OBSERVATIONS ON VISIBILITY OF LIGHTS.

In accordance with the Resolution made under Section III. D by the International Hydrographic Conference held in London, in 1919, and in answer to Circular Letter No. 39 of 1922 issued by the Directing Committee, the International Hydrographic Bureau has received from a certain number of the States Members observations on the visibility of lights on their coasts, which have been made under various conditions during the last few years.

Special Publication No. 2, issued in March, 1924, by the International Hydrographic Bureau, and reproduced in the "*Hydrographic Review*", Vol. 1, N° 2, of May 1924, pages 67-93, on the subject of "*Observations made of Lights in the United Kingdom*", dealt with information which had been collected on the coasts of Great Britain and Ireland during a period of two years only.

The same number of the "*Hydrographic Review*" contained an article entitled "*Visibility of Lights*" by Mr. P. van BRAAM van VLOTEN, Engineer-in-Chief of the Lighthouse Service of the Netherlands, which gave an analysis, in the form of tables and diagrams, of the observations made in the Netherlands during past years.

The object of the present Publication is to inform the States Members, and all those interested in this branch of maritime research, of the results obtained from certain observations recently made in Sweden, Denmark, Belgium, and the Argentine. Also to put forward a certain number of notes which will be useful both in recording the observations and in the examination thereof, with the object of ensuring in the future better coordination of the observations which should be carried out over a considerable period of time and under different climatic conditions.

PREFACE

A certain number of preliminary general considerations on the subject of the visibility of lights, and on the ranges of lighthouses are reproduced hereunder, which, although based in part on theoretical hypotheses possibly open to question, at least are matters of prime interest to the mariner, since they tend to standardise to a certain extent the details to which a Captain has generally to refer in using the Light-List in ordinary practical navigation.

It is known that the determination of the luminous range of a light, which is so important to a navigator, depends not only on the power or luminous intensity of its optical apparatus, but more on various laws which govern the propagation of luminous waves through the atmosphere over the distance travelled from the source of light to the observer, and the extent to which the human eye, at sea and with or without glasses, is susceptible to the fugitive sensation of that amount of residue of light which exists at the extreme limits of the range.

The Swedish Delegate to the International Hydrographic Conference of London, in 1919, reminded the Special Committee of the two principal methods used for determining the range or the visibility of maritime lights as a function of their lumimous intensity:

1. An exclusively empirical method recommended by M. Ribière, which consists of, first, deducing from the observations made at various distances the percentages of visibility corresponding thereto, and then interpolating graphically the percentages corresponding to other distances.

2. A method, based on a formula laid down in 1876 by M. Allard which gives a relation between candle power and optical range.

With regard to the employment of the first method, it is rare that a light is so surrounded by observing stations at various distances that the curve of visibility may be drawn with certainty.

The ranges obtained by the use of a formula would have, in practice a certain uniformity of character which is very desirable, but in view of the numerous criticisms which have been made against the exclusive employment of a strict formula, it is, without doubt, advisable to temper it by introducing into the calculations the results of a long series of precise and methodical observations.

The hypothesis that the transparency of the atmosphere is the same and remains constant throughout the distance over which the luminous wave travels from the apparatus to the eye of the observer is generally admitted. In fact, however, the transparency of the atmosphere varies essentially with atmospheric conditions, and it varies at the same place on the surface of the earth, with the season, and even during the day with the hour, the temperature, the amount of moisture in the air, and the direction of the wind; it increases with height above ground; at an equal height it is generally greater over sea than over land; it varies with the azimuth at which the observation is made; it depends on the general amount of light in the atmosphere due to lunar effects, etc., and when it is a question of distances which extend over several kilometres, it is evident that the transparency of the atmosphere does not remain the same over the whole of the space traversed by the luminous pencil, especially when the visual ray passes over land, sandy shores, highly heated dunes, forests, low coasts or marsh, and also when it follows the general direction of the coast, passing alternately over portions of sea and land or when it crosses mouths or estuaries of rivers.

The causes of variation in range are so numerous that it has been observed that on the same coast two lights situated near to one another and of equal candle power sometimes have very different ranges.

The direct measurement of atmospheric transparency on the sea shore appears to be impossible in practice.

Further, when it is a question of luminous ranges, only average values obtained from a great number of observations can be considered. The results must be applied to each particular case with very great caution, even when on the same portion of the coast where the results of experiments were collated.

The candle powers to be taken into account, both in formulae for visibility and in comparative lists of lights, might be advantageously expressed by means of a standard unit (1) (e. g. the International Candle defined at the International Convention of Ist July, 1909) as they normally appear in practice, and at a distance from an observer coming from the open sea, and not by the result of photometric measurement in the laboratory.

An optical panel of surface Σ when placed before a luminous source

(1) In this connection already certain Light Lists indicate the following Table of Equivalents between various units of luminous intensity.

	Carcel unit.	British candle	Hefner unit.	Decimal candle	Violle
Carcel unit.	1.	9.5	10.9	9.6	0.48
British candle	0.105	1.	1.14	1.01	0.05
Hefner unit	0.092	0.88	1.	0.885	0.044
Decimal candle	0.104	0.99	1.13	1.	0.05
Violle	2.08	19.8	22.6	20.	1.

round the focus of which a certain intrinsic brightness e is emitted over a proper apparent surface σ, has the effect, for an observer at a certain distance, of increasing the surface of the source to the dimensions of the panel, the latter thus becoming for the observer a new source of the same intrinsic brightness but of the apparent dimensions of $\sum$, much greater than σ. Theoretically the apparent maximum intensity would be expressed by the product $\sum e$; but in reality there only remains available outside the lantern (owing to losses due to the aberrations called "*of sphericity*" of the optical system, to dispersion, to refraction or reflection or to the absorption of the lenses) a maximum useful intensity $K \sum e$, the constant K representing the co-efficient of utilisation of the whole optical system.

This co-efficient, of which the practical value may be determined experimentally by photometric measurement, varies between rather wide limits (50 % to 80 %) for the various types and shapes of refractors and reflectors, as well with the nature of the glass, and of the screens of various colours employed.

The seaman perceives the full effect of a light at such a distance only that his eye can embrace the whole optical panel, and when he is in the neighbourhood of the geographical horizon of the light where the pencil has been concentrated by an appropriate displacement in height of the source in its optical system corresponding to the angle of apparent depression. (Sea horizon focus).

Further, in the case of flashing lights, the rotation of the apparatus brings all directions, and consequently all the intensities of the pencil in succession towards the eye the observer thus placed. This happens also when the observer moves across a small fixed sector of a leading light.

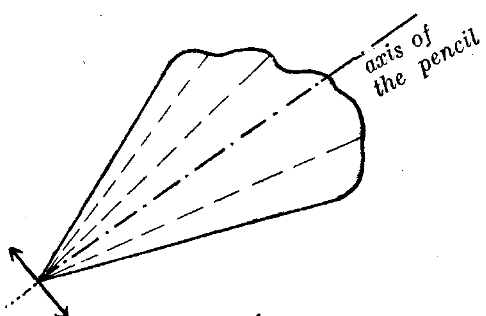

FIG. 1

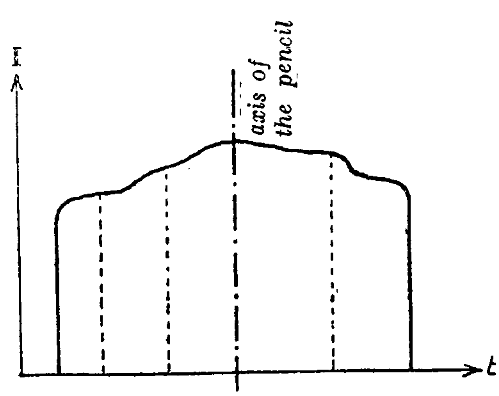

Diagram of Intensity

For certain group-flashing apparatus, the curves of intensity may even present an asymmetry in respect to the central axis in all the different azimuths covered by the angle of divergence of the pencil. (fig. 1).

At the limits of the range, certain exterior parts of the pencil may not reach the observer, and the duration of the flashes and the amplitude of the lighted sector may be found to be affected, thus it would not suffice to define the power of a light by a single figure corresponding, for instance, to the maximum intensity measured along the direction of the axis. The flashes of a light can only be defined exactly by the individual curve corresponding to the various intensities of its pencil. Therefore, a flash cannot be represented by a single power and amplitude.

At sea, the duration of visibility of a flash may be found to be increased or diminished according to the peculiarities of the curve representing the intensities, such as the presence of a more or less extensive maximum or of a special asymmetry.

These various anomalies have caused the greatest value to be placed on the curves which give the percentages of visibility (e. g. annually) directly from observation at different distances on a certain coast; all the particulars of the optical system of the burner and of the local transparency are thus included in the results of the observation.

It is not possible, however, to give all of the characteristic curves for all lights in the Light List; and also in default of being able to obtain the curves of percentage of visibility for all lights under favourable conditions completely, it would at least be advantageous to be able to utilise isolated data obtained from partial observations by adopting, for the purposes of extrapolation, a certain luminous power intended to help in the classification of the lights, and which must be selected in a practically uniform manner. The maximum intensity corresponds occasionally to a narrow and irregular zone of the pencil only, but there exists in all curves a fairly wide part of high intensity on both sides of the central axis, and on each edge of the pencil a point at which the intensity commences to fall somewhat sharply; therefore limits can be taken, between which it is easy to agree that the power would be always greater than a selected extreme value: for instance, 92 % of the maximum intensity (fig. 2).

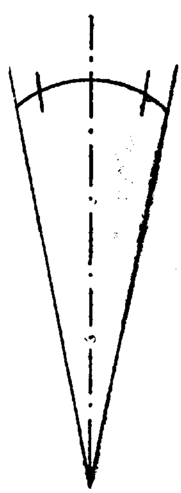

FIG. 2

The adoption of such value would permit the deduction of amplitudes or durations of flashes which would be effectively comparable and practically uniform for the calculation of the ranges in the vicinity of their limits, *i. e.* at the most important point for the navigator. For this purpose, however, a guide is found in the fact that the duration of the flash is based on the speed or period of rotation of the optical system, and on the divergence of the luminous pencil; the maximum divergence corresponds to the horizontal angle at which the useful portion of the source is seen from the centre of the lens, or at the focal distance; and the divergence of the central part of maximum intensity corresponds to the smaller angle, within which the active part of the source is seen from the furthest edge of the panel of the system, on an average 2/3 of the maximum divergence.

In practice it is likewise advisable to take into account under conditions of regular service, the reduction caused by the deterioration of the burner and of the mantle, the blackening of the incandescent filaments, etc. (say from 15 % average to 30 % maximum), as also a reduction of light of about 10 % caused by occultations by the uprights and cross-bars of the lantern (1).

But the candle power of a given optical system should not be considered as a fixed element, independent of the method of utilisation of the system; thus with flashing lights, of which the pencils travel to the horizon with a certain speed which corresponds to the duration of a very short flash, the practical candle power that the eye of the seaman actually perceives is entirely different to that which would be measured by a photometer if the system and the pencil were not moving.

The law enunciated by Messrs. BLONDEL and REY in 1911, as to the perception by the eye of short flashes at the limits of their ranges, allows this practical candle power (viz. the power of a steady and fixed light which is equivalent in range to a revolving light giving flashes) to be deduced from the luminous photometric power measured, when the pencil remains immobile.

Physiological considerations have shown that, in order that visual stimulation of a given observer should commence, it is necessary that his eye should receive a certain luminous intensity corresponding to a limit of lighting (λ) of the retina.

This limit of lighting, which corresponds to the point where the stimulation of the human retina begins, varies with the visual acuteness of different observers, and with different conditions of observations.

Léonce RAYNAUD, working on land in Paris, determined the value

(1) The total coefficient employed in practice by the Netherlands Lighthouse Service is 0.675.

of λ at 0,01 Carcel at 1 kilomètre, *i. e.* 0,1 decimal candle to 1 kilomètre, or 1×10^{-7} metric unit of light. (lux).

For an average eye, under laboratory conditions, Messrs. BLONDEL and REY determined an approximate practical value of 0.5 to 0.6×10^{-7} lux. But at sea, where the conditions of observation are always more difficult (because of the movements of the vessel and of those due to the fact that the eye must make a search in the dark, and also because of the action of the wind, to which the eye is very sensitive) they have adopted the value of $\lambda = 0.3$ decimal candle at 1 kilomètre, deduced from a large number of observations of French Lighthouses.

This value is corroberated by that of $\lambda = 1.14$ Hefner candle at 1 sea mile (1852 metres) found recently in the Netherlands for Dutch lights, viz. $\lambda = 1$ decimal candle to 1 nautical mile.

If the lighting does not pass beyond this limit λ, the visual organs would not be excited and would remain inactive. It is necessary, therefore that the luminous source should emit light of greater intensity in order that the physiological sensation be produced under the influence of its growing intensity.

And, in order that the brain should react to such sensation, this necessary growth of intensity must be maintained during a certain period α capable of giving the constant minimum quantity of lighting $\alpha \lambda$ which will produce the minimum of sensation.

The quantity of light emitted by the source to the observer during a period (t) of a uniform flash of constant intensity will be expressed by the product $E t$ in which E represents the amount of light produced at the distance at which the pupil is situated.

The quantity of light which is transmitted by the optic nerve in order to affect the brain would thus be represented by $(E - \lambda)\, t$.

Consequently the following equation, which satisfies the above mentioned considerations, constitutes the analytical expression of the law enunciated by Messrs BLONDEL and REY. $(E - \lambda)\, t = \alpha \lambda$ (1).

The constant α has been found to lie between the extreme limits 0.15 and 0.35, and is, on an average for the different observers, equal to 0.21 second.

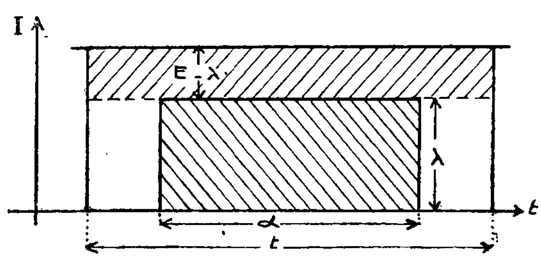

FIG. 3

It the durations are shown graphically as abscissae, and the light (or the intensity, which for an equal distance, is in proportion thereto) as ordinates, the equation is satisfied by the equality of the panelled areas in fig. 3.

