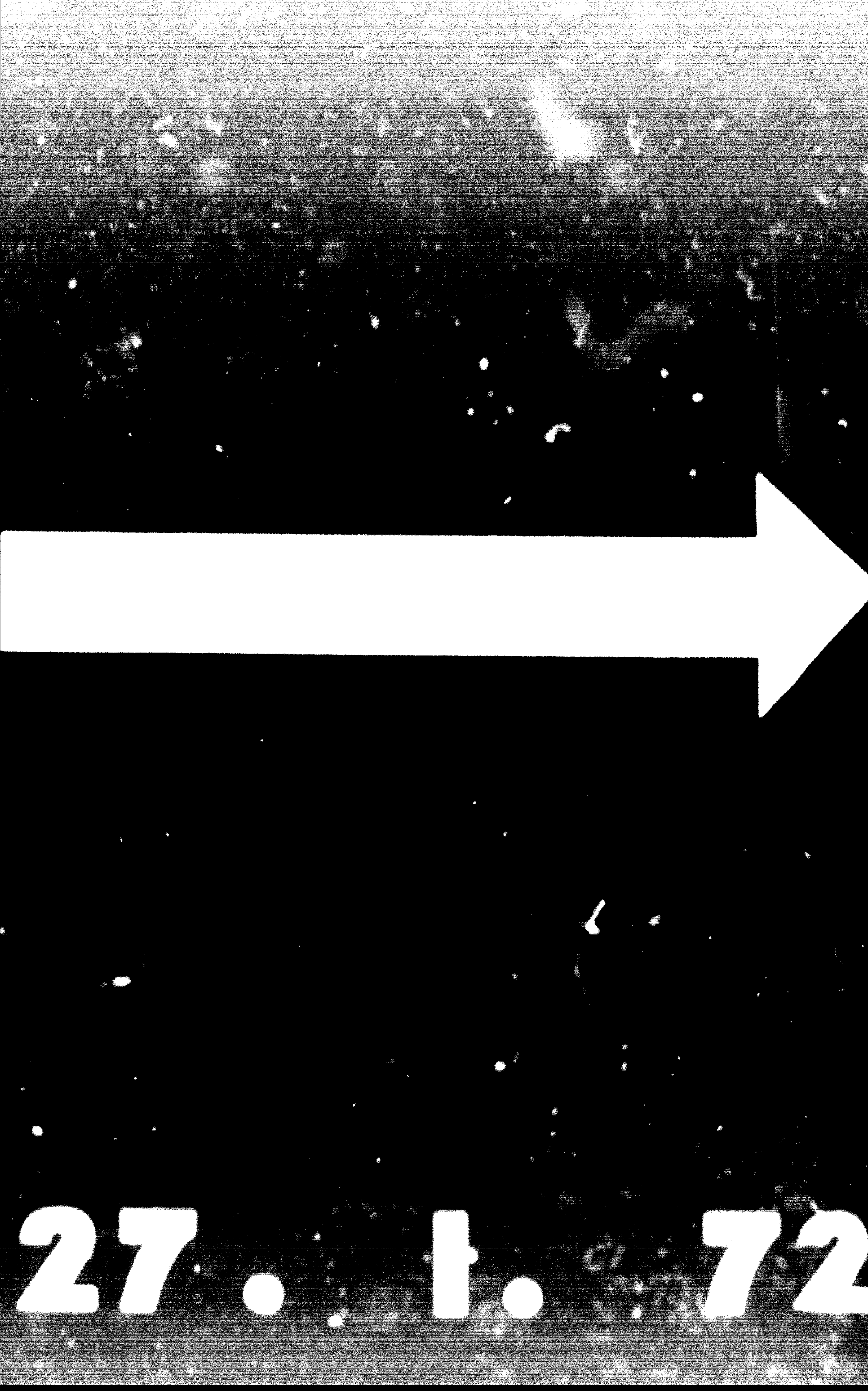
Rubber

Ageing, cracking and creation of checks is caused primarily by ozone /in dry tropical regions up to 8-times more than in a normal climate/, secondly by the temperatures, light and humidity.

For tropical regions thiokol and chloroprene as well as butyl rubber is most suitable. However from the point of view of ageing, as well as temperatures, best resistance is ensured by silicone rubber. It is entirely unsuitable to use natural rubber for the tropical regions /as it has a bad resistance against temperatures and sun radiation/. A temporary protection to rubber of a lesser quality is rendered by the chloroprene solution with added pigment. It may be said that hard rubber is more resistant to climatic influences than soft rubber. A cool climate affects the elasticity, increases the fragility. Foam rubber may be used on protected places only and merely such rubber that has a non-porous surface. By means of design treatment it is possible to prolong the durability of rubber. The rubber parts must be solved in such a manner so that they would not be fatigued by pressure and the bends and breaks would have a largest possible radius.

Surface treatment and paint coats

It may be said about surface treatment in general that the quality depends primarily on the careful preparation of the surface /cleaning, degreasing/. The surface protection of an unprepared surface or not respecting the technological process of surface protection leads to insufficient surface protection with all consequences.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Paints

Protection by means of paints is one of the least costly protections. /Basic principle for the tropical regions : always to choose light shades./ There is a wide range of paints and thus it is impossible to discuss them in this paper.

Surface treatment by means of metals

Besides surface treatment by the paint coating system, protection is achieved as well by metals. /Predominantly by electrolytical deposition, possibly by means of a galvanic layer and paint./

The galvanic deposits must be carried out quite carefully; they must be checked as only by following all of the technical specifications /technological principles and regulations, specified thicknesses/, the surfaces comply with the difficult climatic conditions. Metal plating may not be carried out in mass - in drums or bells with only some exceptions /screws, small parts/. Metal plating must be executed on a freshly prepared, perfectly degreased surface which was previously cleaned.

It is impossible to deal here with all the various techniques of metal plating in detail. /Reference was already made in the paragraphs, discussing the characteristics of the individual materials./

<u>Climatic tests</u>

Climatic tests may be divided into natural tests, in the tropics, which are however rather lengthy as well as costly. A common method of verifying the execution of the individual products or sub-groups are artificial - laboratory tests. As a rule each production company elaborated its own testing methods /provided these methods were not specified in a binding standard/. For example, the Czechoslovak State Standard no. ČSN 03 8131 specifies for the headlights and lighting fittings a test in a condensing chamber at a temperature of + 35°C in a steam bath with a 100 % relative humidity /in absence of sulphur dioxide/.

Conclusion

In conclusion it is necessary to remind that the tropicalisation is a very important branch. All parts, components and accessories must be designed and technologically elaborated with respect to the tropicalisation regulations and recommendations. The degree up to which tropicalization problems were solved on a vehicle is one of the important criteria according to which the customer judges the vehicle.

If a product, its part, component, sub-group or even the whole car is of a good quality with respect to the construction and technology, its functional parameters may still start deteriorating in a short time if the tropicalization is not carried out sufficiently. Only those products which are well tropicalised and have naturally a good quality construction and technology, prove competent in operation. It is true that tropicalisation makes a product costlier and raises its purchase cost but at the same time it prolongs the durability of the product - in some cases, e.g. in lighting engineering components - several times.

VII Economical and production considerations

General considerations

When layout-planning an industrial plant it is necessary to respect not only economical requirements but general national economy requirements /purchasing raw materials, sales of products - on the domestic market as well as for exporting, foreign competition, et sim./, political, military and other as well, especially in countries with a completely or partially controlled national economy. These standpoints are variable from the point of view of time and they require a thorough analysis of the present situation and its further development and thus cannot be the object of our present considerations.

In this short treatise it is possible only briefly to mention the basic requirements which must be respected when proposing the construction of the plant proper. From the economical apect we also wish to consider the influence of those factors that influence the erection of an industrial plant.

Prerequisites for the construction of a production plant

The location, construction and equipment of a plant has a great influence on the economy and productivity of operation. Experiences show that for a certain type and volume of production only a few places in a specific region are as a rule suitable. The same applies in the case of selecting a construction site which depends on the type of buildings we wish to erect, on the mutual relations of the individual departments, the machines and equipment, et sim.

When layout-planning a plant it is necessary to consider all the present as well as future conditions of successful production, i.e. to plan purposefully as well as perspectively so that the original situation would not be soon overcome and circumstances which at the time of the foundation work were not so important would not become of utmost importance and the original conception would thus have to be modified according to them. In such a way production might become more costly and the rentability might drop./Further costs of construction, changes in the plant transportation system, handicapping of the production lines, et sim./

Generally it may be said about the branch of lighting engineering equipment production that it is a branch which does not require great capital investments. The period when the original investment starts returning back is considerably short; according to present experiences it is in average about 3.5 years. From this follows that the production labouriousness is considerably high; thus this branch requires a relatively high number of workers.

Layout planning techniques

When elaborating the project for establishing a plant, the sequence is usually as follows :

a/ For the specified product the most advantageous work process is chosen, necessary co-operation is determined /with whom and to what extent/, the possibility of buying finished components as well as semi-products, energy, water, et sim. is established.

b/ The machines and equipment as well as the extent of other technical installations /in-plant transport, etc./

are determined.

c/ The location of the plant, buildings, their mutual siting will be determined and operation installations /air conditioning/ will be proposed.

d/ The plant organization as well as the production management will be proposed.