This gives, starting from the constant intensity I of a flash which lasts t seconds, the graphic construction for the intensity Ic (or $I\infty$) of the equivalent fixed light as regards range:

$$Ic = I \frac{t}{\alpha + t}$$

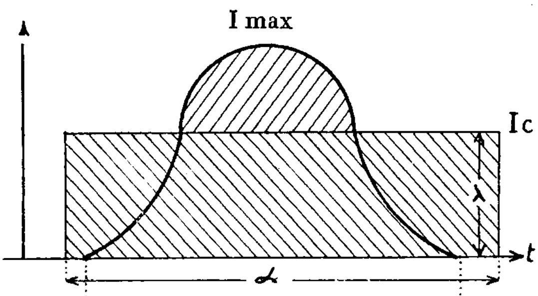

FIG. 4

Although the luminous pencils (the flashes) of lights are not uniform since their intensity varies and takes up the aspect represented in fig. 4, the intensity Ic of the equivalent fixed light as regards range, can be determined by constructing equal areas corresponding to the formula:

$$Ic = \frac{\int_{t_1}^{t_2} I\,dt}{\alpha + (t_2 - t_1)}$$

and if the diagram of intensity be assumed to be a trapezium, the result is approximately:

$$Ic = I\max \times \frac{To + \alpha - \sqrt{\alpha^2 + 2\alpha\,To + T_1^2}}{To - T1}$$

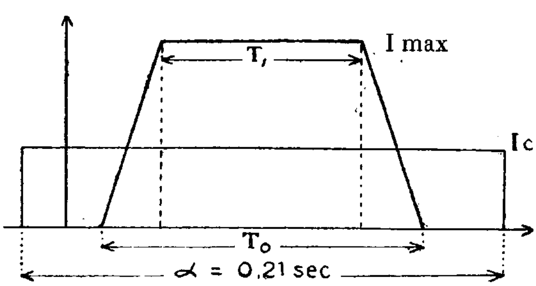

FIG. 5

designating the durations of the passage of the widest and most intense parts of the pencil by To and $T1$ respectively. (fig. 5).

That which corresponds to the quantity expended as pure loss λt in order to provoke the physiological reaction of the human eye is represented in figs. 6 and 7, by the shaded portion ; it will be seen that it would be advantageous to reduce the duration of the flash by increasing its intensity.

The BLONDEL-REY law elaborates by experiment over duration limits of from 1/1000 of a second to more than 1 sec., and it is interesting to note that the human eye can, under special conditions, perceive such short durations.

But in practical navigation the conditions are very different from those of the laboratory; when a light, which is suspected to exist within a certain arc of the horizon, is searched for in the middle of the night,

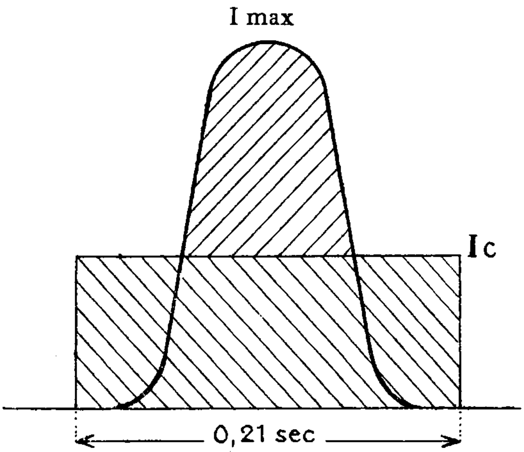

FIG. 6

Concentrated flash from a metallic reflector

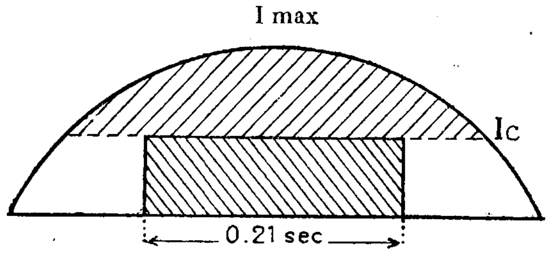

FIG. 7

Extended flash from a lenticular panel

the eye-ball is kept constantly in motion and the line of sight is moving at a certain speed; so that in the dark a point on the horizon cannot be fixedly looked at during a period of time greater than a certain value δ. And, if the light for which a search is being made can only be perceived at the limit of range, at the end of a duration greater than δ, it will never be sighted, because the eye will have ceased to be fixed on the point in question immediately after the elapsed period δ.

On the other hand, if it were possible to fix the sight on the same light for a period exceeding δ, though at first no light would be perceived, in the end, however, it would be discovered.

Therefore it is obvious that it is quite useless to institute flashes of a greater duration than δ, because, for a longer duration, it would be necessary to calculate their photometric power or intensity as though this duration were reduced to the time during which it can act effectively on the searching eye, viz. to δ.

It is difficult to determine δ practically, *i. e.* the period during which a searching eye remains fixed on a definite point at night.

It is already known, from the curve of ranges of a white flash, according to its effective duration, that little range is gained when the duration is increased beyond half a second.

Taking as a basis the observations made by the French Administration of Lights, the value of δ has been estimated at 0.4 sec. Some reciprocal observations of equivalent lights made in the Netherlands led to a slightly greater value (0.7 sec.) being taken for δ.

In any case, the rôle played by the eye in applying the preceeding

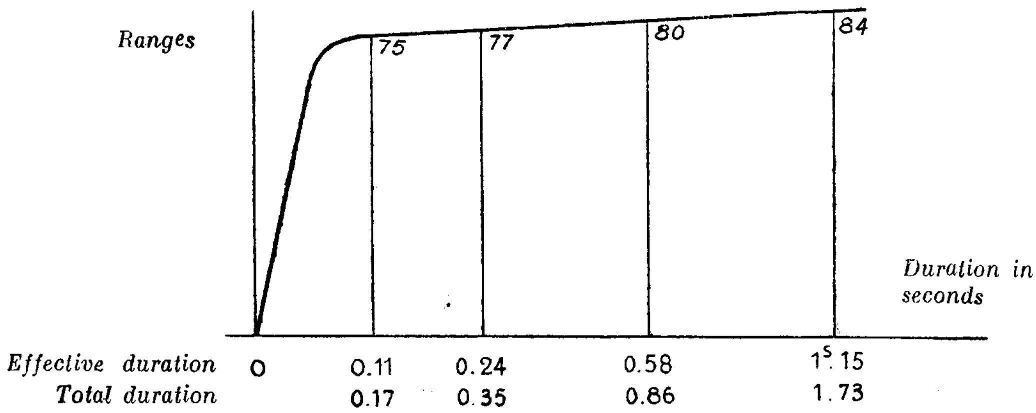

Fig. 8. — Curve of ranges of a white flash according to its effective duration

methods, in order to compare flashing lights in the neighbourhood of the limits of their ranges, leads to research as to what would be the intensity of the equivalent light as regards range, of which the duration of the flash would be δ seconds.

$$I\,\delta = I c \frac{\alpha + \delta}{\delta}$$

The firm of SAUTTER-HARLÉ gives the candle powers of apparatuses by the intensities of equivalent lights as regards range, of which the flash would be of a duration of 0.4 sec. I_{04}.

The considerations briefly set out above might serve as a basis for the adoption of a uniform method for the practical definition of the intensities and the durations of flashes in so far as they interest the mariner, and such that they might be uniformly listed in the Light List.

METHOD OF REDUCTION OF OBSERVATIONS.

It is by following, generally, the previous preliminary considerations, which have been enumerated solely for the purpose of bringing them before mariners, without attempting, at present, to attribute definite numerical values to the various coefficients — international agreement as to these values might be reached after discussion — that the various observations of the Swedish, Danish, Belgian, and Argentine lights, received to date by the International Hydrographic Bureau, have been analysed and compared.

Having calculated the percentage of visibility, *i. e.* the positive number of times that the source of light has been perceived, divided by the total number of observations, both positive and negative, of the light, during the total period covered by the observations; the lights which have been sufficiently observed from surrounding points at different distances have been chosen for the purpose of drawing the graph of the curve of visibility for each, analagous to that of fig. 9.

When the curve appears to be defined with sufficient precision, (which occurs in very few cases only) the probable ranges for 90 %, 75 %, and 50 % of visibility have been read off the graph, as well as the probable percentage of visibility corresponding to the geographical range calculated for a height of eye of the observer of 5 metres above mean high water. (1).

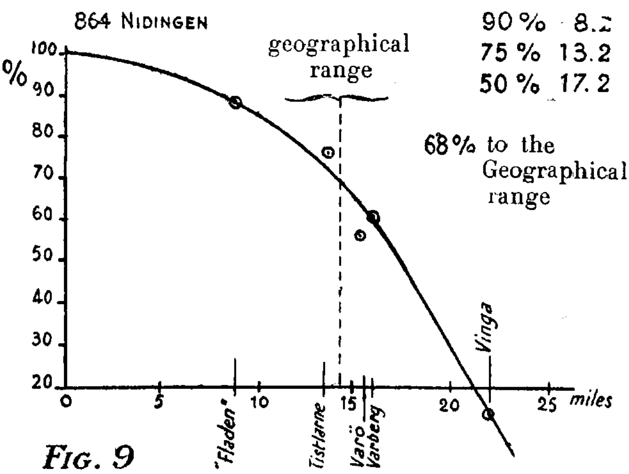

FIG. 9

This last percentage is of great interest for important lights and for main coast lights, and it might be inserted beside the geographical range in the Light List with advantage to the mariner.

The inclusive cœfficient of utilisation 0.7 has been applied to the candle power of the lights. Those of the lights of which the duration of the flash was stated to be less than 0.4 sec. have first been approximately reduced to the intensity of the fixed equivalent light *Io* by

(1) See below under note on Geographical Ranges.

constructing the graph on squared paper for which the trapezoidal form of fig. 5 has been accepted for the curve of intensity, and the value of 0.21 for the parameter α ; secondly, the powers have been restored to those of the equivalent flashing light of 0,4 sec. of duration by the formula :

$$I\,0.4 = Ic\,\frac{0.21 + 0.4}{0.4} = Ic \times 1{,}5$$

Then the lights were classified by the candle power thus obtained with a view to comparing these with the luminous ranges obtained, and corresponding to the percentages 90 %, 75 %, and 50 % respectively, and to drawing the representative graphs as in fig. 10, which should permit which of the lights should be classified in the same geographical region, wherein similar atmospheric transparency is to be found, to be determined.

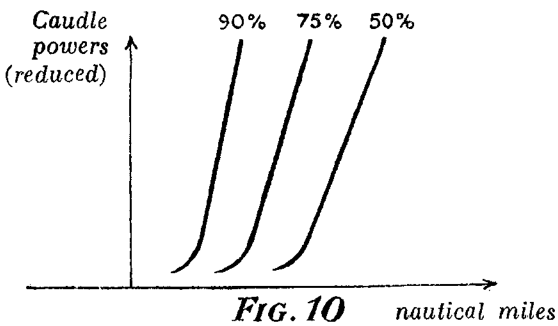

FIG. 10

The elements for the neighbouring lights are deduced from the above in accordance with their powers, and this, in default of observations from suitably placed points, would allow the probable curve of percentages of visibility to be constructed for each of them.

The representative points of the isolated observations should fall in the vicinity of the curve thus constructed, and thus must be verified afterwards.

Further, it is of interest also to return to the old formula of ranges enunciated by ALLARD, of which the equation $\lambda = \frac{L\,a^x}{x^2}$ granted the hypotheses already mentioned, expresses the value of the limit of light λ as a function of the candle power L, of the cœfficient of atmospheric transparence a, and of the range x, which limit is necessary in order to affect the retina, taking into account the absorption of the atmospheric medium which is supposed to be uniform.

However, it is important before all to specify carefully the nature of the elements which enter into this formula :

λ is the minimum amount of light perceptable at sea by an eye of normal acuteness, expressed, *e. g.* in international candles per nautical mile, if the distance, or range x is to be expressed in nautical miles (of 1852 m.) also. L represents the power or luminous intensity of a light of which the duration (duration of the flash) is at least equal to the time during which an average eye can be fixed (when searching during the night) on a point on the horizon (0.4 sec.) expressed in the unit selected (in the suggested case the international candle).

The cœfficient of atmospheric transparency a will represent the available proportion of light which remains after having traversed a path in the atmosphere equal to the unit chosen to express the distance x (in this case the nautical mile) (1).

By taking $y = \log\left(\frac{L}{x^2}\right)$ then equation above gives $y + x \log a = \log \lambda$ (1)

and selecting the lights of a certain region in which the transparency is supposed to be invariable, ($\log a =$ constant) endeavour has been made to verify graphically (showing x as abscissae and the corresponding values $y = \log \frac{L}{x^2}$ as ordinates for 90 %, 75 %, and 50 % of visibility respectively, that the straight lines obtained satisfying to the equation (1) meet satisfactorily on the same original ordinate $y_o = \log \lambda$ and that the value of λ, which is deduced, corresponds at any rate closely, with the minimum of perceptible light. (graph fig. **11**).

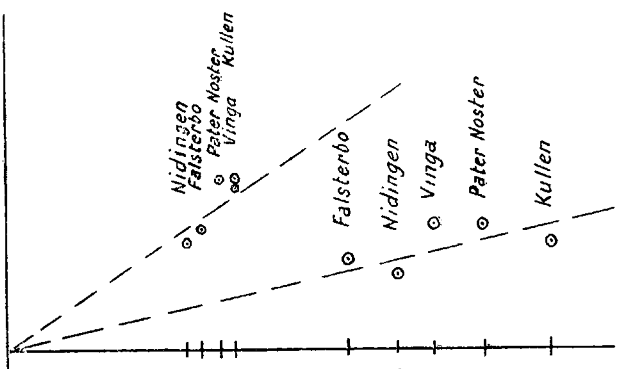

FIG. 11

Finally, taking the value of λ = 0.3 lux, a "logarithmic diagram of the ranges" as indicated by ALLARD was constructed, (see Plate I) on which the scale of abscissae represents sea miles, the scale of ordinates the values of $\log \frac{\lambda}{L}$ and the curve corresponding to the function $y = \log\left(\frac{1}{x^2}\right)$ is drawn on the same scale.

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(1) If observation is made with field glasses of magnifying power G, the equation (1) will become $\lambda = \frac{L\,a^x}{x^2} \times G^2$ or $\lambda = \frac{L\,a^x}{x^2} \times n\,G^2$ admitting n to be the coefficient of the glasses.

The intersection of the curve $y = log\,(\frac{1}{x^2})$ with the straight line $y + x\,log\,a = log\,\frac{\lambda}{L}$ which passes through the original ordinate $log\,\frac{\lambda}{L}$ corresponding to the luminous power of the light and which makes the angle corresponding with the axis of the abscissae with the transparency ($log\ a$) desired for a visibility of 90 %, 75 %, 50 %, etc. will give in abscissae, the range corresponding to this percentage.