Before ordering the elaboration of the project it is necessary to know:

the assortment of goods to be produced,

the marketing possibilities of the products and

from this following production volumes which the plant should produce per year.

Selection of the most advantageous work process

The work process must be chosen according to the design of the lighting fitting and its technological process. The modern production process naturally presumes lot production. The larger the produced lots, the larger may the profits of the plant be, the products cheaper and thus capable of competition on the market.

Selection of the design and technological process

In such a case when the motor vehicle lighting engineering equipment is introduced as an entirely new branch, it is necessary to decide, how to start with the preparation of the production -

a/ whether with one's own construction and technology,

b/ or with a construction and technology gained on the basis of licences.

The alternative a/ represents a considerable delay in production as especially some of the types of lighting fittings

/main headlights/ are quite complicated and their design requires top quality, i.e. well-developed techniques and experienced designers. Technological experiences are of no minor importance.

/We presume such an aim - that the plant produces from the beginning products on a top level with respect to their photometry, esthetics as well as operation./

Alternative b/ seems to be more advantageous. When a product is manufactured on the basis of a licence then it is quite normal that together with the design, the technological procedure is purchased as well. This solution has a number of advantages. Practically no delay occurs and the products will be of top level quality - if the technological process is respected, etc. After some time it is possible to pass over to the plant's own design.

Further on it is necessary to stress, that it is not advantageous to establish a production plant for the assembly of lighting engineering equipment. Of the total volume of work, assembly work takes up 12 - 15 % only. When we consider costs per transport and special packing, e.g. of vacuumed mirrors, the total effect will be very low.

However for some cases it is necessary to consider partial transport. The production plant does not have as a rule its own glass works, plastics processing plant, rubber plant. It does not produce lamps itself. Thus it is necessary to consider which products are to be imported by the foreign suppliers /usually lamps/ and which it will be possible to manufacture in co-operation at home.

The most difficult problem from the co-operation point of view is the engaging of a glass works which will produce the cover glass. In case that there is no such a glass work at home, it will be advantageous to establish it - in case that there are presumptions for it from the point of view of raw materials. Co-operation with a remote glass work /abroad/ is not so flexible. The same applies for ensuring pressings from plastics.

It would be ideal if all the co-operating plants were as near as possible to the main plant.

The production of the other parts is not so difficult with respect to the materials. Possible import of the materials from abroad may render them more costly but the increase in the cost due to transportation usually is not so considerable.

It is also necessary to consider the problems of electrical energy and supply water sources. For a plant of a medium size /with a basic production volume of about 6 million dollars/ a consumption of /electrical/ energy of 4 - 5 millions of kWh/year may be considered and a water consumption of about 200.000 m^3/year.

Specification of the machine equipment

As it was already mentioned above in this chapter, it is presumed to equip the plant with single purpose machines. Thus it is impossible to specify what types of machines will be included unless the precise structure of the production is known. However it may be roughly said that the plant will include the following departments: /production/ pressing shop - grinding shop - turning shop - electroplating shop - surface treatment shop - assembly shop - tool shop.

The departments must be situated in such a sequence so that the route for the inside-the-plant transportation /the products are usually placed on pallets which may be absolutely transport is achieved by means of high-lift trucks./ are decreased to a minimum. It is possible as well to arrange at least some of the departments in the form of a production line so that conveyors could be exploited /e.g. in the electroplating shop/. A complete arrangement of the entire production process in line may be carried out - under the presumption of an economical exploitation of all the equipment - only in case of a large lot production /about 1000 pcs of lighting fittings per hour./

Labour and labour qualification

The problem of labour is closely related to the question of how to organise the production process. The problem of labour may be divided into two categories :

a/ labour for small lot production;

b/ labour for large lot production.

Each technique requires a different composition of labour from the qualification point of view.

In the case of small lot production a great number of qualified labour is required for the production of lighting engineering equipment. It may be said that in a medium-large plant the ratio of qualified workers to auxiliary workers is about 1 : 2 - 3.

On the other hand in large lot production, the requirement of qualified workers is not so high. For production, trained unqualified workers will usually suffice and a small number of highly qualified workers /setters, repairmen of special machines et etc./. In such a case, the ratio of qualified and unqualified workers will be about 1 : 8 - 10.

From this it may deduced that for development countries it is most advisable to introduce a large lot production with such lines /from the point of view of labour qualification/.

Small lot production can never be sufficiently organized in lines. From this, the need for qualified workers follows, able to work independently, possibly on more workplaces.

Plant location

Plant location must be selected with respect to the following criteria :

- the distance of the raw material sources,
- the location of the market for the products,
- the market of labour,
- the distance of the co-operating plants,
- the means and expenses of transportation of raw materials, products and employees,
- the suitability of the sites,
- a sufficient supply of water,
- a source of electrical energy,
- possible tax and other alleviations,
- insurance, rent height, et sim.

As it was already mentioned in the preceding paragraphs, it is possible to distribute the buildings in such a manner so that the individual departments would be linked up. As it was emphasized in the introduction, the plant must be constructed with respect to the perspective development. Thus the selection of the buildings must be well considered as they have an important influence on the production and its economy.

According to the location and size of the designed buildings, with respect to the production process, the layouts of the departments, stores, in-operation stores, water, compressed air, electrical energy distribution systems et sim. and other operational equipment /air conditioning et sim./ are planned.

Production organization and control techniques

It is presumed that the production sections are arranged predominantly with respect to the technology and that the responsibility for production control is divided among the individual production departments or workshops /foremen, supervisors, dispatchers/. /See above, Chapter VII./

To co-ordinate the linking production shops mutually is recommended by means of unfinished product supplies /temporary storages/.

Production task specifications and surveys of their fulfilling, data about work-in-progress, numbers of produced parts may be elaborated by means of punch-card techniques and by employing a small automatic computer for batch data processing.

Most advantageous seems to be the introduction of a two-shift operation in the basic production areas. In the auxiliary departments the number of shifts will be subject to the ensuring of a continuous operation of the basic production.

It is impossible to consider here the organization in detail not only due to its large extent but also due to the fact that it depends on conditions which may vary from case to case.

In conclusion it may be said that practically the entire agenda of control may be nowadays carried out with the aid of punch-card techniques and an automatic computer. This leads to considerable savings of labour in the administration.

The requirement of introducing the computer brings with itself not only progressive calculation methods but new organisation methods as well /Stopping the increase in the number of administration clerks in case of increased production; increased production by a better exploitation of machines and equipment, rendering the survey of demand and consumption of material supplies and work-in-progress products more precise and fast, et sim./

Conclusion

In conclusion to this chapter it may be said that in order to be able to start layout-planning a plant /branch/, it is necessary to ask for expert advice not only regarding economics but production as well - advice, relating to the problems of the situation, its appreciation and decision whether to erect the plant or not.

Also the elaboration of the project must be ordered from a company that is engaged in such activity.

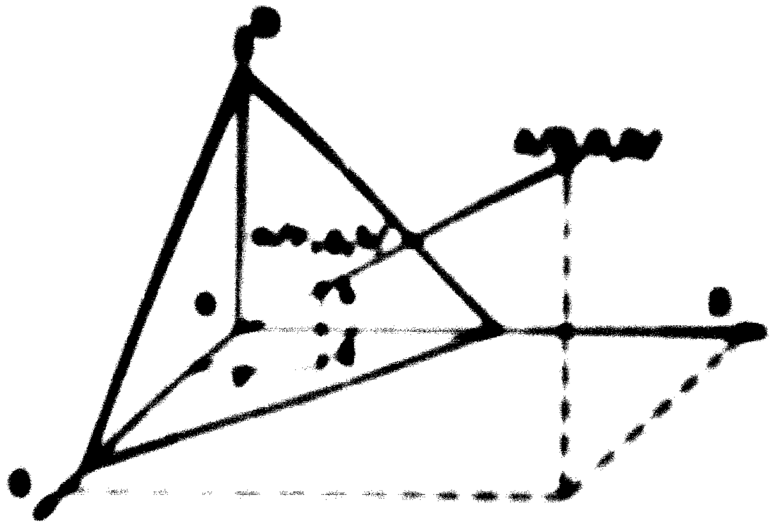
However, generally it may be said that better presumptions for a wider development of the lighting engineering equipment industry have those countries which are larger in size, are partially consolidated from the national economy point of view, where the motor vehicle industry is under development and which therefore have better perspectives of a voluminous domestic market. At the beginning it is usually impossible to presume exporting the products. However it is practically possible to introduce in addition the production of lighting engineering equipment in any state, as it does not impose such high requirements on the quality of the construction and especially on the production technology.

S u p p l e m e n t

/ Drawings - Diagrams - Photographs /

Number of tables and figures : [illegible]

Number of photographs : 9



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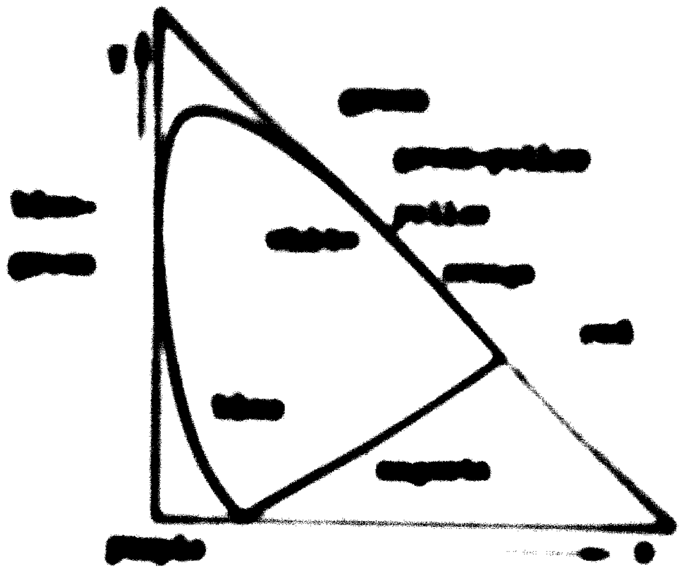

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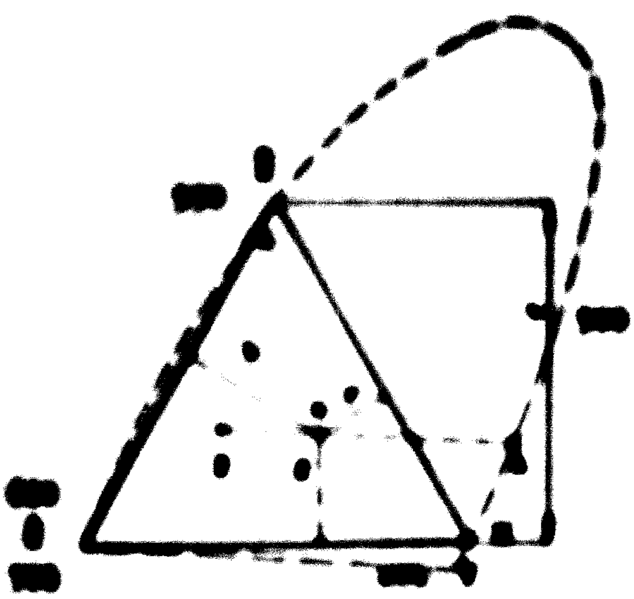

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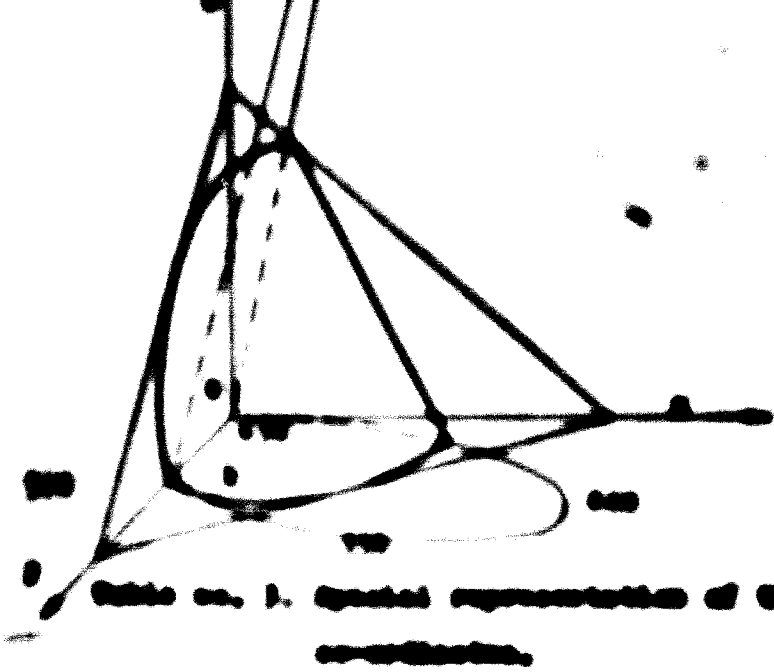

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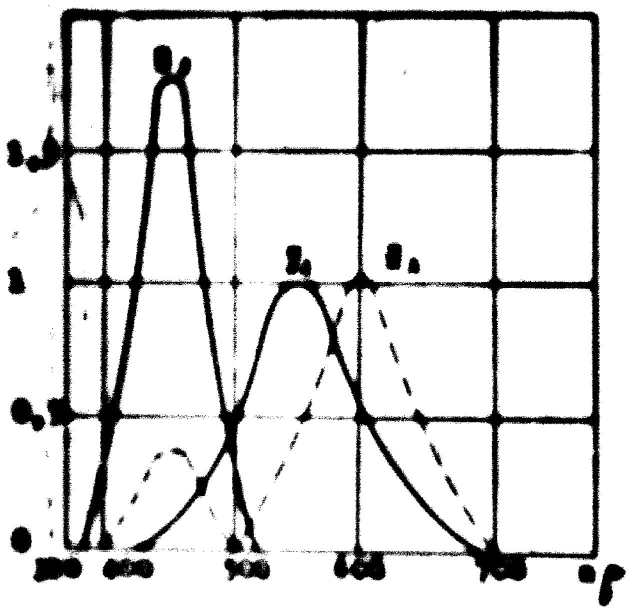
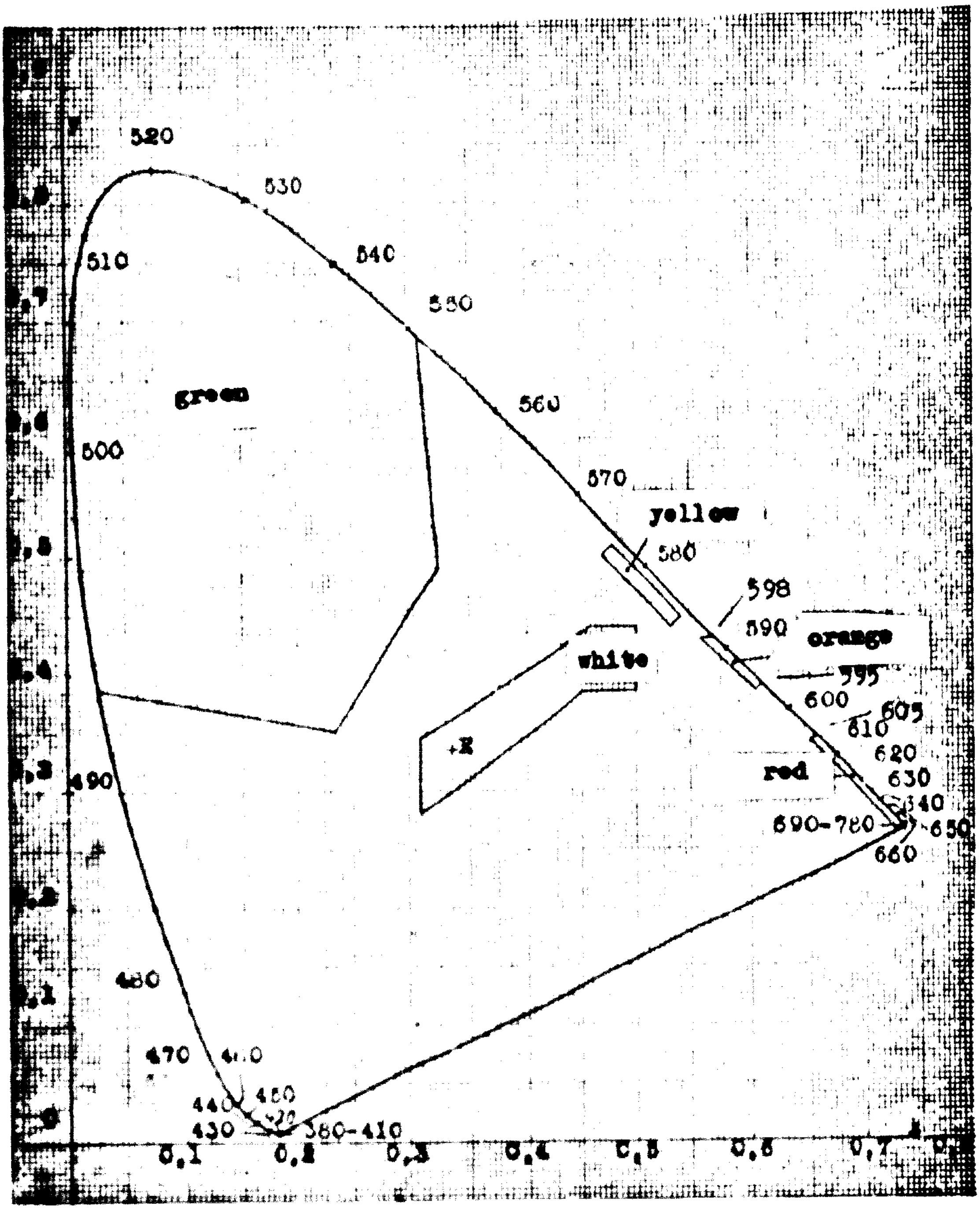


Table no. 4. Three basic components of white light.