The graphs which give the percentages in function of the direct observations for certain appropriate lights, and consequently the ranges corresponding to 90 %, 75 %, and 50 %, have been used to draw, on the diagram, the inclined straight lines which correspond to the different percentages respectively. (see plate I). In order to compare the straight lines, which correspond to the same percentage for different lights, a straight line parallel to each of them and which passes through the original ordinate corresponding to the intensity 100.000 candles, was drawn. Thus the group of straight lines such as is represented in fig. 12 is obtained, from which is chosen, as best possible, the average direction which in the same atmospheric region corresponds best to each of the percentages under consideration.

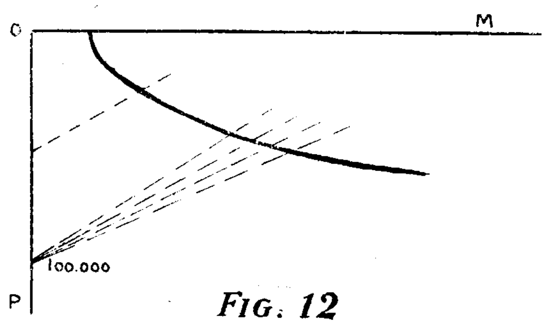

FIG. 12

Therefore, by means of these directions, the curve of visibility for a light of a certain region, of which the observations are incomplete, can be constructed as stated above.

OBSERVATIONS OF SWEDISH LIGHTS

The observation of Swedish Lights received by the Bureau were taken during a period of 10 years, from 1913 to 1922 inclusive. Unfortunately, during the war period 1914-1918, a certain number of observations had to be interrupted. Further, each year, during the period of ice when navigation is interrupted, certain lights are not exhibited. The same thing applies each year in high latitudes where the days are very long during the summer months; according to geographical position certain lights are not shown from the middle of June to the early days of August. Besides, the characters and powers of some of the lights have been modified, and this likewise has reduced the total number of observations during the ten years.

Nevertheless, the observations have been collated and the percentages of visibility are shown in column 7 of Table (I). This table indicates also the peculiarities in the observations of each light.

The lights are classifield in the numerical order of the Swedish Light List, the bracketed numbers relate to foreign lights which the Swedish stations were able to observe.

Table II gives information concerning the pairs of stations where reciprocal observation of lights was feasible.

It has been possible to draw the curves of visibility with relative precision for the lights enumerated in Table III, wherein the ranges corresponding to the percentage 90 %, 75 %, and 50 % have been indicated.

These quantities have been assembled in two graphs; one for the powers up to 10.000, and the other for higher powers. (plate II).

It will be noticed that the drawing of the curves by geographical regions is still rather uncertain among figurative points, probably on account of a lack of perfect homogeneity in detail of observation.

If, for example, the dotted curves are admitted for the region of the approaches to the Baltic Sea and of the Straits, and an endeavour is made to extrapolate the probable visibilities among them of the lights of Smyggehuk, Haken, Ven, Helsingborg, Hallands Vadero, (Nakke Hoved) and (Middelgrund fort), it will be found that the results will only fit in approximately with the observations collected during the period indicated, as shown by the following table.

On the other hand, the elements of table III have been assembled on the "*Diagram of Ranges*", and they have been drawn, as mentioned above, through a single point on the axis of the ordinates. Then, from

	Power (reduced)	Power calculated	Power observed
SMYGGEHUK	5.250	90	85
HÄKEN	800	69	66
VEN	3.500	86	79
HALSINGBORG	14.700	89 85	83 82
HÄLLANDS VADERÖ	7.000	85 73	82 71
(NAKKE HOVED)	165.000	96 86	93 83
(MIDDLEGRUNDS FORT)	90.000	87 80	84 80

the groups of lines obtained, an attempt has been made to collect together the straight lines of the same geographical region, and by means of straight lines obtained for 90 %, 75 %, and 50 % respectively, an endeavour has been made to construct the diagrams of visibility of these lights, the direct observations of which did not permit this to be done. This has given approximate results only. (See fig. 12, the dotted straight lines shown on Plate I, and the following recapitulatory Table).

LIGHT	Reduced candle power	By graphs			By diagram			Observed percentage	Corresponding percentages calculated	
		90 %	75 %	50 %	90 %	75 %	50 %		By graphs	By diagram
Smyggehuk	5.250	7.	12.3	17.	6.1	10.8	15.	85	90	88
Haken	800	3.4	7.2	11.5	4.5	7.5	10.	66	69	68
Ven	3.500	6.4	11.3	15.7	5.7	9.9	13.8	79	86	83
Halsingborg	14.700	7.5	13.0	18.3	7.1	12.9	18.5	83 83	89 85	89 85
Hallands Vaderö	7.000	7.2	12.8	17.7	6.3	11.3	16.	82 71	85 73	81 67
(Nakke Hoved)	165.000*	9.7	15.	21.	9.4	17.5	26.8	93 83	96 86	96 87
Middelgrunds F.	90.000*	9.4	14.6	20.2	8.8	16.4	24.6	84 80	87 80	88 85

Consequently it has not been possible to determine the percentages for the probable visibilities at geographical range of the majority of lights in a sufficiently certain manner by employing solely the observations which had been recorded.

OBSERVATIONS OF DANISH LIGHTS.

The observations of Danish lights received by the Bureau extend over a period of four years, from 1921 to 1924 inclusive.

They have been treated in the same manner as the preceding observations and on various graphs for the region of the approaches to the Baltic Sea and of the Straits.

Table I^A assembles the details for each lights; the annual percentages of visibility for the years 1921, 1922, 1923, and 1924 are shown. It will be noticed, after inspection of these four colums, that all the percentages of visibility for the year 1924 are much lower (on an average 10 % for the mean distances) than all of those for the three other years, which shows that, from one year to another, the general atmospheric conditions for the same region may sometimes be very variable, and that observations for visibility, if they are to present any homogeneity in results, should be taken during a fairly considerable number of years.

OBSERVATIONS OF BELGIAN LIGHTS

The observations of Belgian lights received by the Bureau cover a period of a single year. They were made by noting at each light-house or light-ship, whether neighbouring lights were seen distinctly, feebly, or not at all.

A certain amount of confusion may exist as to the manner of appreciating whether a light is seen feebly, especially flashing lights, such as that of Westkapelle, for which the reflection of the flash on clouds lying beyond the limits of the geographical range might be mistaken for the light itself; and it appears better to adhere to the notation "*positive*" (seen) or "*negative*" (not seen) for registering the observed visibility.

The observations extend over such a short period that it does not appear to be advantageous to draw up a table of results.

OBSERVATIONS OF LIGHTS OF THE ARGENTINE REPUBLIC

The observations of lights received from the Argentine by the Bureau relate to the year 1921. They deal with 29 lighthouses, and were made, generally, by ships travelling away from the light and observing the distance limit at which the source of light ceased to be visible.

This method is more precise than that of noting the distance at which a light commences to be perceived when approaching from seaward, for under these circumstances the estimation of the position of the vessel under way, and of the distance, might be less exact. It gives the extreme range for each case directly, without, however, surpassing the geographical range corresponding to the observer, since beyond that, the appreciation is wanting.

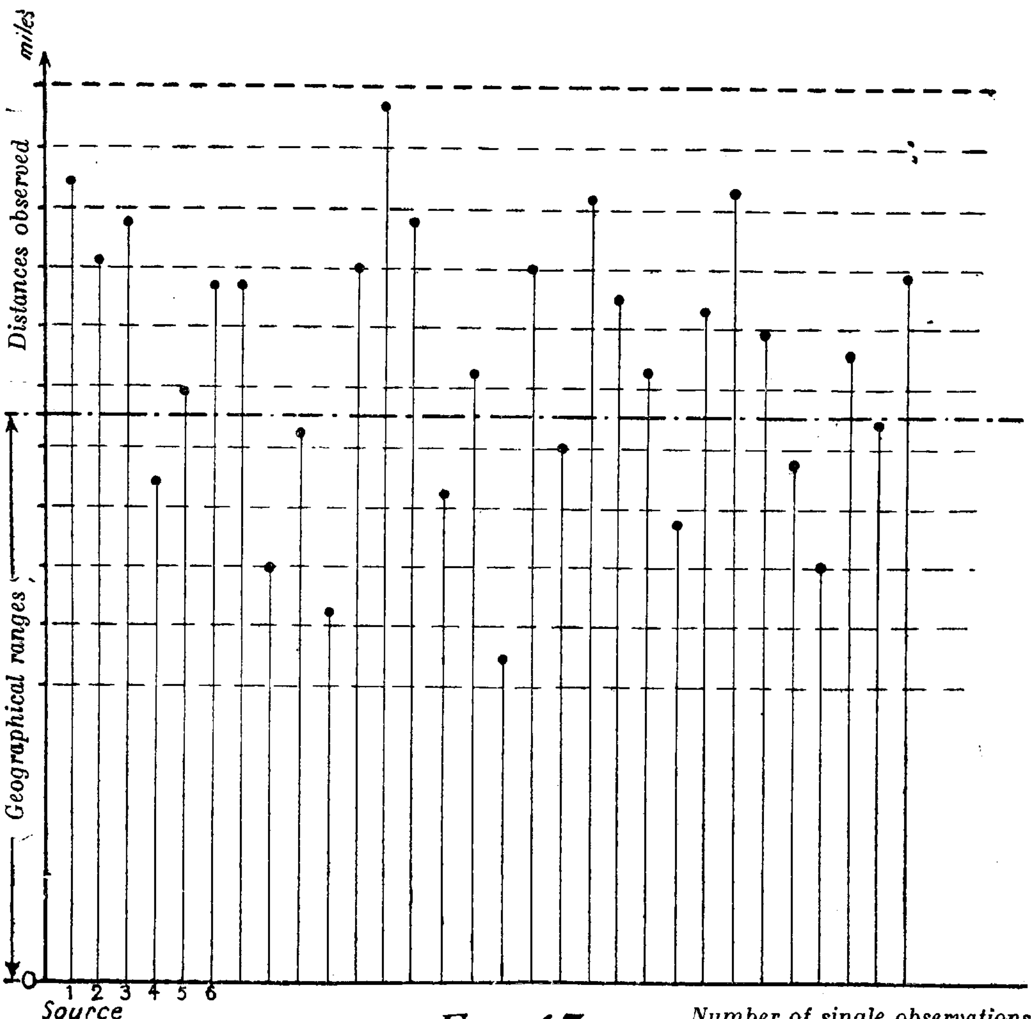

FIG. 13

It is rather a delicate matter therefore, to deduce the percentages of visibility at different distances from these observations at the limit of range. In the case of certain lights, the observations of which during the year have been particularly numerous (*i. e.* San Antonio, Punta Mogotes, Punta Medanos, Isla Leones, San José, Isla Raza, Punta Delgada, Cabo Aristazabal, etc.) the percentages of visibility of some of them have been graphically calculated by noting for each light, on parallel and equi-distant ordinates, equal in number to that of observations, as many points at distances from the original axis proportionate to the limit of visibility observed.

Dividing up the ordinates into equidistant series, or zones, by lines parallel to the abscissae, each corresponding to an average distance from the original axis (the source), a proportion of visibility has been obtained in each zone by counting the ordinates which cross or penetrate into that zone.

But it will be readily conceived that this method of obtaining a curve of visibility for each light must be based on a very considerable number of observations in order to attain any accuracy. When the number of observations is small, the percentages which are obtained in this way are of but very low value.

When the observations are numerous, by drawing a parallel to the abscissae corresponding to the geographical range of the light — as calculated from the altitude of the source of light indicated in the Light List, — the above graph allows the manner in which the observations are distributed on each side of this line to be seen. This gives a concrete idea of the visibility of the light with reference to its geographical range.

ANALYSIS OF THE OBSERVATIONS AS A WHOLE AND CONCLUSIONS

From an examination of the preceding observations the conclusion is arrived at that a series of observations accomplished carefully, continuously, and methodically, during one year only, is insufficient for the purpose of obtaining average percentages with moderate accuracy, and even where a series of observations has been carried on over a period of several years, it is not sufficient in cases where the lights do not lend themselves, on account of their situation, to observations from various distances.

If, on the other hand, a synoptic table of annual percentages was carefully drawn up, similar to that which has been commenced for Denmark, at the end of several years a period could be chosen, including the whole of the years of varying atmospheric conditions, in order to obtain average percentages with some degree of accuracy.

For discontinuous or interrupted observations, the solution of the problem would naturally take a somewhat longer time, and in order to utilise the observations to better advantage it would be advisable to show the distribution of the observations during the different months, supplying at the same time, for the purpose of analysis, some general information as to the atmospheric conditions during each month.

A primary investigation of observations, similar to that given in the attached tables, shows which lights and which groups of lights lend themselves the best to the purposes of obtaining observations for visibility, and for which it is appropriate to continue making observations over a lengthy period with particular care.

Certain lights, however, important to navigation either on account of their characters or of their geographical positions, would merit observation from other positions than those of adjacent lighthouses and from vicinities better distributed around them; but, although this type of observation has been considered in certain countries, it naturally remains subordinated to the expense which such an organisation of an observation service would entail.

The theoretical conclusions mentioned above indicate also that the visual acuteness of the observers has considerable effect, and it would be advisable in order to obtain strict homogeneity in the systematic observations, to carry out the observations under definite conditions (the eye at rest, sheltered from the wind, in the dark and sheltered from the glare of adjacent lights) and by an experienced personnel.

NOTES ON GEOGRAPHICAL RANGE

Geographical Range, which is given in Light Lists in the form of tables, is usually calculated by assuming that the refracted visual trajectory LT, tangent to the earth at T, is circular and is of radius $\frac{R}{K}$, R being the earths radius and K the total cœfficient of terrestrial atmospheric refraction. ($K = 2\gamma$).

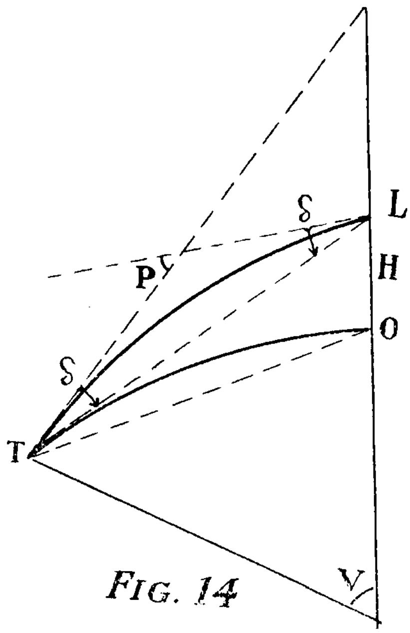

FIG. 14

In fig. 14, taking LOT to be a right angled triangle then H (elevation) = P (range) × tan LTO.