Table no. 6. Colorimetric triangle. /Determination of the chromatic regions./



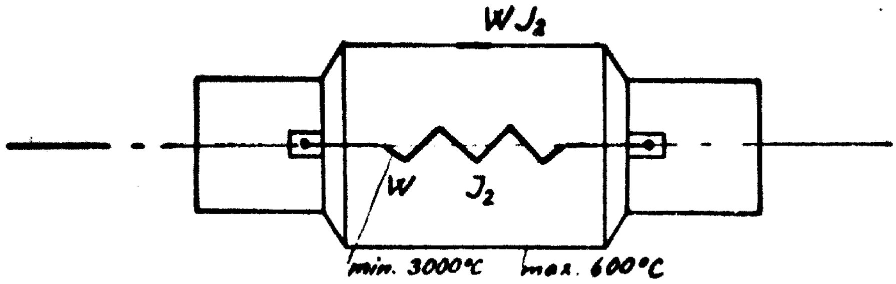


Table no. 7. Principle of the iodine "W" lamp.

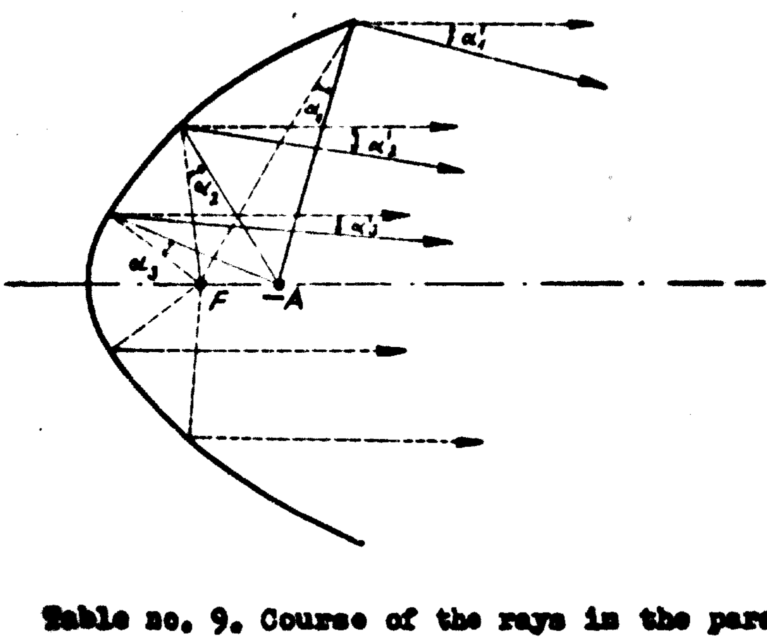


Table no. 9. Course of the rays in the parabola.

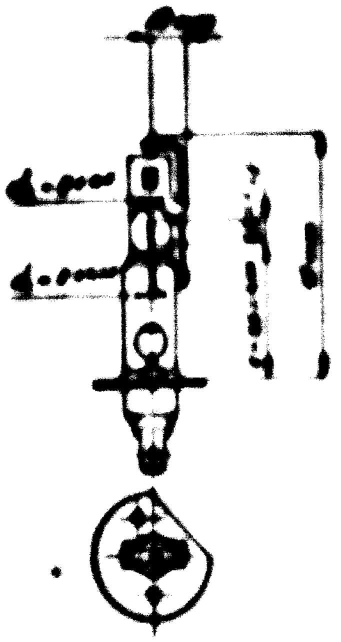


Figure no. 8 a.

Type H_1

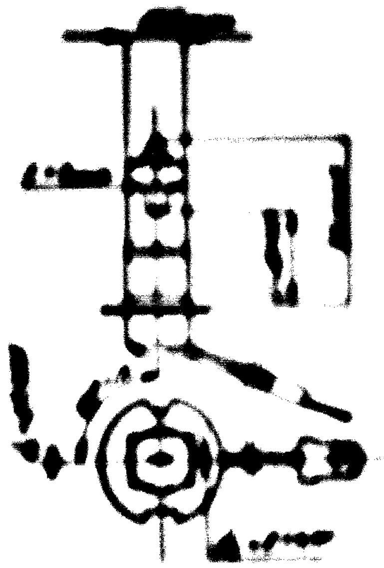


Figure no. 8 c.

Type H_3

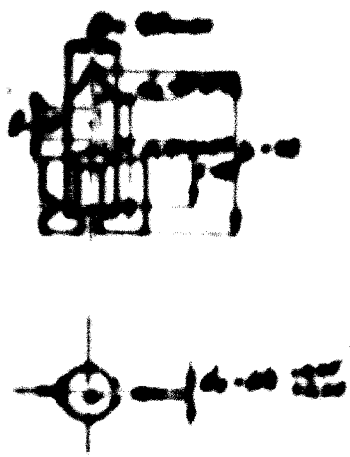
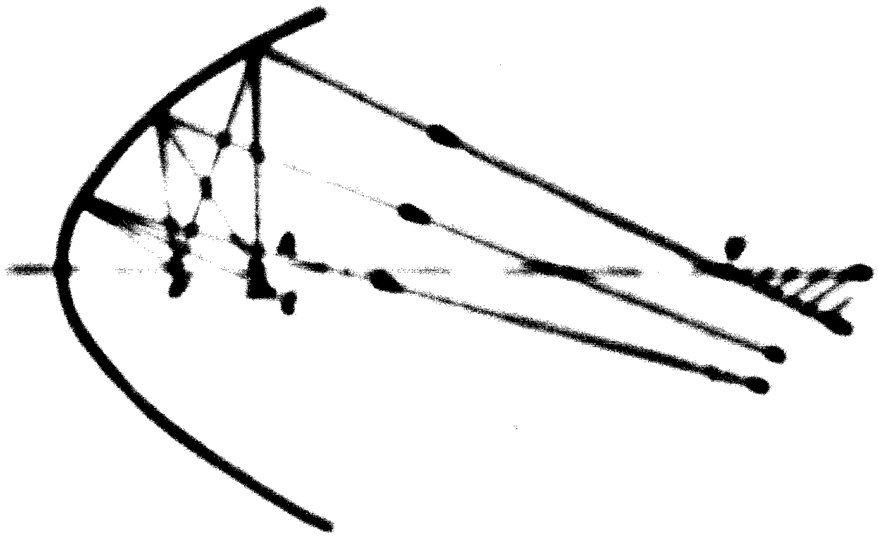


Figure no. 8 b.

Type H_2

Figures no. 8 a, b, c. Iodine "H" lamps.

[illegible]



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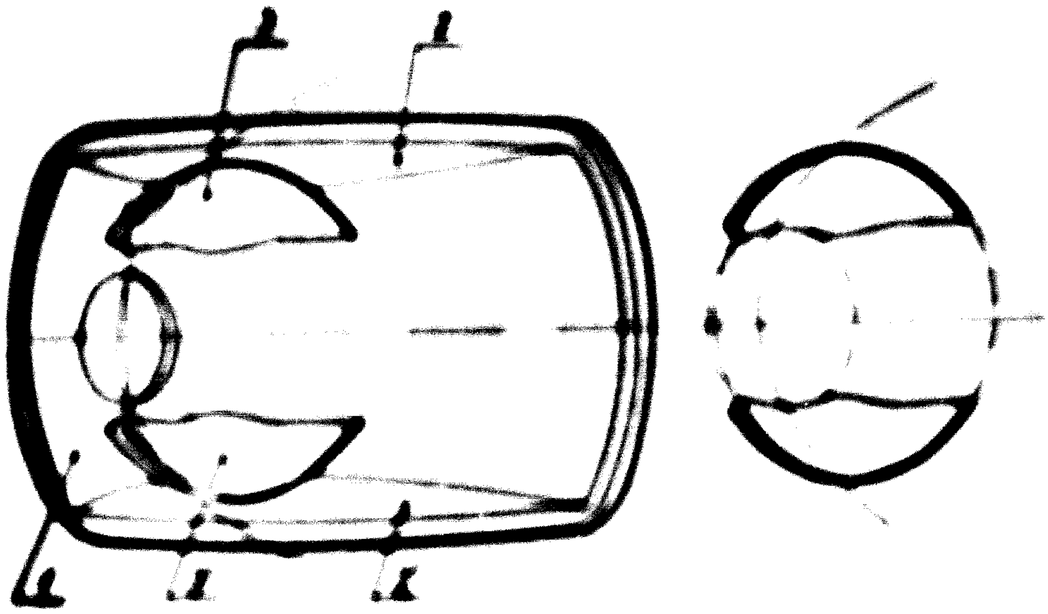

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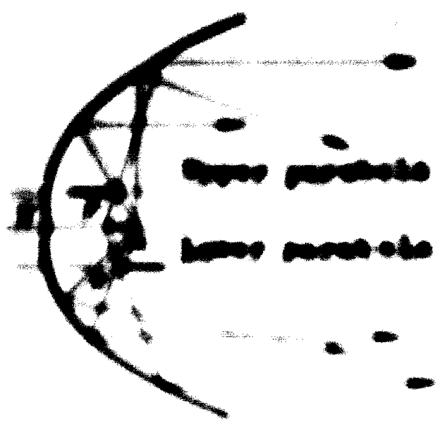


Table no. [illegible]. Reflector with [illegible] focus.

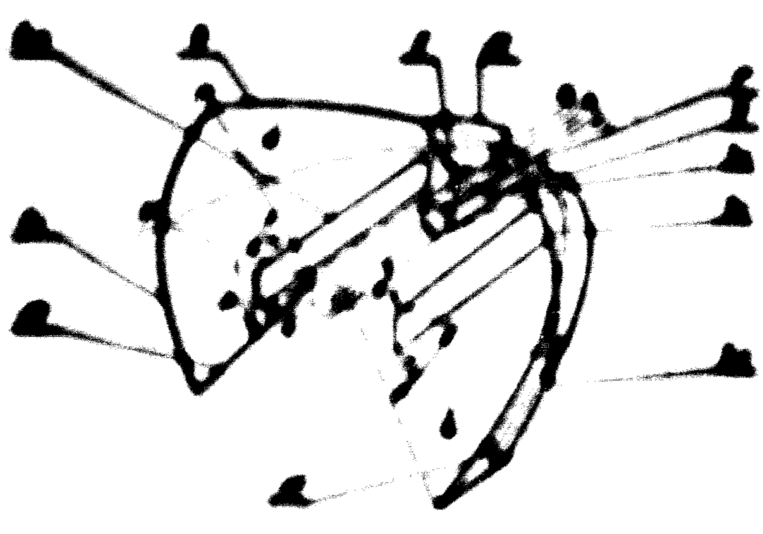


Table no. [illegible]. Reflector according to the French patent no. [illegible].

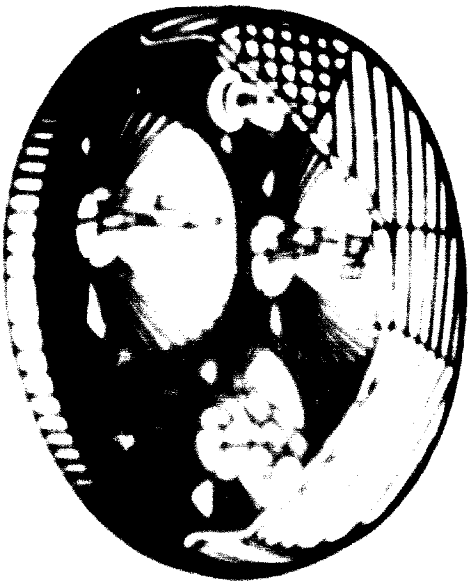


Figure no. 14a.
Headlight of the
Balder system.

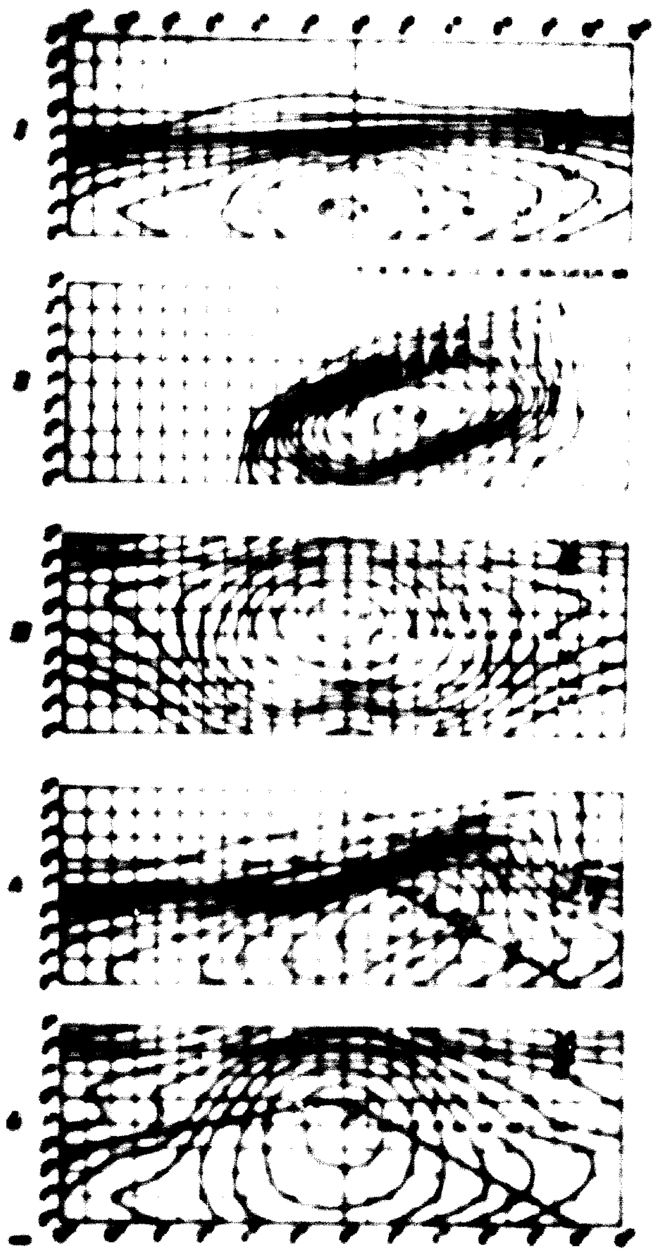
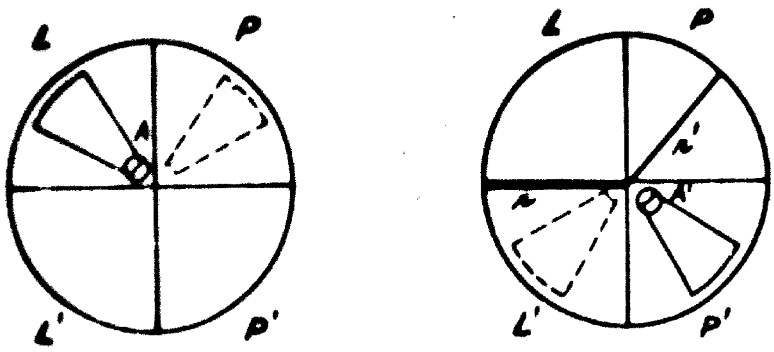


Table no. 14b.
Diagrams with the
distribution of
the individual
and composed lights'
isolux lines.



Headlight　　　　Wall

Table no. 15. Principle of solving the headlight pattern.

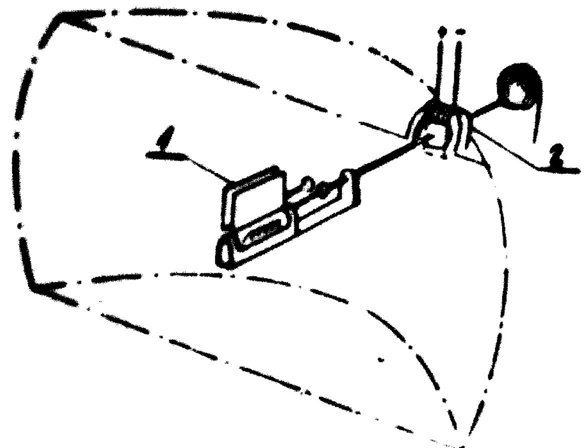
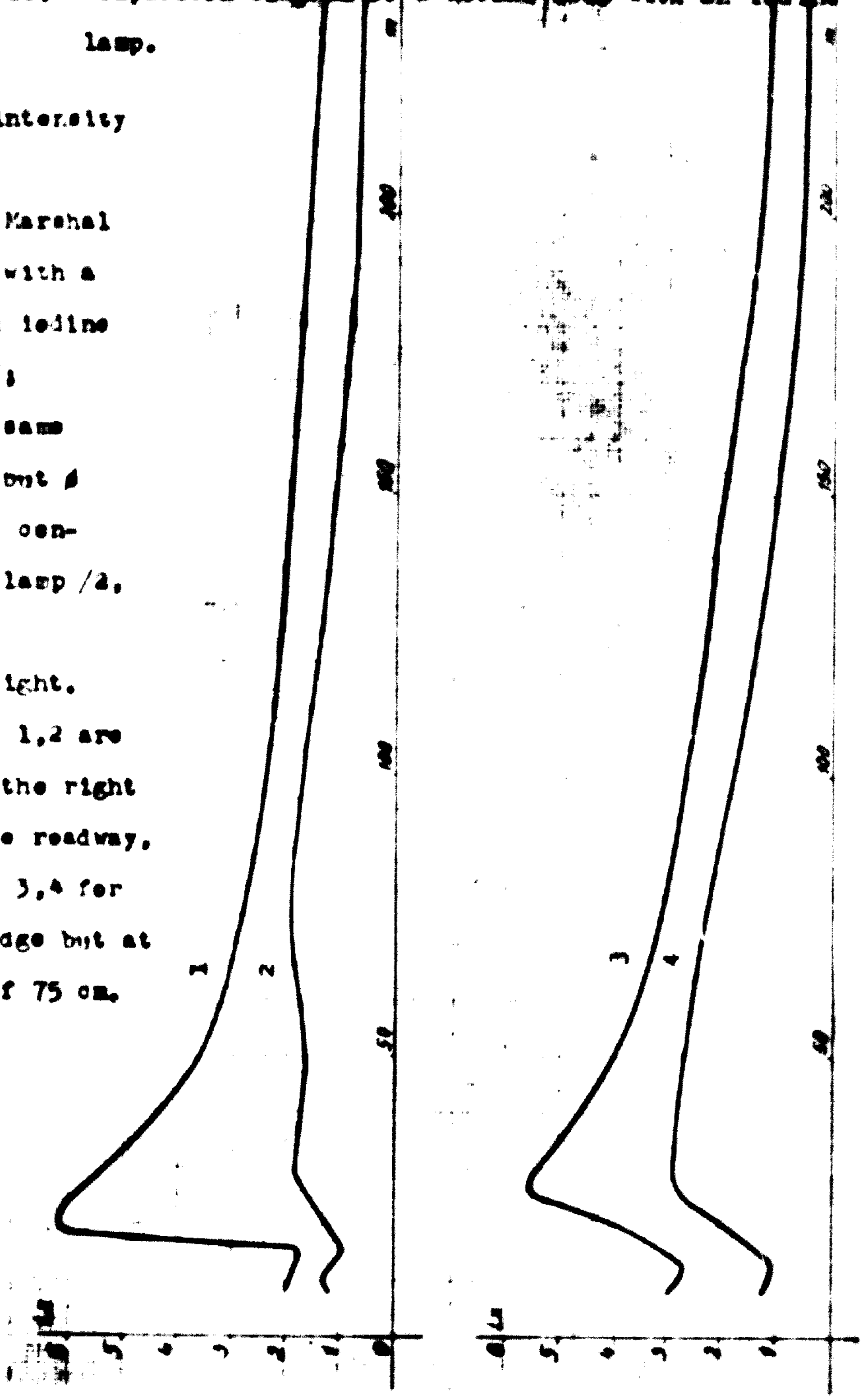