ρ (refraction) = $K \times V$ (geocentric angle).

$$LTO = \tfrac{1}{2} V - \delta = \tfrac{1}{2} V (1 - K)$$

$$\tan V = \frac{P}{R}$$

therefore $H = P \frac{1-K}{2} \times \frac{P}{R}$ and hence the formula $P = \sqrt{\frac{2\,R}{1\text{-}K}} \sqrt{H}$ (1)

which practically gives the optical range up to the point of contact in terms of the elevation of the object and of the cœfficient of atmospheric refraction.

If K is but small with reference to the unit, this formula may be written:

$$P = (1 + \tfrac{1}{2}K) \sqrt{2\,R\,H}$$

the quantity $P_1 = \sqrt{2\,R\,H}$ is the length of the tangent LT, (fig. 15), and $\frac{1}{2}$ K $\sqrt{2\ R\,H}$ or $\gamma \sqrt{2\,R\,H}$ is the increase of geographical range due to refraction.

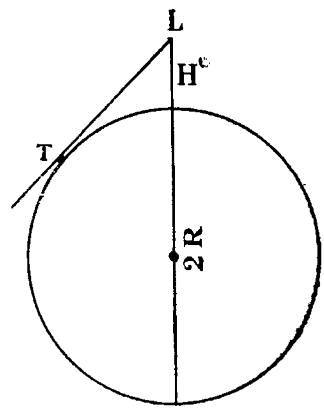

FIG 15

The value of the radical $\sqrt{\frac{2\,R}{1\text{-}K}}$ varies with the values selected for R and K, and according to the units in which P and H are expressed; and it would appear useful to indicate to

L at 0° $R = 6.378.000$ mètres.	
L at 30° $R = 6.373.000$	»
L at 50° $R = 6.366.000$	»
L at 70° $R = 6.359.000$	»

the navigator the average limits of the errors which he might expect to find in the ranges and in the depressions.

By taking for R a uniform value for all the places on the earth (the construction of the formula assumes already that the earth is spherical) selected from the figures in the table here given, which indicates approximately the values of the earths radius at various latitudes, no error over half of one per cent will be introduced, and this is quite negligible in the requirements of navigation.

The uncertainty as to the value of atmospheric refraction is much more appreciable. Without taking into account the occasionally negative or of any too greatly abnormal values of K, it has been noticed on certain coasts that K varies from 0.00 to 0.50, though remaining usually between 0.07 and 0.13 with an average value which has been taken to be about 0.10.

The corresponding values of the radical, the ranges being expressed in nautical miles and the elevation in metres, are as follows:

$K =$ 0.00 ...	.... $1 - K = 1$	$\sqrt{\frac{2R}{1-K}}$ = 1,93
0.07 ...	.... 0.93	.... 2.00
0.10 ...	.... 0.90	.... 2.03
0.13 ...	.... 0.87	.... 2.07
0.50 ...	.... 0.50	.... 2.73

It will be seen therefore that the ranges which would be given by a table based, for instance, on the formule P (miles) = 2.03 $\sqrt{H}$ (metres), would be liable, on account of such varied atmospheric conditions, to be increased or decreased by 2 % to 3 %, and these increases or decreases might in exceptional cases, amount to the order of one quarter of the range indicated.

The following table shows the geographical ranges as deduced from the indications given in the different Light Lists for an elevation of the source of light of 100 metres, and an elevation of the eye of O, (which corresponds, in principle, to ten times the value of the radical of the formula).

The slight divergence of these numbers, which however do not exceed one nautical mile in the example chosen, are the result of the method of drawing up the tables.

Country	Ranges for 100 m. and 0 m.	Formulæ
NORWAY......................	20.8.	
SWEDEN......................	20.8.	
DENMARK	20.8.	
NETHERLANDS................	20.2.	
GT. BRITAIN	20.03.	$P = 1.146 \sqrt{H}$ feet..... $2.07 \sqrt{H}$ m.
		$P = \sqrt{\frac{4}{3}} \sqrt{H}$ feet or $P = 1.555 \sqrt{H}$ fett.... $2.09 \sqrt{H}$ mètres
		ou: – $P = \frac{8}{7} \sqrt{H}$ feet P = 1.143 $\sqrt{H}$ feet.... $2.07 \sqrt{H}$ mètres
		$P =$ (Lenght of the tangent) $\times (1 + 0.08)$
		$P =$ (Length of the tangent) $\times (1 + \frac{1}{13})$
FRANCE	20.9.	
ITALY	20.40.	$P = 2.04 \sqrt{H}$.
PORTUGAL	20.40.	
BRASIL	20.40.	
U. S. A.	20.0.	
ARGENTINE	20.81.	$P = 2.08 \sqrt{H}$.
JAPAN	20.08.	$P =$ (Length of the tangent) $\times (1 + 0.08)$
SIAM..........................	12.96.	

Various formulæ exist for the correction of the average value of the cœfficient of the terrestrial (astronomic) refraction for temperature and low atmospheric pressure, altitude above sea level, and even for the hygrometric state of the air.

For an average hygrometric condition, according to the formula used, when the temperature varies from 10° to 30° *C.* ((49° to 86° *F.*), and the pressure from 710 m/m to 790 m/m (27.95 to 31.10 inches) of mercury, values of K included between 0.07 and 0.14 will be obtained; but these formulæ are still only imperfectly adapted to the practical requirements of navigation.

Consequently it would appear desirable that the various States should inform the International Hydrographic Bureau:

1. What formula is usually employed for calculating geographical range.

2. What are the cœfficients K or γ of average atmospheric refraction which have been observed on their coasts, also the extreme normal and abnormal limits which have been observed in these cœfficients under various circumstances, and the rules which appear to be suitable for navigation.

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Should any reader be aware of other publications which might be included in the above bibliographical information, it is requested that he will be kind enough to advise the International Hydrographic Bureau.

If suitable, such complementary data will be published for the benefit of the readers of the "*Hydrographic Review*".

TABLE I.

OBSERVATIONS OF LIGHTS

SWEDEN 1913-1922

Nº in Light list 1924.	NAME OF OBSERVED LIGHT	Height above high water in meters.	Power in Hefner units	Geographical range in miles (eye: 5 meters).	Percentage of visibility at mean geogr. range %	Number of years during which observations were made	Actual number of days during which Light was exhibited	Annual period of Lighting (*)	Yearly number of observations missing, owing to lighting after 21 h. & extinction before 3 h.	Approximate number of observations recorded.	Percentage of visibility of light observed. %	Distance from light observed in miles.	Distance of horizon of observer in miles.	NAME OF OBSERVING STATION	Nº in Light list 1924.
1	2	3	4	5	6	a	b	c	d	e	7	8	9	10	11
16	*Rödkallen*	25.	34.000	14.8		10 10	1785	Out from 1 June to 10 July	177	3440 3380	91 92	7.7 11.3	5.5 5.2	*Germundsö* Norströmsgrund	5 18
18	Norströmsgrund	6.5	250	9.7		10	1320	d°		3490	73	11.3	10.2	*Rödkallen*	16
45	*Ratan Norra* (blanc)	26.2	850	15.		10 10	2234	Out from 10 June to 10 July	161	5670 5520	59 37	11.4 12.2	12.0 8.8	*Stora Fjäderägg* *Bergudden*	48 49
(1623)	*Valsörarne* (blanc)	37.8	27.000	17.1	66	8 7		Out from 25 May to 25 July		4400 3381	24 84	23.2 13.4	12.0 9.5	*Stora Fjäderägg* *Holmögadd*	48 60
(1623)	*Valsörarne* (rouge)	37.8	25.500	17.1	53	8 7		d°		4496 3367	17 70	23.2 13.4	12.0 9.5	*Stora Fjäderägg* *Holmögadd*	48 60
59	*Jägarören* (blanc)	12.5	600	11.8		10		Out from 25 May to 25 July		5430	61	7.9	12.0	*Stora Fjäderägg*	48
60	*Holmögadd*	21.4	50.000	14.3		10 10	2577	d°	156	5800 5500	80 80	12.0 11.8	8.8 8.7	*Bergudden* *Fjärdgrund Holmsund*	49 50
61	*Sörgadden* (B.)	3.	50	8.1		10		Light from 1 August to 30 Novembr		3130	89	3.4	9.5	*Holmögadd*	60
62	*Nordvalen* (B)	3.	200	8.1		10		d°		3200	91	3.7	9.5	»	»
64	*Vegagrundet* (B)	3.	200	8.1		8		d°		2488	63	8.8	8.7	*Fjärdgrund Holmsund*	50
(1622)	*Norskär*	32.	171.000	16.1		6		Out from 25 May to 20 July		2418	84	12.6	6.8	Sydosbrotten	71
70	*Bonden* (rouge)	35.	1.000	16.6		7		d°		2996	77	8.2	6.8	»	»
80	*Ytternäsan* (rouge)	6.8	150	9.9		10		Out from 25 May to 20 July		5410	50	6.3	17.5	*Högbonden*	81
81	*Högbonden*	75.	15.000			10 10	3563	d°	136	9190 8100	48 71	24.9 16.8	9.5 9.8	*Skag* *Lungö*	74 83
83	*Lungö* (bk.)	23.2	18.000	22.2		10	3320	d°	144	8070	72	16.8	17.7	*Högbonden*	81
95	*Härnö*	20.	80	13.7		10		d°		5710	83	1.7	9.8	*Lungö*	83
98	*Astholmsudde* (blanc)	14.5	300	12.2		10		d°		6540	60	10.2	11.2	*Bremö*	102
99	*Draghällan* (blanc)	11.9	3.000	11.6		10	2735	d°	140	7008	73	10.9	11.2	*Bremö*	102
101	*Lörudden* (blanc) 15-8-19. Aga	5.	40 200	9.1		6 3		d°		4093 2453	19 20	13.2	11.2	*Gran*	103
102	*Bremö*	30.	15.000	15.8		10 10	3503	d°	139	7500 8480	79 81	10.9 12.7	7.0 11.2	*Draghällan* *Gran*	99 103
103	*Gran*	30.	2.700	15.8		10	3464	d°	136	8670	71	12.7	11.2	*Bremö*	102
114	*Agö*	27.	5.000	15.2		10	3161	d°	129	6550	85	10.4	5.5	*Saltviksudde*	127
127	*Saltviksudde* (blanc)	7.3	4.000	10.		10	2481	Out from 1 June to 15 July	130	6440	86	10.4	10.5	*Agö*	114
141	*Storgrundet* (B)	3.	200	8.1		10		Out from 15 Decembr to 15 July		4320	97	1.8	10.3	*Storjungfrun*	140
149	*Trödjehällan* (vert)	5.	37	9.1		10		Out from 1 June to 15 July		6940	4	7.5	8.7	*Eggegrund*	170

(*) These lights are not lit during the period en navigation is interrupted owing to ice in the vicinity.

Nº in Light List 1924.	NAME OF OBSERVED LIGHT	Height above high water in meters.	Power in Hefner units	Geographical range in miles (eye : 5 meters).	Percentage of visibility at mean geogr. range %	Number of years during which observations were made	Actual number of days during which Light was exhibited.	Annual period of Lighting (*)	Yearly number of observations missing, owing to lighting after 21 h. & extinction before 3 h.	Approximate number of observations recorded.	Percentage of visibility of light observed. %	Distance from light observed in miles.	Distance of horizon of observer in miles.	NAME OF OBSERVING STATION	Nº in Light list 1924.
1	2	3	4	5	6	*a*	*b*	*c*	*d*	*e*	7	8	9	10	11
151	*Limö* (blanc).........	29.4	420	15.7		4		Out from 1st June to 15 July		2963	84	6.1	8.7	*Eggegrund*	170
	15-7-17		600			5				3325	90				
153	*Bönan* (vert).........	4.3	25	8.7		10		dº		6990	61	7.0	8.7	»	»
170	*Eggegrund* (blanc) ..	18.5	1.800	13.3		10	3485	dº	116	6060	24	14.7	5.4	Västra Banken........	181
						10				8650	59	13.7	7.7	*Björn*..................	182
171	*Skutskär*	3.9	40	8.5		5		dº		3600	65	6.3	8.7	*Eggegrund*	170
	1-11-17		200			5				3523	79				
179	*Ostra Finngruns-banken* (B)	3.	200	8.1		8		Out from 15 Decembr to 15 July		3528	68	7.7	6.8	Finngrundet	178
180	*Västra Finn-grundsbanken* (B) .	3.	50	8.1		7		dº		3024	26	6.6	5.4	Västra Banken........	181
181	Västra Banken........	7.	4.500	10.		10	2570	Out from 16 January to 1 May	118	6050	16	14.7	8.7	*Eggegrund*	170
182	*Björn* (blanc)	13.8	2.700	12.		10	3421	dº	115	8580	59	13.7	8.7	*Eggegrund*	170
						10				6010	13	15.5	5.4	Västra Banken........	181
						10				8550	73	13.0	12.4	*Orskär*	184
182	*Björn* (rouge).........	13.8	2.700	12.		10	3421	dº	115	8580	55	13.7	8.7	*Eggegrund*	170
						10				6030	99	15.5	5.4	Västra Banken........	181
						10				8710	66	13.0	12.4	*Orskär*	184
183	*Argos grund* (B)	3.	200	8.1		10		Out from 15 Decembr to 15 July		10.090	36	6.0	12.4	*Orskär*	184
184	*Orskär*	36.5	7.600	17.		10	3555	dº	114	8660	68	13.2	7.6	*Björn*..................	182
						9				5004	96	4.4	5.0	Grepen.................	185
						10				6370	71	4.6	6.6	Grundkallen...........	198
185	Grepen...................	6.	70	9.6		6	1337	dº	114	3240	90	4.4	12.4	*Orskär*	184
	1919		500			3				1727	96				
						6	743			3316	80	6.7	9.1	*Djursten*...............	186
						3				1795	91				
186	*Djursten*	20	3.300	13.7		9	2656	dº	110	4896	93	6.7	5.0	Grepen.................	185
192	*Käringön* (B)	3.	40	8.1		7		Out from 6 June to 6 July		4769	80	5.6	9.1	Djursten	186
	27-9-1920		200			2				1365	89				
(1549)	*Märket*.................	16.8	61.900	12.9	70	7		dº		4123	61	13.5	6.6	Grundkallen...........	198
						7				5649	92	6.4	14.2	*Understen*	199
						7				5684	84	11.8	9.0	*Svartklubben*..........	200
196	*Gassten*	3.	65	8.1		10		dº		8400	95	2.3	9.0	*Svartklubben*..........	200
198	Grundkallen (blanc)	10.5	4.500	11.2	82	10	2687	dº	111	6240	68	15.6	12.4	*Orskär*	184
						10				6000	71	13.3	14.2	*Understen*	199
198	» (rouge)		2.250		74	10				5870	57	15.6	12.4	*Orskär*	184
						10				6320	61	13.3	14.2	*Understen*	199
199	*Understen*	48.5	3.000	18.7		6	2120	dº	108	3630	83	13.3	6.6	Grundkallen...........	198
	31-5-19		10.000			2	731			1383	89				
						6				5289	91	6.6	9.0	*Svartklubben*..........	200
						2				1823	93				
200	*Svartklubben*..........	19.5	18.000	13.6		10	2567	dº	106	8830	91	6.6	14.2	*Understen*	199
(1522)	*Sälskär* (blanc)........	29.6	2.700	15.6		7		Out from 15 June to 1 July		5677	46	21.8	14.2	*Understen*	199
(1522)	*Sälskär* (rouge)	29.6	16.700	15.6		7				5733	46	21.8	14.2	*Understen*	199
227	*Simpnäsklubb*.........	13.7	600	12.1		10	3632	dº	102	9310	34	12.6	11.2	*Söderarm*..............	234
						10				8840	33	10.5	8.5	*Tjärven*	235
						10				8850	97	1.1	5.2	*Näskubben*	228

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228	*Näskubben*	6.5	100	9.8		10	3587	Out from 15 June to 1 July	89	8910	97	1.1	7.5	*Simpnäsklubb*	227
230	*Arholma Norra* (bl.)	9.5	200	10.8		2		Out from 6 June to 6 July		1825	95	3.	7.5	»	»
	2-11-21		2.000			1				921	96				
						2				1825	95	2.1	5.2	*Näskubben*	228
						1				817	96				
230	*Arholma Norra* (rou.)	9.5	18	10.8		6		d°		5229	89	3.	7.5	*Simpnäsklubb*	227
	till 12-12-18					6				5197	90	2.1	5.2	*Näskubben*	228
231	*Arholma Södra*	16.	40	12.7		6		d°		5259	92	3.2	7.5	*Simpnäsklubb*	227
	12-12-18		200			2				1825	95				
	9-11-21		2.000			1				816	96				
						6				5202	92	2.3	5.2	*Näskubben*	228
						2				1825	95				
						1				845	97				
(1520)	*Flötjan*	11.6	700	11.5		4		d°		3676	64	11.9	11.2	*Söderarm*	234
234	*Söderarm*	30.3	7.500	15.8	67	10	2921	d°	100	9060	78	12.6	7.5	*Simpnäsklubb*	227
						10				8930	95	2.6	8.5	*Tjärven*	235
						4				1948	19	18.4	6.5	Svenska Björn	261
						10				8870	58	18.6	11.3	*Svenska Högarne*	262
235	*Tjärven*	17.5	14.000	13.1	76	10	3585	d°		9060	96	2.6	11.2	*Söderarm*	234
						10				8840	84	10.5	7.5	*Simpnäsklubb*	227
(1521)	*Lagskär*	39.6	7.300	17.4		2		d°		1369	60	16.6	8.5	*Tjärven*	235
	1919		740.000			3				2266	78				
						2				857	28	15.0	6.5	Svenska Björn	261
						3				1783	85				
						2				1431	68		11.2	*Söderarm*	234
						3				2717	72				
261	Svenska Björn	10.	850	11.		5	1322	d°	94	3046	21	18.4	11.2	*Söderarm*	234
	9-10-21		3.000			1	260			627	3				
						5				2974	44	15.6	4.3	*Svenska Högarne*	262
						1				624	47				
262	*Svenska Högarne* (bl	31.	16.000	15.9		10	3587	d°	93	9310	39	18.6	11.2	*Söderarm*	234
						8				4280	69	15.6	6.5	Svenska Björn	261
						10				9000	69	17.4	11.8	*Grönskär*	263
262	*Svenska Horgarne* (r.	31.	13.000	15.9		10		d°		9250	67	18.6	11.2	*Söderarm*	234
						8				4312	60	15.6	6.5	Svenska Björn	261
						10				8980	68	17.4	11.8	*Grönskär*	263
263	*Grönskär*	33.8	6.000	16.4	73	10	3593	d°	90	8890	71	17.4	11.3	*Svenska Högarne*	262
						8				5944	90	8.5	6.5	Almagrundet	264
						10				9570	0.5	23.8	9.6	*Huvudskär*	288
264	Almagrundet	10.	9.000	11.		1	365	d°		901	84	8.5	11.8	*Grönskär*	263
	24-1-14		3.000			7	2106			5160	85				
						1				1050	1	20.9	9.6	*Huvudskär*	288
						7				5812	1				
269	*Adkubben* (blanc)	6.3	200	9.7		9		d°		6894	91	4.1	11.8	*Grönskär*	263
289	*Landsort* (blanc)	44.5	15.000	18.2	65	10	3652	d°	80	9500	6	25.9	9.6	*Huvudskär*	288
						10				9040	91	8.5	6.1	*Masknuv*	291
						10				9110	63	10.0	8.	*Hävringe*	485
289	*Landsort* (rouge)	44.5	9.000	18.2	55	10		d°	80	9530	4	25.9	9.6	*Huvudskär*	288
						10				9020	89	8.5	6.1	*Mäsknuv*	291
						10				9100	52	19.	8.	*Hävringe*	485

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290	*Viksten*	15.6	300	12.6		10		Out from 6 June to 6 July		8880	91	4.5	6.1	*Mäsknuv*	291
291	*Mäsknuv*	9.	440	10.7		10	3652	d°	81	9110	86	8.5	13.6	*Landsort*	289
298	*Ostra Röko* (vert) 6-12-1913	8.5	5 37	10.5		1 9		d°		881 8110	86 91	3.7	6.1	*Mäsknuv*	291
313	*Grankubben* (vert)	13.	75	11.9		10		d°		8780	86	5.1	13.6	*Landsort*	289
314	*Skoren*	5.6	370	9.4		10		d°		8000	68	8.8	13.6	*Landsort*	289
315	*Oxnö*	24.3	370	14.5		10		d°		7900	71	10.1	13.6	*Landsort*	289
363	Kopparstenarna	7.8	9.000	10.2		3	800	d°	70	1845	84	11.5	13.0	*Gotska Sandön*	364
364	*Gotska Sandön* (Bx)	41.6	50.000	17.7		3	3652	d°	68	2034	91	11.5	5.7	Kopparstenarna	363
364	*Gotska Sandön* (F.)	37.	6.500	17.0		3		d°	68	2028	88	11.5	5.7	Kopparstenarna	363
376	*Ostergarn*	36.2	100.000	16.8		10	3652	d°	34	9100	66	16.3	9.3	*När*	401
401	*När*	20.8	10.000	14.		10 10 10	3652	d°	28	9680 9400 9130	54 18 15	16.3 16.4 24.8	12.3 6.6 15.5	*Ostergarn* *Faludden* *Hoborg*	376 411 421
411	*Faludden*	10.4	10.500	11.1	50	10 10	3652	d°	20	9000 9110	25 56	16.4 9.2	9.3 15.5	*När* *Hoborg*	401 421
421	*Hoborg* 8-11-1915	57.9	7.500 500.000	20.1		2 7 2 5	3287	d°	20	1822 6655 1822 4423	77 87 41 69	9.2 23.1	6.6 15.1	*Faludden* *Stora Karlsö*	411 442
420	*Heligholmen* (vert)	13.	75	11.9		8		d°		7584	76	5.6	6.6	*Faludden*	411
422	*Hoborgs rev* (B)	4.	200	8.7		8		d°		6472	93	3.8	15.5	*Hoborg*	421
442	*Stora Karlsö*	55.	38.000	19.7		10 10	3652	d°	33	8160 9100	73 7	23.1 28.0	15.5 11.4	*Hoborg* *Olands N. Udde*	421 567
450	*Skansudde* (rouge)	7.	60	10.		10	3652	d°	26	9100	2	10.5	15.1	*Stora Karlsö*	442
471	*Oxelösund*	4.	80	8.7		9		d°		6966	79	7.2	8.0	*Hävringe*	485
485	*Hävringe inre*	15.6	3.000	12.6		10	3652	d°	75	9100	53	19.	13.6	*Landsort*	289
						10				9060	41	13.3	8.5	*Arkö*	524
487	*Grässkären* (blanc) 6-7-1915	12.5	300 600	11.8		2 7		d°		1822 6364	57 54	11.7	8.5	*Arkö*	524
487	*Grässkären* (rouge) 6-7-1915 (vert)	12.5	75 75	11.8		2 7		d°		1822 6194	99 89	2.8 2.8	8.0 8.0	*Hävringe* »	485 485
493	*Femörehuvud*	11.5	65	11.5		10 10	3652	d°	75	8990 9020	81 51	12.2 10.8	8.0 8.5	*Hävringe* *Arkö*	485 524
524	*Arkö inre*	17.3	2.500	13.0		10	3652	d°	64	9100	71	13.3	8.0	*Hävringe*	485
545	*Häradskär* (Bk)	35.6	267.000	16.7		10		s°		8440	60	18.7	9.2	*Storkläppen*	546
546	*Storkläppen*	20.5	2.700	13.9		10	3652	d°	52	9110	79	8.7	12.2	*Sparö*	547
547	*Sparö* (f. blanc)	36.	850	16.8		10	3652	d°	50	9090	78	8.7	9.2	*Storkläppen*	546
547	*Sparö* (F. rouge)	36.	900	16.8		10		d°	50	8900	72	8.7	9.2	*Storkläppen*	546

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566	*Olands N. Grund* (B).	3.5	200	8.4		10		Out from 6 June to 6 July		6560	77	7.0	11.4	*Olands N. Udde*........	567
567	*Olands N. Udde*........	31.5	50.000	16.		10	3652	d°	36	9100	9	28.	15.1	*Stora Karlsö*	442
						10				9100	2	29.6	10.2	*Storkläppen*............	556
						10				9100	21	23.8	12.2	*Späro*.....................	547
568	*Högby*	21.7	115.000	14.3		10	3652	d°	8	9110	3	30.6	16.1	*Stora Karlsö*	442
						10				9100	11	13.2	11.4	*Olands N. Udde*......	567
569	*Kapelluden*	29.7	72.000	15.7		10	3652	d°	8	9090	23	20.5	9.4	*Högby*	568
570	*Segerstad*...............	21.	22.000	14.1		10		d°		9110	54	11.8	13.0	*Olands S. Udde*	571
571	*Olands S. Udde*	41.	150.000	17.5	62	9	3227	d°		7110	74	11.8	9.3	*Segerstad*...............	570
						9				7848	76	14.6	10.5	*Garpen*	628
						9				6255	87	10.5	5.0	Utgrunden	636
						9				8315	10	27.4	11.2	*Utklippan*..............	678
573	*Hornsudde*	10.	100	11.		10		d°		8970	25	11.2	8.6	*Dämman*	582
574	*Furö Finnrevet*	14.5	600	12.3		10		d°		9240	39	13.2	8.6	*Dämman*	582
599	*Skäggenäs*	10.	6.500	11.		4	3501	d°	10	3368	89	2.0	5.6	*Ispeudde*...............	600
						10				10230	86	8.	7.5	*Grimskär*...............	617
600	*Ispeudde*...............	7.4	1.600	10.1		3	1095	d°	5	2647	90	2.0	6.5	*Skäggenäs*	599
	3-8 16............		600			6	2160			5000	71				
						3				3283	77	7.2	7.5	*Grimskär*...............	617
						6				5689	44				
617	*Grimskär*...............	13.8	2.500	12.1		10	3565	d°	8	8550	79	8.0	6.5	*Skäggenäs*	599
						4				3192	80	7.2	5.6	*Ispeudde*...............	600
601	*N. Angöringsbojen* .	3.4		8.3		10		d°		6410	81	2.7	7.5	*Grimskär*...............	617
	N. Minningen (roug		30			10		d°		8390	86	2.5	7.5	»	»
	N. Minningen (vert).		15			10		d°		8260	84	2.5	7.5	»	»
604	*Oswallsgrundet* (rou.)	3.2	30	8.2		10		d°		8420	90	1.5	7.5	»	»
	Oswallsgrundet (v.) .	3.2	15	8.2		10		d°		8500	89	1.5	7.5	»	»
606	*Huvudet* (rouge).......	3.2	30	8.2		10		d°		8510	93	1.1	7.5	*Grimskar*...............	617
	Huvudet (vert).........	3.2	15	8.2		10		d°		8490	92	1.1	7.5	»	»
	N. Omböjningen					10		d°		8130	94	0.8	7.5	»	»
	S. Omböjningen......					10		d°		8170	96	0.6	7.5	»	»
	Prästör (rouge).......		30			10		d°		8310	96	0.16	7.5	»	»
	Prästör (vert)		15			10		d°		8650	97	0.3	7.5	»	»
	Trädgårdsgrund	3.2	130	8.2		10		d°		8710	98	1.6	7.5	»	»
628	*Garpen* (blanc)........	26.2	6.000	15.		10	3652	d°		9060	64	14.6	13.0	*Olands S. Udde*	571
628	*Garpen* (rouge)	26.2	1.500	15.		10		d°		6910	92	4.6	5.0	Utgrunden	636
636	Utgrunden	6.	32	9.6		8	2355	d°		5685	79	4.6	10.5	*Garpen*	628
	16-9-21		125			1	287			677	85				
671	*Utlängan* (rouge)....	8.2	175	10.4		9		d°		3744	88	4.6	11.2	*Utklippan*..............	678