Table no. 17. Principle of the French patent no.1,296,036 G1b16.

Table no. 16. Comparison diagram of a normal lamp with an iodine lamp.

Luminous intensity curves:
a/ of the Marshal headlight with a ∅ 135 with iodine lamp /1,3/
b/ of the same headlight but ∅ 170 with a conventional lamp /2, 4/ for the distance light.
The curves 1,2 are valid for the right edge of the roadway, the curves 3,4 for the same edge but at a height of 75 cm.



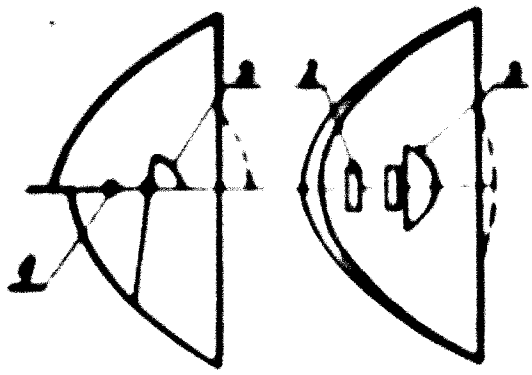


Figure no. 18. Headlight with two filaments a divided and an elliptical mirror.

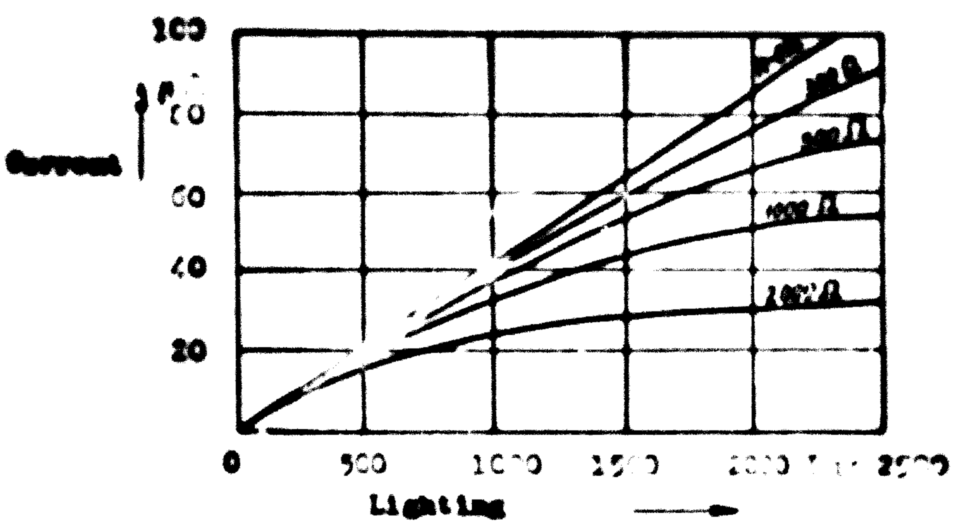


Table no. 22a. The dependence between lighting and electric current in case of a selenium photoelectric cell / R - load resistance /.

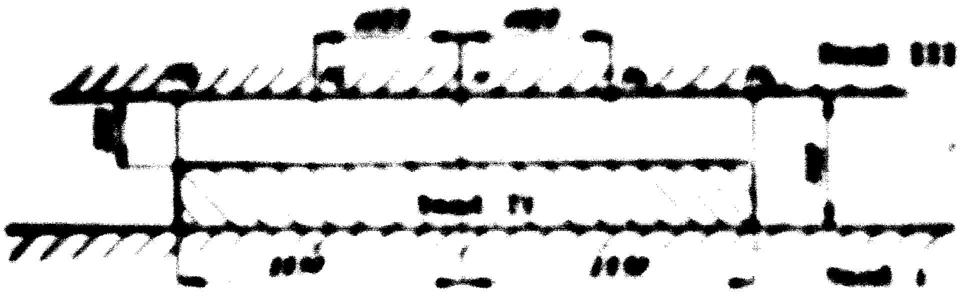


Table no. 19. Test wall for distance and asymmetrical passing lights.

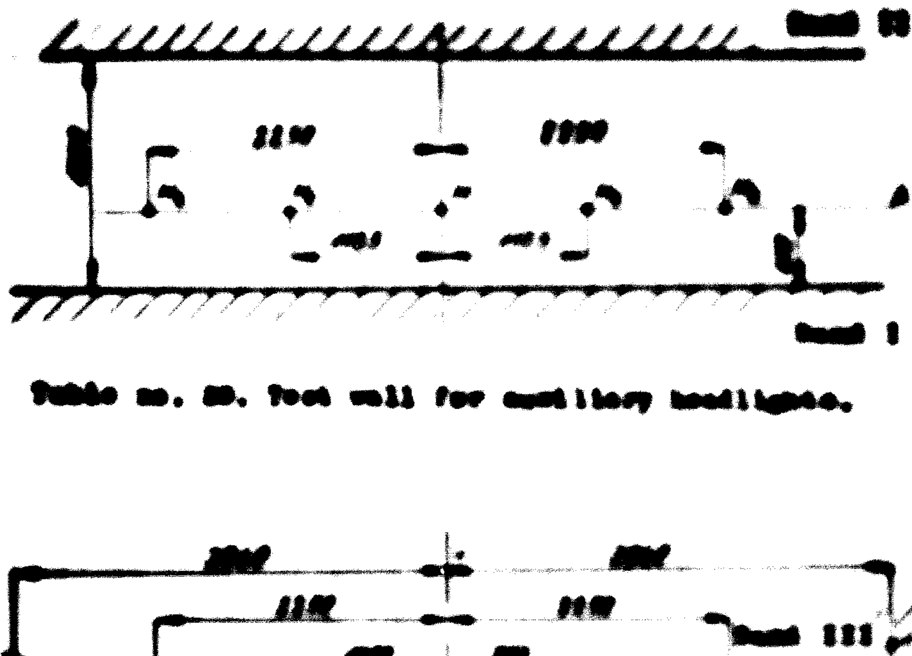


Table no. 20. Test wall for auxiliary headlights.