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678	*Utklippan* (F. blanc).	30.3	15.000	15.8		9		Out from 6 June to 6 July		7317	7	29.4	17.1	*Hanö*........................	715
678	*Utklippan* (E. blanc)	30.3	95.000	15.8		9	3018	dº		7335	7	29.4	17.1	*Hanö*........................	715
707	*Tärnö* (vert)	31.	80	15.9		10		dº		8990	60	7.4	17.1	*Hänö*........................	715
715	*Hanö*........................	70.5	65.000	21.7		8	2585	dº	19	6818	12	29.4	11.2	*Utklippan*..................	678
735	*Lägerholmen* (rouge)	17.0	1.000	13.		10		dº		8920	56	13.2	17.1	*Hanö*........................	715
(832)	*Hammeren*	91.0	16.000	24.2		10		dº		9800	59	20.9	11.3	*Sandhammaren*	752
(833)	*Hammer-Odde*..........	21.	12.000	14.		10		dº		9780	7	21.0	11.3	»	»
754	*Ystad inre*...............	16.	650	12.7		7	2643	dº	13	6056	8	17.2	9.0	*Smygehuk*	757
758	Trälleborgs redd.......	7.	600	10.		10		dº		8960	80	7.0	9.0	*Smygehuk*	757
767	*Falsterbo*	23.8	15.000	14.5	53	6	2158	dº	27	5238	28	18.2	9.0	*Smygehuk*	757
						6				5178	75	11.3	5.4	Trälleborgs redd	758
						5				4235	94	5.5	6.5	Falsterbo rev	766
						5				4230	68	12.5	6.8	Oskarsgrundet	775
						5				4195	40	13.9	5.3	Kalkgrundet	776
757	*Smygehuk* (blanc) ...	19.6	7.500	13.6	45	9	3310	dº	19	7893	85	7.0	5.4	Trälleborgs redd	758
						9				8262	6	18.2	9.9	*Falsterbo*	767
757	*Smygehuk* (rouge).....	19.6	3.200	13.6	38	9		dº	19	7776	79	7.0	5.4	Trälleborgs redd	758
						9				8208	1	18.2	9.9	*Falsterbo*	767
762	*Trälleborg*..............	16.9	380	12.9		10	3646	dº		8860	96	1.6	5.4	Trälleborgs redd	758
(707)	*Stevns*....................	64.	60.000	20.8		5		dº		4240	84	10.9	6.5	Falsterbo rev	766
						10				9340	77	13.5	9.9	*Falsterbo*	767
(705)	Drogden	10.	12.000	11.		5		dº		4345	67	10.6	9.9	*Falsterbo*	767
						5				4275	91	5.0	6.8	Oskarsgrundet	775
						5				4185	87	7.0	5.3	Kalkgrundet	776
						5				4725	54	10.1	9.3	*Malmö*......................	787
766	Falsterborev...........	10.	3.500	11.		5	1746	dº	23	4460	87	5.5	9.9	*Falsterbo*	767
775	Oskarsgrundet	11.	2.800	11.3	65	4	1879	dº	28	3440	59	12.5	9.9	*Falsterbo*	767
						5				4143	97	2.0	5.3	Kalkgrundet	776
						5				4250	92	4.5	5.0	Malmö redd............	777
						5				4230	89	5.2	9.3	*Malmö*......................	785
776	Kalkgrundet	6.8	1.500	9.9		5	1879	dº	28	4215	97	2.0	6.8	Oskarsgrundet	775
						5				4210	97	2.6	5.0	Malmö redd............	777
						5				4225	94	3.6	9.3	*Malmö*......................	785
785	*Malmö yttre västra* ...	9.8	270	10.9		5		dº		4250	88	5.2	6.8	Oskarsgrundet	775
						5				4215	94	3.5	5.3	Kalkgrundet	776
						5				4325	96	2.2	5.	Malmö redd............	777
787	*Malmö inre*............	20.8	3.000	13.8		5	3652	dº	29	4245	97	2.5	5.	Malmö redd............	777
(689)	*Nordre-röse*............	14.	9.000	12.2	35	5		dº		4235	70	8.6	5.	Malmö redd............	777
										5460	55	10.4	9.3	*Malmö*......................	787
(653)	*Middelgrunds Fort*....	30.	600.000	15.8	68	9		dº		8073	80	12.7	9.3	*Malmö*......................	787
						5				4270	84	10.4	5.	Malmö redd............	777
790	*Barsebäck*	5.3	500	9.2		6		dº		5244	38	8.9	9.3	*Malmö*......................	787
						5				4170	69	6.8	5.	Malmö redd............	777

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Nº in Light List 1924. 1	NAME OF OBSERVED LIGHT 6	Height above high water in meters. 3	Power in Hefner Units 4	Geographical range in miles (eye : 5 meters). 5	Percentage of visibility at mean geogr. range % 6	Number of years during which observations were made a	Actual number of days during which Light was exhibited b	Annual period of Lighting (*) c	Yearly number of observations missing, owing to lighting after 21 h. & extinction before 3 h. d	Approximate number of observations recorded. e	Percentage of visibility of light observed % 7	Distance from light observed in miles. 8	Distance of horizon of observer in miles. 9	NAME OF OBSERVING STATION 10	Nº in Light List 1924 11
(634)	*Kronborg* (blanc)	33.8	1.000	16.4		10		Out from 6 June to 6 July		9050	79	8.5	6.1	*Haken*	802
						10				9100	77	7.6	11.1	*Ven*	803
						6				5046	81	8.8	6.5	Svinbadan	824
(634)	*Kronborg* (rouge)	33.8		16.4		10		d°		8930	75	8.5	6.1	*Haken*	802
						10				9100	67	7.6	11.1	*Ven*	803
802	*Haken*	9.	1.100	10.7		5	1793	d°	35	4265	66	8.2	8.4	*Hälsingborg*	817
803	*Ven*	29.7	5.000	15.6		6	2158	d°	35	5232	79	7.8	8.4	»	»
817	*Hälsingborg*	17.	21.000	13.		9	3287	d°	36	8216	83	7.8	11.1	*Ven*	803
						5				4206	83	9.7	6.5	Svinbadan	824
(628)	*Nakke-Hoved)*	54.	250.000	19.5		6		d°		5070	93	6.3	6.5	Svinbadan	824
						10				9590	83	11.5	19.2	*Kullen*	831
(631)	Lappe-Grund	10.	12.000	11.		6		d°		5298	94	2.1	8.4	*Hälsingborg*	817
	22-9-19		3.500			3				2610	94				
						6				5698	86	7.8	6.5	Svinbadan	824
						3				2477	88				
(625)	Gilleleje-Flak N.	10.	12.000	11.		4		d°		3412	87	7.1	6.5	Svinbadan	824
824	Svinbadan	10.	700	11.		6	2051	d°	39	5508	67	7.9	19.2	*Kullen*	831
(93)	*Hesselö*	40.		17.5		10		d°		9630	57	24.8	19.2	*Kullen*	831
831	*Kullen*	88.5	500.000	23.9	58	6	2158	d°	43	5040	91	7.9	6.5	Svinbadan	824
						6				5250	88	9.5	9.3	*Hallands Väderö*	839
						6				5118	63	22.6	8.5	*Tylö*	841
832	*Kullen nedre* (blanc)	11.5	260	11.5		6		d°		5268	69	9.5	9.3	*Hallands Väderö*	839
832	*Kullen nedre* (rouge)	11.5	65	11.5		6		d°		5298	36	9.5	9.3	*Hallands Väderö*	839
832	*Kullen nedre*	11.5	260	11.5		6		d°		5028	79	8.1	6.5	Svinbadan	824
						6				5742	97	0.2	19.2	*Kullen*	831
839	*Hallands Vädero* (bl.)	20.6	10.000	13.8	69	7	2534	d°	41	6722	82	9.5	19.2	*Kullen*	831
						7				6069	71	13.2	8.5	*Tylö*	841
839	*Hallands Väderö* (r.)	20.6	10.000	13.8	61	7		d°	41	6750	77	9.5	19.2	*Kullen*	831
						7				6083	64	13.2	8.5	*Tylö*	841
841	*Tylö*	17.2	30.000	13.	73	9	3126	d°	42	7713	79	13.2	9.3	*Hallands Väderö*	839
						9				7632	9	20.2	10.9	*Morups Tange*	854
854	*Morups Tange* (blanc	29.	15.000	15.5		9	3049	d°	48	7443	61	11.9	9.5	*Varberg*	858
857	*Lilla Middelgrund* (b)	3.5	130	8.4		6		d°		4710	8	13.0	10.9	*Morups Tange*	854
						6				4518	95	12.4	9.5	*Varberg*	858
858	*Varberg* (blanc)	21.4	14.800	14.2	66	9	3240	d°	50	7830	77	11.9	10.9	*Morups Tange*	854
						9				8181	60	15.5	9.2	*Nidingen*	864
858	*Varberg* (rouge)	21.4	11.500	14.2	61	9		d°		7821	66	11.9	10.9	*Morups Tange*	854
						9				8208	58	15.5	9.2	*Nidingen*	864
859	*Varbergs hamn*	7.1	250	10.0		9		d°		7929	96	0.7	9.5	*Varberg*	858
861	Fladen	10.	2.300	11.0		6	2102	d°	54	5424	62	8.8	9.2	*Nidingen*	864

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Nº in Light List 1924	NAME OF OBSERVED LIGHT	Height above high water in meters.	Power in Hefner Units	Geographical range in miles (eye : 5 meters).	Percentage of visibility at mean geogr. range %	Number of years during which observations were made	Actual number of days during which Light was exhibited.	Annual period of Lighting (*)	Yearly number of observations missing, owing to lighting after 21 h. & extinction before 3 h.	Approximate number of observations recorded.	Percentage of visibility of light observed %	Distance from light observed in miles.	Distance of horizon of observer in miles.	NAME OF OBSERVING STATION	Nº in Light List 1924
1	6	3	4	5	6	a	b	c	d	e	7	8	9	10	11
864	*Nidingen*	20.2	10.000	13.8	70	9	3569	Out from 6 June to 6 July	53	7884	61	15.5	9.5	*Varberg*	858
						6				4950	88	8.8	6.5	Fladen	861
						10				8860	75	13.7	9.7	*Tistlarne*	868
						10				9120	57	15.3	6.7	*Varö*	869
						10				8840	14	21.8	13.8	*Vinga*..............	908
867	*Malö* (rouge)	5.	150	9.1		8		d°		7256	88	2.8	9.2	*Nidingen*	864
860	*Klaback*..............	14.	600	12.2		5		d°		4555	55	11.2	9.2	*Nidingen*	864
868	*Tistlarne* (blanc).......	22.8	15.000	14.4		10	3569	d°	58	9050	41	13.7	9.2	*Nidingen*	864
						10				9010	85	3.5	6.7	*Varö*	869
						10				8850	62	8.2	13.8	*Vinga*..............	908
870	*Rättaren*	5.6	200	9.4		10		d°		8980	90	1.8	6.7	*Varö*	869
871	*Donsöhuvud*	4.9	200	9.		3		d°		2736	87	2.6	6.7	*Varö*	869
908	*Vinga*..............	46.	101.000	18.4	55	10	3634	d°	58	9150	18	21.8	9.2	*Nidingen*	864
						10				9110	89	8.2	9.7	*Tistlarne*	868
						10				9060	73	16.5	12.1	*Pater Noster*..........	927
904	*Buskär*..............	22.	600	14.4		10		d°		9030	94	2.5	13.8	*Vinga*..............	908
905	*Böttö*	13.7		12.1		10		d°		9030	93	4.0	13.8	*Vinga*..............	908
906	*Brännäsbraten*........	6.7	200	9.8		10		d°		9010	76	4.6	13.8	*Vinga*..............	908
923	*Ramholmen Södra* ...	5.3	40	9.2		2		d°		1678	93	3.5	12.1	*Pater Noster*..........	927
	6-7-1915..........		200			7				6293	93				
927	*Pater Noster*..........	35.6	108.000	16.7	71	10	3634	d°	60	9060	74	16.5	13.8	*Vinga*..............	908
						10				8700	81	12.6	11.8	*Maseskär*..............	945
						10				9060	0.3	27.5	12.8	*Hallö*..............	961
928	*Marstrand*..............	7.	200	10.		1									
	17-11-1914.......		400			8		d°	58	911	95	3.5	12.1	*Pater Noster*..........	927
										7104	94				
(17)	Läsö-Trindel	10.		11.		10		d°		8960	70	12.8	13.8	*Vinga*..............	908
945	*Maseskär*..............	33.8	60.000	16.4		10	3634	d°	62	9040	80	12.6	12.1	*Pater Noster*..........	927
						10				10180	66	14.9	12.8	*Hallö*..............	961
951	*Osö*	15.4	40	12.5		5		d°		4464	96	1.2	8.2	*Islandsberg*	949
	1-10-1918		200			4				3587	96				
961	*Hallö*..............	39.2	72.000	17.4		10	3634	d°	65	9200	78	14.9	11.8	*Maseskär*..............	945
						10				9070	83	10.2	8.2	*Islandsberg*	949
						10				9060	89	5.0	7.9	*Klövskär*	968
						10				9090	74	13.5	11.6	*Väderöbod*..............	972
966	*Holländarberg*.........	18.4	270	13.3		4		d°		3553	77	3.4	7.9	*Klövskär*	968
	25-4-1917		200			5				4561	83				
						4				3593	3	12.4	11.6	*Väderöbod*..............	972
						5				4604	44				
967	*Skarvasätt*..............	11.3	270	11.4	6	4		s°		3563	50	3.2	7.9	*Klövskär*	968
	25-4-1917		200		48	5				4557	88				
						4				3593	2	12.	11.6	*Väderöbod*	972
						5				4547	44				
968	*Klövskär*	15.	600	12.5		10	3624	d°	64	9040	20	5.0	12.8	*Hallö*..............	961
970	*Langholmen*	7.7	270	10.1		4		d°		3624	65	6.9	7.9	*Klövskär*	968
	20-8-1917..........		400			5				4557	76				

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N° in Light List 1924	NAME OF OBSERVED LIGHT	Height above high water in meters.	Power in Hefner Units	Geographical range in miles (eye : 5 meters).	Percentage of visibility at mean geogr. range %	Number of years during which observations were made	Actual number of days during which Light was exhibited	Annual period of Lighting (*)	Yearly number of observations missing, owing to lighting after 21 h. & extinction before 3 h.	Approximate number of observations recorded	Percentage of visibility of light observed %	Distance from light observed in miles.	Distance of horizon of observer in miles.	NAME OF OBSERVING STATION	N° in Light list 1924
1	2	3	4	5	6	a	b	c	d	e	7	8	9	10	11
971	*Magholmen*............	15.4	270	12.6		4		Out from 6 June to 6 July		3624	65	7.4	7.9	*Klövskär*	968
972	*Väderöbod* (blanc)....	32.	48.000	16.1	70	10	3502	d°	67	9040	71	13.5	12.8	*Hallö*......................	961
						10				9040	82	9.1	7.9	*Klövskär*	968
						10				8610	69	17.5	11.7	*Ursholmen*	989
972	*Väderöbod* (rouge) ...	32.	24.000	16.1	62	10		d°	67	9070	70	13.5	12.8	*Hallö*......................	961
						10				9080	78	9.1	7.9	*Klövskär*	968
						10				8560	61	7.5	11.7	*Ursholmen*	989
987	*Ramskär*................	19.	650	13.5		4		d°		3632	71	4.5	11.7	*Ursholmen*	989
988	*Svangen*	21.5	750	14.3		5	3624	d°		4580	79	4.5	11.7	*Ursholmen*	989
989	*Ursholmen*	33.	10.000	16.2	68	10	3634	d°	69	9110	65	17.5	11.6	*Väderöbod*............	972
						4				3624	92	4.5	9.5	*Svangen*	988
						10				8800	94	5.6	6.3	Grisbadarne	994
(971)	*Färder*	47.	222.000	18.5	70	10				8820	71	18.0	11.7	*Ursholmen*	989
						10				8670	84	12.7	6.3	Grisbadarne	994
(974)	*Torbjörnskjär* (bl.)....	25.7	2.486	14.9	61	10				8700	68	11.5	11.7	*Ursholmen*	989
						10				8570	87	5.1	6.3	Grisbadarne	994
(974)	*Torbjörnskjär* (r.).....	25.7	2.608	14.9	34	10				8700	58	11.5	11.7	*Ursholmen*	989
						10				8670	84	5.1	6.3	Grisbadarne	994
994	Grisbadarne	9.5	1.300	10.9		10	3547	Out from 6 June to 6 July	69	8530	77	5.6	11.7	*Ursholmen*	989

(*) These lights are not lit during the period when navigation is interrupted owing to ice in the vicinity.

TABLE 1[A]

OBSERVATIONS OF LIGHTS

DENMARK 1921-1924

Nº in Light list. 1924.	NAME OF LIGHT OBSERVED	Height above high water in meters.	Power in Hefner units.	Geogr. range (eye: 5 meters) in miles.	Percentage of visibility at mean geogr. range %	Pourcentage of visibility of light observed in 7					Distance from light observed in miles.	Distance of horizon of observer in milles	NAME OF OBSERVING STATION	Nº in Light list. 1924.
						1921	1922	1923	1924	mean 1921-1924				
1	2	3	4	5	6	a	b	c	d	e	8	9	10	11
49	*Blaavands-Huk*	55	180.000	19.7		73	79.	80.5	70.5	76.	11.4	10.6	*Soedenstrand*..........	15
60	*Bovbjerg*	62	16.000	20.6		54.	58.5	56.5	48.	54.	19.4	14.3	*Lodbjerg*	69
69	*Lodbjerg*	48	80.000	18.8		56.	51.	50.5	43.5	50.	19.4	15.9	*Bovbjerg*	60
						47.	52.	50.5	42.	48.	20.5	16.4	*Hanstholm*	78
78	*Hanstholm*	65	8.000.000	21.		64.5	69.	67.	61.	65.	20.5	14.3	*Lodbjerg*	69
86	*Rubjerg-Knudde*......	90	240.000	24.2		83.	83.	86.	77.	82.	9.8	15.4	*Hirshals*	89
89	*Hirshals*	57	140.000	20.0		83.	86.5	86.	76.	83.	9.8	19.4	*Rubjerg-Knudde*......	86
						54.	61.	55.5	47.	54.	24.1	13.6	*Skagen*..................	93
93	*Skagen*..................	44	200.000	18.1		56.	61.	56.	44.5	54.	24.1	15.4	*Hirshals*	89
						96.	98.	98.5	96.5	97.	2.4	7.6	*Hojen*	92
						79.	83.5	82.	71.	79.	15.	11.2	*Hirsholm*...............	102
102	*Hirsholm*...............	30	36.000	15.8		73.	76.5	77.	65.5	73.	15.	13.6	*Skagen*..................	93
						84.	87.5	87.	77.	84.	12.2	8.2	*Nordre-Ronner*	104
104	*Nordre-Ronner*	16	2.000	12.7		61.	64.5	56.	49.5	58.	12.2	11.2	*Hirsholm*...............	102
115	*Hesselo*..................	40	120.000	17.5		60.	57.5	54.	45.5	54.	22.	15.	*Nakke-Hoved*...........	223
151	*Fornæs*	32	350.000	16.1		73.	73.	72.	64.	70.	19.3	14.4	*Hjelm*	158
158	*Hjelm*	50	100.000	19.		62.	60.5	54.5	47.5	56.	19.3	11.6	*Fornæs*	151
						88.	89.	86.5	79.5	86.	10.1	8.4	*Sletterhage*.............	164
						73.	71.5	72.	62.	70.	15.9	11.4	*Sejro*	212
190	*Œbelo*	20	60.000	13.7		68.	67.	70.	59.	66.	15.2	12.2	*Vestborg*................	195
195	*Vestborg*................	35	60.000	16.8		82.	82.5	82.5	72.5	80.	11.1	10.	*Revsnæs*	208
208	*Revsnæs*	24	150.000	14.6		76.	78.5	81.	71.	76.	11.1	12.2	*Vestborg*................	195
						72.	71.	74.	63.	70.	12.8	11.4	*Sejro*	212
						67.5	70.5	71.5	62.	68.	14.1	8.4	*Romso*...................	329
212	*Sejro*	31	35.000	15.9		73.	73.5	73.	63.	71.	15.9	14.4	*Hjelm*	158
						78.	78.5	73.	63.	71.	15.9	14.4	*Revsnæs*	208
216	*Sjoelanda Rev* (B) ...	14	350	12.2		35.	34.5	34.5	27.	33	14.2	14.4	*Hjelm*	158
223	*Nakke-Hoved*..........	54	250.000	19.8		69.	71.	68.5	57	66.	22.	12.9	*Hesselo*..................	115
251	*Trekroner*	20	2.000	13.7		97.	96.5	96.	94.	95.	2.	11.2	*Middelgruns-Fort*....	274
						93.	92.5	92.	87.	91.	4.7	7.6	*Nordre-Rose*...........	293
274	*Middelgrunds-Fort*...	30	300.000	15.8		97.5	97.5	97.5	94,5	97	2.	9.1	*Trekroner*	251
						97.	96.5	96.	93.5	96	5.1	7.6	*Nordre-Rose*...........	293
284	*Flak Fort*	21	17.000	14.		97.	96.5	96.	94.	96.	2.4	11.2	*Middelgrunds-Fort*...	274
									90.	90.	4.0	9.1	*Frekrener*...............	251
293	*Nordre-Rose*...........	14	8.000	12.2		91.5	90.5	91.	85.5	90.	5.1	11.2	*Middelgrunds-Fort*...	274

Nº in Light list. 1924.	NAME OF LIGHT OBSERVED	Height above high water in meters.	Power in Hefner units.	Geogr. range (eye: 5 meters) in miles.	Percentage of visibility at mean geogr. range %	Percentage of visibility of light observed in 7					Distance from light observed in miles.	Distance of horizon of observer in miles	NAME OF OBSERVING STATION	N° in Light list. 1924.
						1921	1922	1923	1924	mean 1921-1924				
1	2	3	4	5	6	*a*	*b*	*c*	*d*	*e*	8	9	10	11
317	*Sprogo*	44	35.000	18.1		79.	81.	81.	71.	78.	12.3	8.4	*Romso*	329
						79.	80.	80.	70.5	77.	11.7	9.3	*Omo*	359
						82.	82.	81.	74.5	80.	11.1	7.1	*Hov*	353
329	*Romso*	17	6.000	13.		71.	68.5	70.	59.5	67.	14.1	10.1	*Resnæs*	208
						76.	73.5	76.5	64.	72.	12.3	13.6	*Sprogo*	317
333	*Knudshoved*	14	2.000	12.2		94.5	93.5	94.	86.	92.	4.7	13.6	*Sprogo*	317
354	*Trannekjær*	14	3.500	12.2		62.	63.5	—	—	63.	13.3	9.3	*Omo*	359
			5.000			—	—	57.	49.5	54.				
359	*Omo*	21	11.000	14.		75.	74.5	77.5	68.	74.	11.7	13.6	*Sprogo*	317
						90.	90.5	90.5	85.	89.	6.1	7.1	*Hov*	353
						71.	72.5	73.	65.	70.	13.3	7.6	*Trannekjær*	354
388	*Baago*	12	600	11.6		50.	53.5	51.5	40.	46.	11.5	11.2	*Helnaes*	396
396	*Helnæs*	30	6.000	15.8		57.5	54.5	56.	50.5	55.	12.6	11.6	*Skjoldnaes*	397
						85.	86.5	83.5	77.	83.	7.6	10.6	*Taksensand*	403
397	*Skjoldnaes*	32	60.000	16.1		80.	81.	79.5	69.5	77.	12.6	11.2	*Helnæs*	396
						87.	90.5	87.	80.	81.	8.7	10.6	*Taksensand*	403
401	*Norborg*	27	6.000	15.2		79.	79.	78.5	69.	76.	9.8	11.2	*Helnæs*	396
403	*Taksensand*	28	6.000	15.3		86.	85.5	—	—	86.	7.6	11.2	*Helnæs*	396
414	*Kegnæs*	32	2.000	16.1		75.	75.5	71.	62.	71.	10.3	11.6	*Skyjoldnæs*	397
430	*Hyllekrog*	19	85.000	13.5		58.5	59.5	56.5	50.5	56.	16.3	10.4	*Gjedser*	437
437	*Gjedser*	26	140.000	15.0		67.5	71.	68.5	62.	67.	16.3	8.9	*Hyllekrog*	430
448	*Hellehavn-Nakke*	40	3.300	17.5		65.5	56.5	47.	42.	53.	17.2	16.3	*Stevns*	308
454	*Hammeren*	91	16.000	24.2		96.5	98.	97.	95.	97.	0.8	9.3	*Hammer-Odde*	456
						81.	81.	80.5	72.5	79.	15.	11.	*Christianso*	464
564	*Hammer-Odde*	21	10.000	14.		77.	74.5	—	—	76.	14.4	11.	*Christianso*	464
			12.000			—	—	70.	62.	66.				
464	*Christianso*	29	50.000	15.5		79.	75.	74.	65.	73.	15.	19.5	*Hammeren*	454
						81.	80.	78.5	70.5	77.	14.4	9.3	*Hammer Odde*	456
						87.5	87.	86.5	79.	85.	11.4	9.1	*Svaneke*	471
471	*Svaneke*	20	35.000	13.7		87.5	88.	86.	79.	85.	11.4	11	*Christianso*	464
594	*Vejro*	19	6.000	13.5		71.	71.	72.	68.	70.	10.8	9.3	*Omo*	359

TABLE 2.

RECIPROCAL OBSERVATIONS OF LIGHTS

SWEDEN 1913-1922

Light List Nº of Light A	NAME OF LIGHT A	Power of Light A in Hefner units.	Percentage of visibility of A from B %	Distance between A & B in miles.	Percentage of visibility of B from A %	Power of light B in Hefner units.	NAME OF LIGHT B	Light List Nº of Light B.
1	2	3	4	5	6	7	8	9
16	**Rödkallen**	34.000	92	11.3	73	250	*Norstromsgrund*	18
81	**Högbonden**.................	15.000	71	16.8	72	18.000	Lungö..................	83
99	**Draghällan**	3.000	73	10.9	79	15.000	Bremö	102
114	**Agö**.........................	5.000	85	10.4	86	4.000	Saltviksudde	127
170	**Eggegrund**..................	1.800	16	14.7	24	4.500	*Västra Banken*	181
185	*Grepen*	70	80	6.7	93	3.300	Djustern	186
		500	91					
184	**Orskär**......................	7.600	68	13.2	12.4	2.700	Björn (*blanc*)	182
					12.4	2.700	Björn (*rouge*)	182
			96	4.4	90	70	*Grepen*	185
					96	500		
			71	15.6	68	4.500	*Grundkallen* (blanc)	198
					57	2.250	» (*rouge*).....	198
199	**Understen**	3.000	83	13.3	71	4.500	*Grundkallen (blanc)*	198
		10.000	89		61	2.250	» (*rouge*).....	198
			91	6.6	91	1.800	Svartklubben	200
227	**Simpnäsklubb**.............	600	34	12.6	78	7.500	Söderarm	234
			33	10.5	84	14.000	Tjärven	235
			97	1.1	97	100	Näskubben	228
234	**Söderarm**	7.500	95	2.6	96	14.000	Tjärven	235
262	*Svenska Högarne (blanc)*	16.000	69	15.6	44	850	*Svenska Bjorn*	261
	» » (*rouge*)	13.000	60		47	3.000	» »	261
263	**Grönskär**	6.000	71	17.4	69	16.000	*Svenska Hogarne* (bl.) .	262
					68	13.000	» » (*rouge*	262
289	**Landsort** (*blanc*)..........	15.000	91	8.5	86	440	Masknuv..................	291
	» (*rouge*)	9.000	89					
			63	19.	53	3.000	Hävringe.................	485
			52					
363	*Kopparstenarne*...........	9.000	84	11.5	91	50.000	Gotska Sandön (Bx) ...	364
					88	6.500	» » (F.) ..	
401	**När**	10.000	54	16.3	66	100.000	Ostergarn	376
411	**Faludden**	10.500	56	9.2	77	7.500	Hoborg	421
					87	500.000	»	»
442	Stora Karlsö	38.000	73	23.1	41	7.500	Hoborg	421
					69	500.000	»	»
				28.	9	50.000	Olands N. Udde.........	567