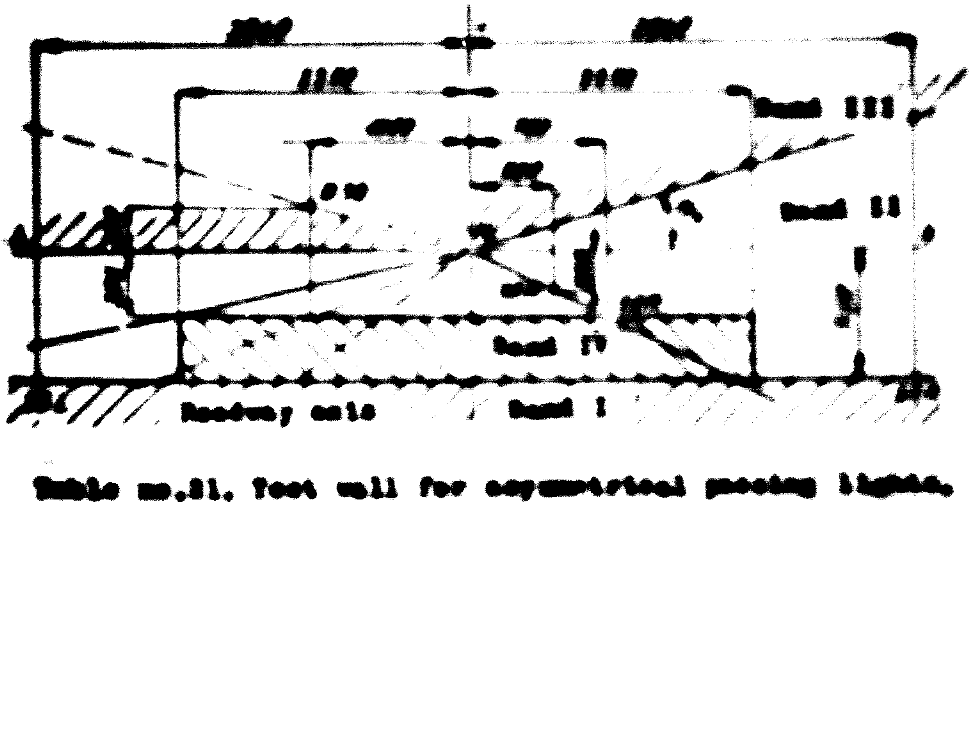
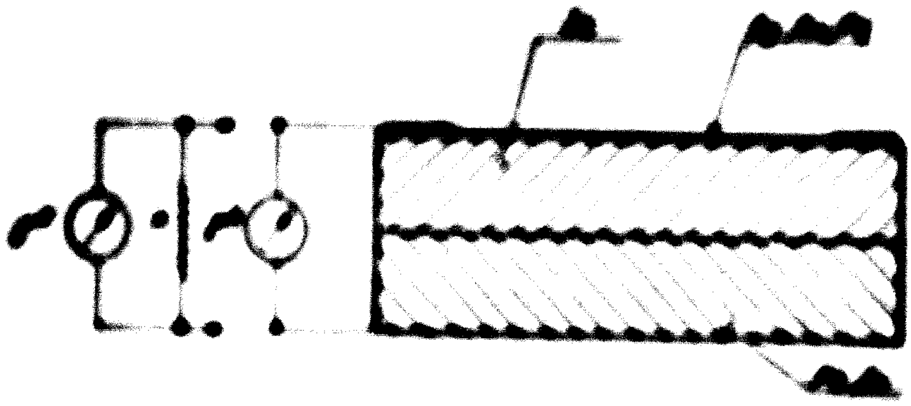
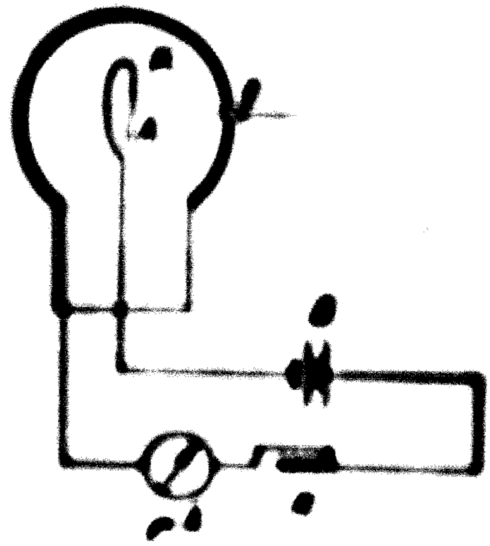


Table no.21. Test wall for asymmetrical passing lights.





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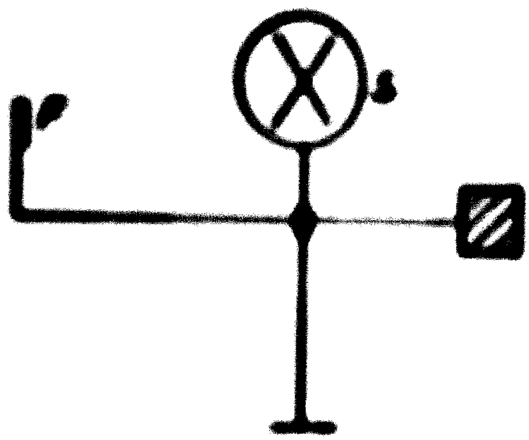

Figure no. [illegible]. Principle of the [illegible]

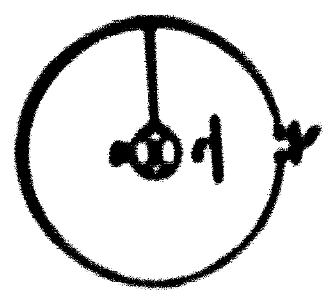

Figure no. [illegible]. Principle of the [illegible].

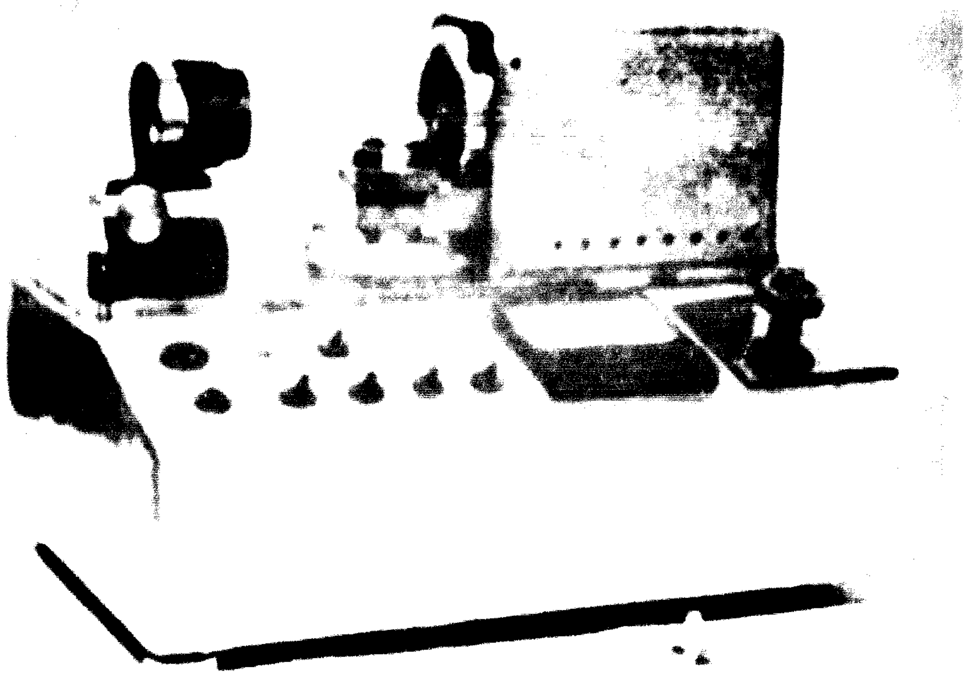

Figure no.26.
Test lamps
selecting
instrument.

Figure no.27.
Photograph of a
picture of the
lamp's filament
system, projected
by the test lamps
selecting
instrument.

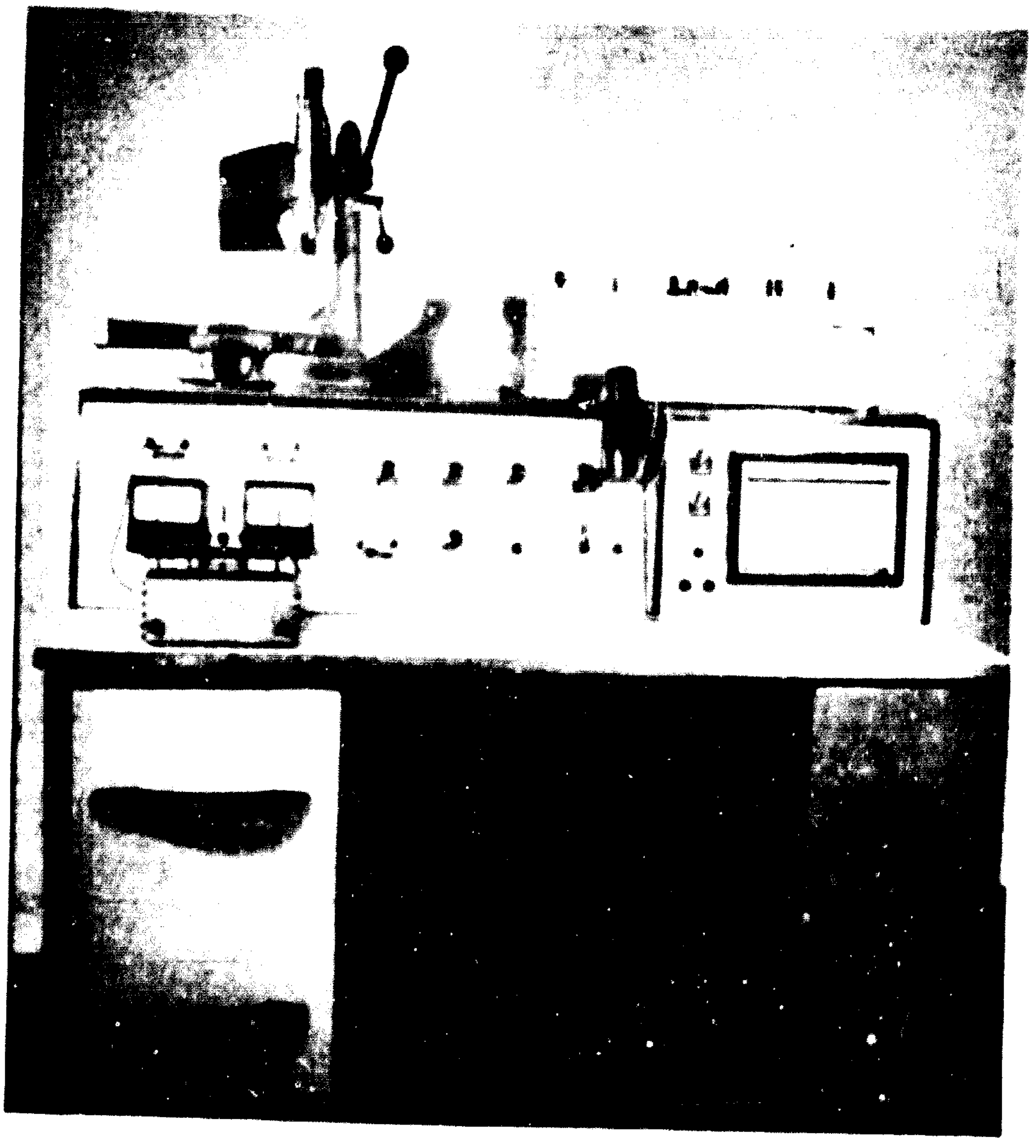

Figure no. 28. Goniophotometer equipped with a recording device.