Light List N° of Light A 1	NAME OF LIGHT A 2	Power of Light A in Hefner units. 3	Percentage of visibility of A from B % 4	Distance between A & B in miles. 5	Percentage of visibility of B from A % 6	Power of light B in Hefner units. 7	NAME OF LIGHT B 8	Light List N° of Light B. 9
546	**Storkläppen**	2.500	79	8.7	78	850	Sparö (*blanc*)............	547
					72	900	» (*rouge*)	»
571	**Olands S. Udde**..........	150.000	74	11.8	54	2.200	Segerstad	570
			76	14.6	64	6.000	Garpen	628
599	**Skäggenäs**	6.500	89	2.	90	1.600	Ispeudde.................	600
					71	600	»	»
			86	8.	79	2.500	Grimskar	617
617	**Grimskär**..................	2.500	80	7.2	77	1.600	Ispeudde.................	600
					44	600	»	»
628	*Garpen*	1.500	92	4.6	79	32	*Utgrunden*	636
					85	125	»	»
678	**Utklippan** (Bx)	95.000	7	29.4	12	65.000	Hanö......................	715
	» (F.)	15.000	7					
758	*Trällegorsredd*	600	80	7.	85	7.500	Smygehuk (*blanc*).......	757
					79	3.200	» (*rouge*).......	»
767	**Falsterbo**	15.000	28	18.2	6	7.500	Smygehuk (*blanc*).......	757
					1	3.200	» (*rouge*)	»
			94	5.5	87	3.500	*Falsterbo rev*.............	766
775	*Oskarsgrundet*	2.800	59	12.5	68	15.000	Falsterbo..................	767
			97	2.	97	1.500	Kalkgrundet	776
			89	5.2	88	270	Malmö yttre västra ...	785
803	**Ven**..........................	5.000	79	7.8	83	21.000	Hälsingborg	817
831	**Kullen**	500.000	91	7.9	67	700	*Svinbadan*	824
			88	9.5	82	10.000	HallandsVädero (*blanc*)	839
					77	10.000	» » (*rouge*)	»
839	**Hallands Vadero** (*rouge*).	10.000	71	13.2	79	30.000	Tylö	841
»	» » (*blanc*)	10.000	64					
858	**Varberg** (*blanc*)	14.800	77	11.9	61	15.000	Morups Tange...........	854
»	» (*rouge*)..........	11.500	66					
			60	15.5	61	10.000	Nidingen..................	864
			58					
864	**Nidingen**..................	10.000	88	8.8	62	2.300	*Fladen*	861
			75	13.7	41	15.000	Tistlarne	868
			14	21.8	18	101.000	Vinga	908
908	**Vinga**.......................	101.000	89	8.2	62	15.000	Tistlarne	868
			73	16.5	74	108.000	Pater Noster.............	927
927	**Pater Noster**..............	108.000	81	12.6	80	60.000	Maseskär	945
			89	5.	20	600	Klövskär	968
			74	13.5	71	48.000	Väderöbod (*blanc*).......	972
					70	24.000	» (*rouge*)	»
982	**Ursholmen**.................	10.000	65	17.5	69	48.000	Väderöbod (*blanc*).......	972
					61	24.000	» (*rouge*).......	»
			92	4.5	79	750	Svangen....................	988
			94	5.6	77	1.300	*Grisbadarne*	994

TABLE 2 A

RECIPROCAL OBSERVATIONS OF LIGHTS

DENMARK 1920-1923

Light List Nº of Light A 1	NAME OF LIGHT A 2	Power of Light A in Hefner units. 3	Percentage of visibility of A from B % 4	Distance between A & B in miles. 5	Percentage of visibility of B from A % 6	Power of light B in Hefner units. 8	NAME OF LIGHT B 9	Light List Nº of Light B. 6
69	Lodbjerg	80.000	50	19.4	54	16.000	Bovbjerg	60
			48	20.5	65	8.000.000	Hanstholm	78
89	Hirshals................	140.000	83	9.8	82	240.000	Rubjerg-Knudde ...	86
			54	24.1	54	200.000	Skagen	93
102	Hirsholm	30.000	73	15	79	200.000	Skagen	93
			84	12.2	58	16.000	Nordre Ronner	104
115	Hesselô...............	120.000	54	22	66	250.000	Nakke-Hoved	223
158	Hjelm..................	100.000	56	19.3	70	350.000	Fornaes...............	151
			70	15.9	71	35.000	Sejrô	212
208	Revsnœs..............	150.000	70	12.8	76	35.000	Sejrô	212
			76	11.1	80	60.000	Vestorg	195
			68	14.1	67	6.000	Romsô................	329
251	Trekroner	2.000	95	2	97	300.000	Middelgrunds Fort.	274
293	Nordre Rôse	8.000	90	5.1	96	300.000	Middelgrunds Fort.	274
317	Sprogó................	35.000	78	12.3	72	6.000	Romsô................	329
			77	11.7	74	11.000	Omô	359
359	Omô	11.000	70	13.3	63	3.500	Trannekjaer	354
					54	5.000	»	»
396	Helnaes...............	6.000	55	12.6	77	60.000	Skjoldnaes	397
			83	7.6	86	6.000	Taksensand	403
430	Hyllekrog	85.000	56	16.3	67	140.000	Gjedser................	437
464	Christiansô	50.000	73	15	79	16.000	Hammeren	454
			77	14.4	76	10.000	Hammer-Odde.......	456
					66	12.000	» »	»
			85	11.4	85	35.000	Svaneke................	471

TABLE 3.

OBSERVED LIGHT	Power in Hefner Units.	Power × 0 6	Ranges (in miles) corresponding to percentages.		
			90 %	75 %	50 %
Märket	61.000	36.600	7.6	11.4	16.
Söderarm	7.500	4.500	7.8	13.2	18.4
Grönskär	6.000	3.600	9.2	15.2	20.
Landsort	15.000	9.000	9.2	14.8	19.5
Olands. S. Udde	150.000	53.000	9.	14.	19.
Christianso	50.000	30.000	8.8	14.2	—
Falsterbo	15.000	9.000	8.6	10.8	15.2
« Drogden »	12.000	7.200	5.8	9.	12.4
« Oskarsgrundet »	2.800	1.700	4.8	9.	13.6
Kullen	500.000	270.000	10.	16.6	24.
Nidingen	10.000	6.000	8.2	13.2	17.2
Vinga	101.000	60.600	10.	14.4	18,8
Pater Noster	108.000	65.000	9.5	15.2	21.
Hällö	72.000	43.200	7.2	13.2	—
Väderöbod	48.000	28.800	6.8	12.8	—
Ursholmen	10.000	6.000	7.2	13.2	—
Hirsholm	36.000	21.600	9.2	14.2	19.4
Skagen	200.000	99.000	7.6	16.6	25.
Hjelm	100.000	60.000	8.8	14.2	—
Revsnoes	150.000	54.000	6.	11.4	—

Equation of Ranges

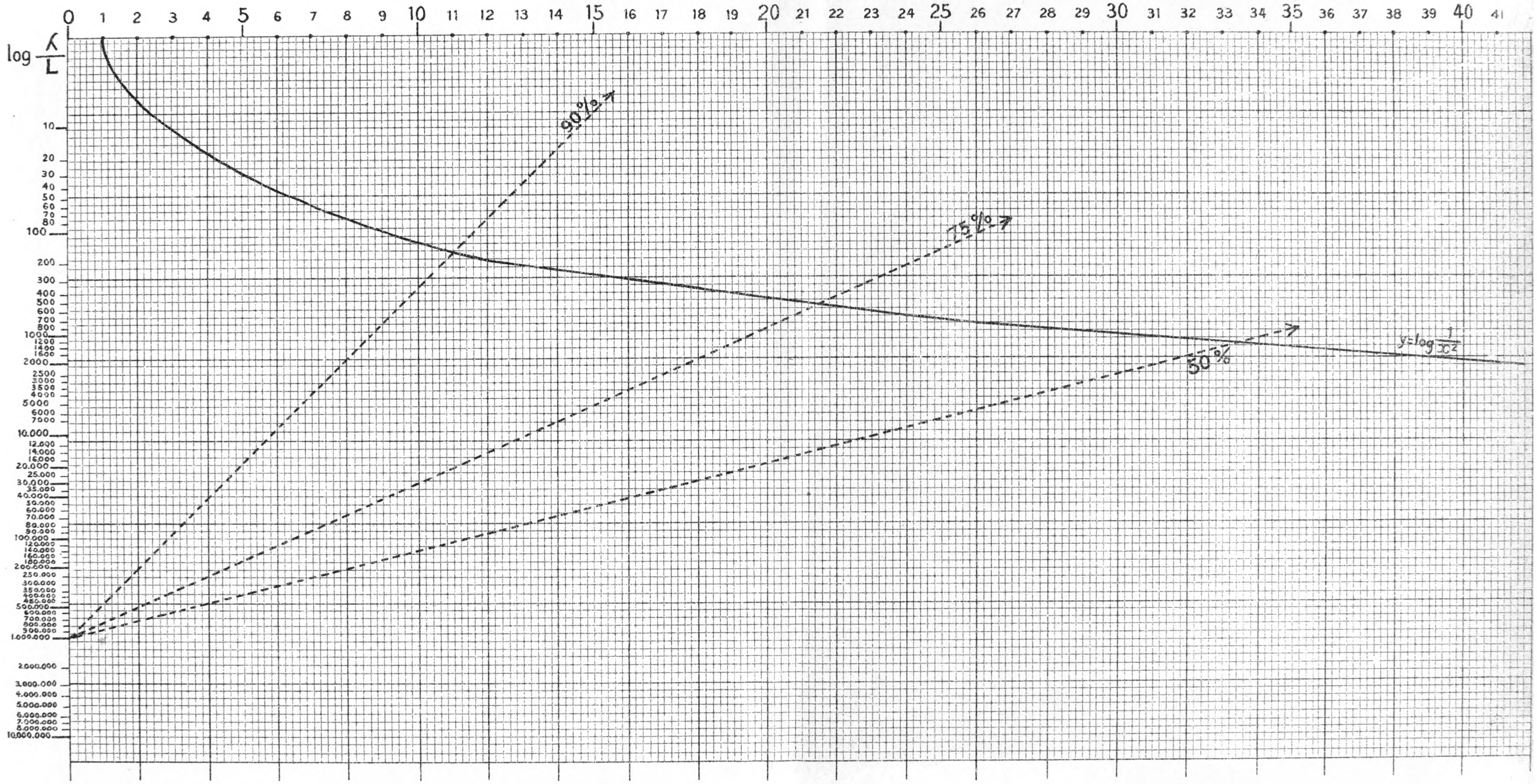
Plate I

$\lambda = \dfrac{L a^x}{x^2}$ $\quad$ $\lambda = 1.14$ Hefner Unit, $\lambda = 1.02$ Intern^l candle } at 1 nautical mile

L = effective candle power λ

a = co-efficient of transparency for 1 nautical mile

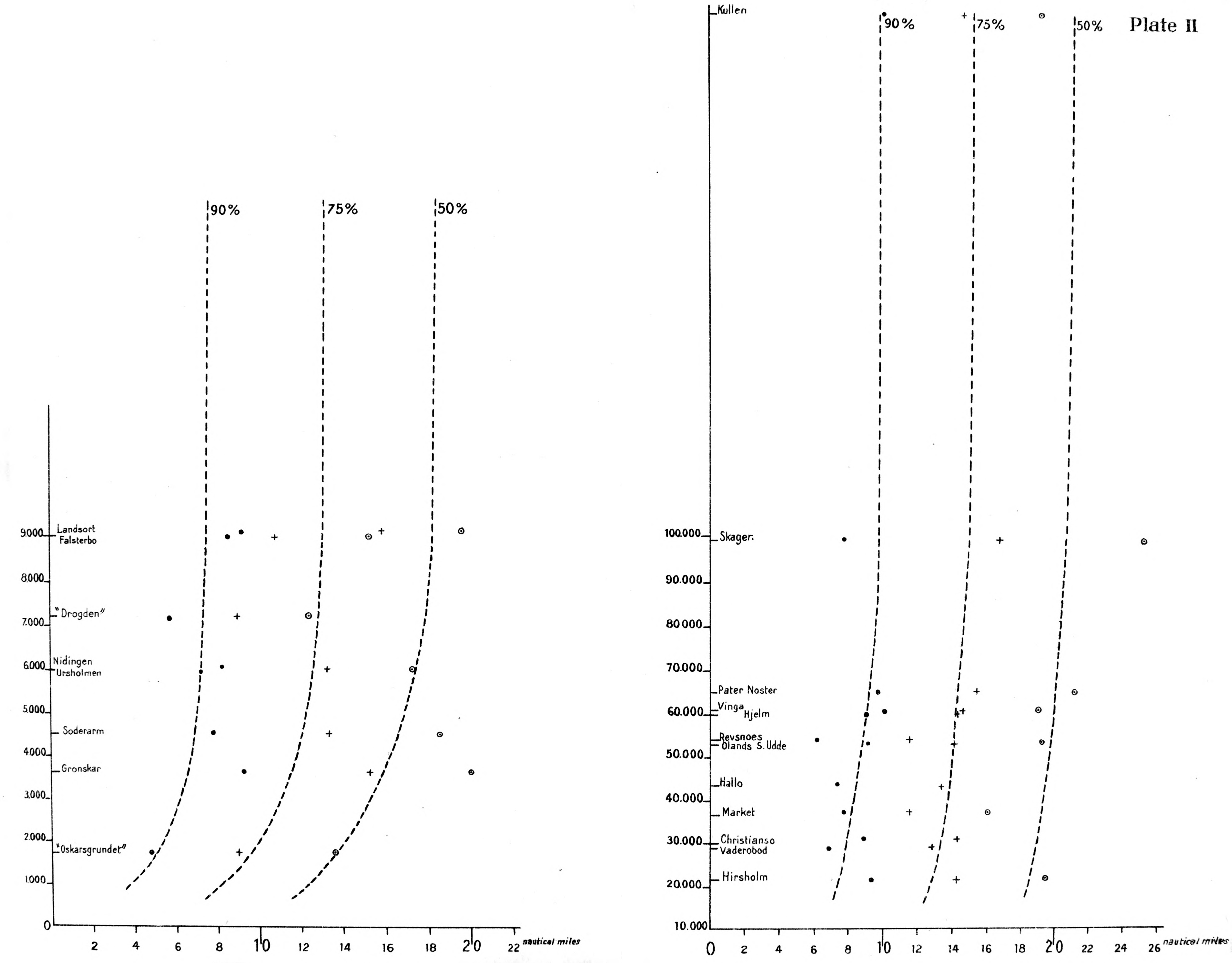
Ranges in nautical miles x



Range is obtained by intersection between curve $y = \log \frac{1}{x^2}$ and the straight line $y = (-\log a)\,x + \log \frac{\lambda}{L}$ cutting the original ordinate corresponding to candle power L and making an angle with the abcissae the tangent of which $(-\log a)$ corresponds to the probable co-efficient of transparency.

NOTE *(pecked lines correspond approximately to percentages encountered when entering the Baltic.)*

Plate II


90%
75%
50%
Landsort
Falsterbo
"Drogden"
Nidingen
Ursholmen
Soderarm
Gronskar
"Oskarsgrundet"
9.000
8.000
7.000
6.000
5.000
4.000
3.000
2.000
1000
0
2 4 6 8 10 12 14 16 18 20 22
nautical miles
Kullen
Skagen
Pater Noster
Vinga
Hjelm
Revsnoes
Olands S. Udde
Hallo
Market
Christianso
Vaderobod
Hirsholm
100.000
90.000
80.000
70.000
60.000
50.000
40.000
30.000
20.000
10.000
0 2 4 6 8 10 12 14 16 18 20 22 24 26
nautical miles