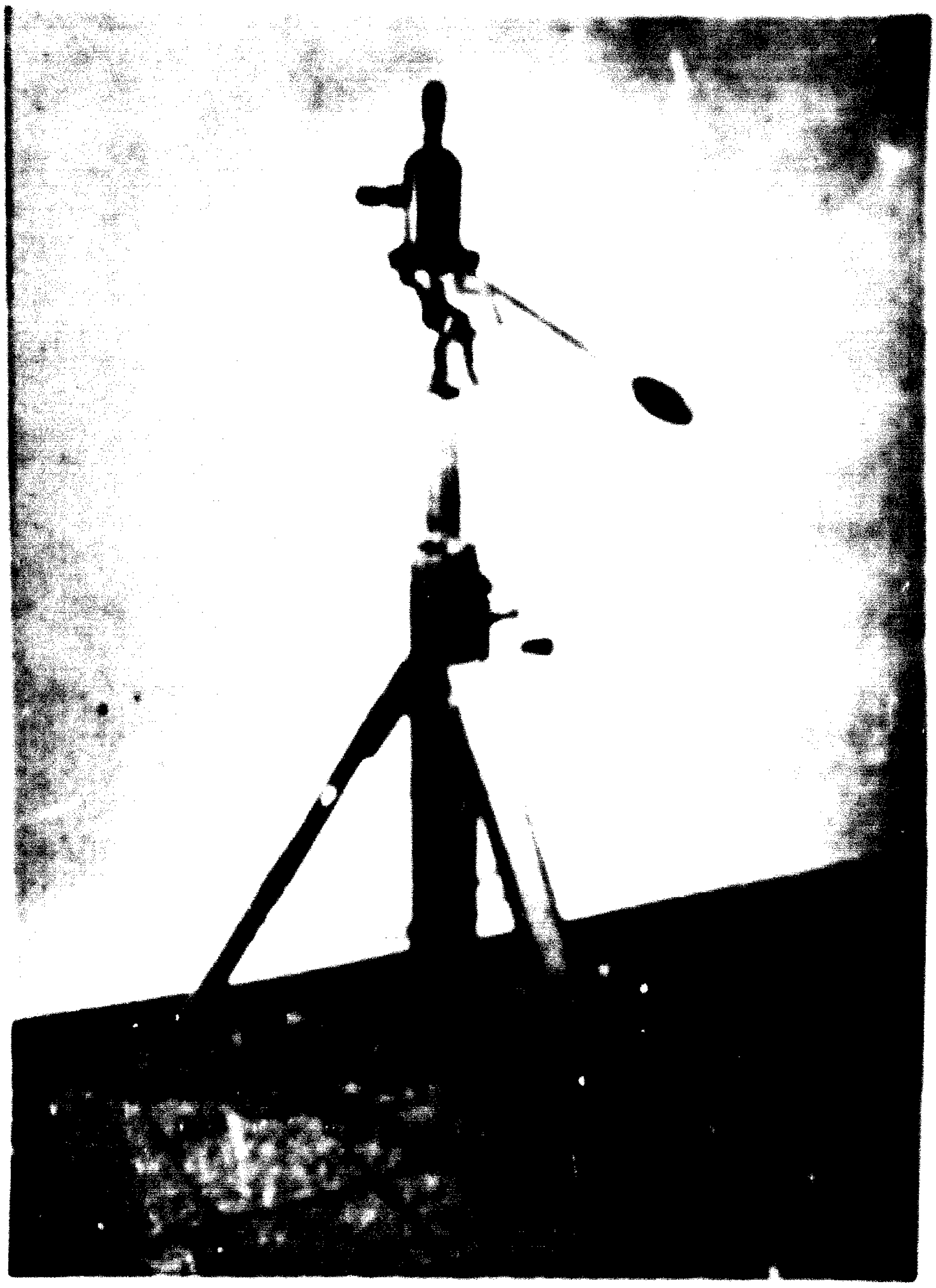

Figure no. [illegible]. Goniophotometer. Head with measuring photoelectric cell.

Figure [illegible] [illegible]

of the [illegible] [illegible] of [illegible]

[illegible], [illegible] and control table.

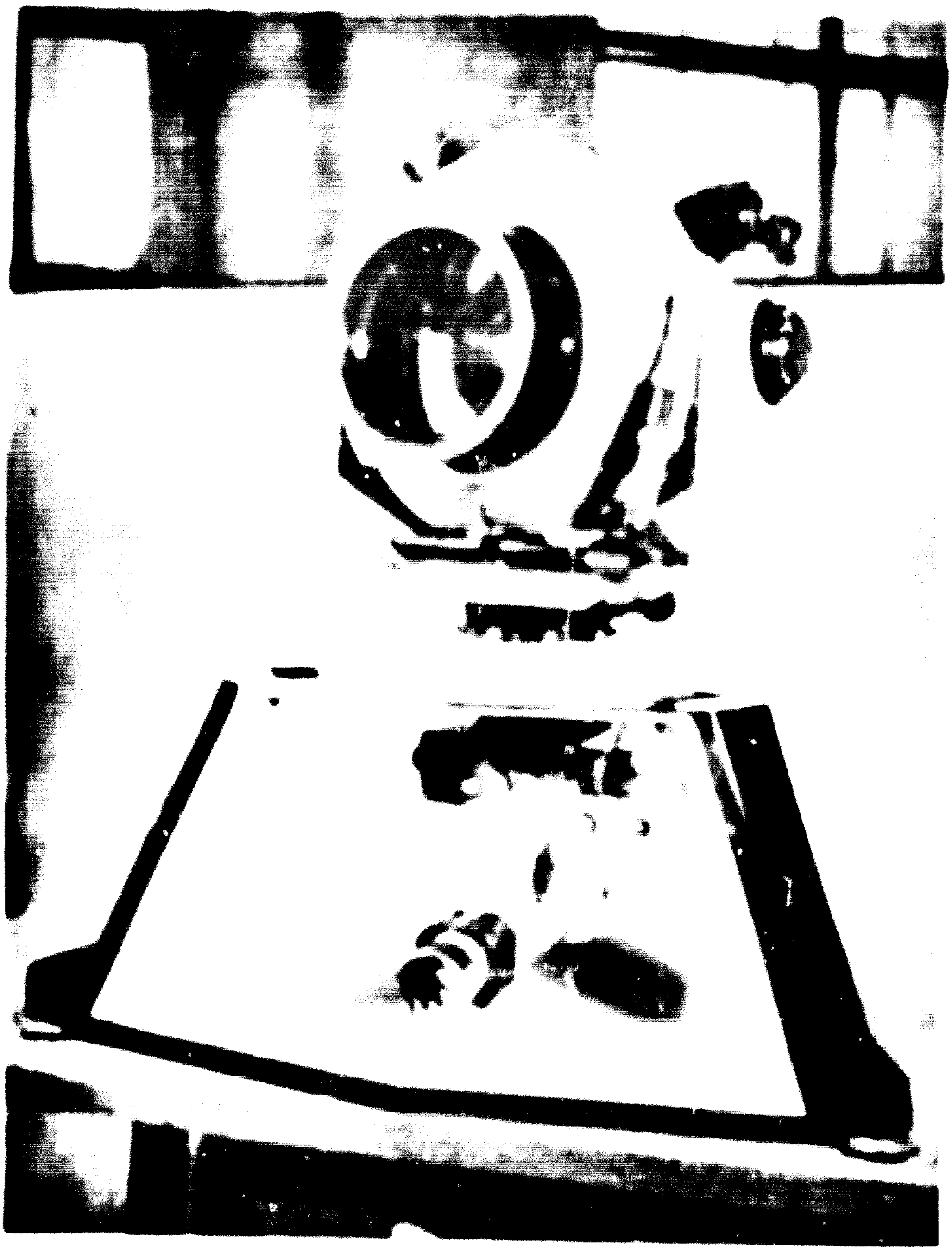

Figure no. 31. Equipment for semi-automatic measuring of the photometric properties of headlight inserts. Stand with clamping and turning devices.

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