VISUAL ACUITY IN CONNECTION WITH TELEVISION

by G. J. FORTUIN.

The information obtained when looking at a two-dimensional, flat object, e.g. a photograph or a television picture, is determined on the one hand by the sharpness and contrast of the image itself, and, on the other, by the properties of the observer's eye and the conditions of observation (brightness, distance between the eye and the object).

The property of the eye that is decisive in this respect, viz. the visual acuity, can be expressed quantitatively by the angle \( \theta_0 \) subtended at the eye by the smallest perceptible detail. This angle is frequently assumed to be approximately one minute of a degree, but it is highly misleading to attribute a fixed value to \( \theta_0 \). As will be seen, \( \theta_0 \) depends not only on the luminance, but also to a very considerable extent on the contrast. Furthermore, there may be individual differences, which may be accentuated by insufficient correction of refraction errors (wrong spectacles, or no spectacles at all). Moreover the age of the observer greatly affects the value of \( \theta_0 \).

In television the smallest detail in the vertical direction is determined by the scanning width: in the case of a 625-line, 30 \( \times \) 40 cm picture this width is approximately 0.5 mm. The smallest detail in the horizontal direction is determined by the highest modulation frequency, and it can be assumed that it is of the same order of magnitude. If \( d \) be the size of the smallest detail, then the maximum distance at which it can be discerned, is \( a = d/\theta_0 \). With \( d \approx 0.5 \text{ mm} \) and \( \theta_0 = 1' \), it follows that \( a = 1.8 \text{ m} \). This, of course, is only an approximation, for \( a \) is actually a dependent on all the above-mentioned factors which affect the value of \( \theta_0 \).

It is evident that as a rule the observer wants to watch the screen from a distance at which it is just possible for him to discern the smallest details with smallest contrasts. As the contrast between the lines of the image and the spaces in between is greater than the smallest contrast the observer wants to see, the scanning lines themselves will also be clearly distinguished. Experience has shown that viewers do not object to this.

It is important in this connection to consider more closely the factors influencing the value of \( \theta_0 \).

In 1951 Philips' Medical Department carried out extensive research into the relationship between visual acuity, contrast and brightness in connection with the age of the observer\(^1\), and the results obtained in this work are applicable to the problem under discussion. The 228 persons tested (of ages varying from 7 to 64 years) comprised school children, applicants for jobs, and in the higher age categories, employees of the Philips works. To permit conclusions of practical value to be drawn from the tests, all these persons were subjected to the examination in their normal, every-day circumstances, i.e., no attempts were made to improve their eyesight, for example, by means of spectacles. The original object of the investigation was to examine the influence of age on vision during very delicate manufacturing operations (assembling of radio tubes) and to what extent this can be compensated by raising the level of illumination. The tests partly confirmed earlier results about the relationship between visual acuity, contrast and brightness\(^2\), which could now be combined into a single empirical formula, also containing a factor concerning the influence of the observers' age on his visual acuity.

Testing procedure

Since an object can be fairly easily recognized according to its shape (this is illustrated, e.g. by the varied shapes of printed letters), it is desirable in an investigation into visual acuity to use some kind of standardized object. In the present case a so-called Landolt ring was used for this purpose (fig. 1).

The rings are on a white panel (fig. 2) which is divided into 16 \( \times \) 11 squares, in each of which a black or grey paper Landolt ring is pasted. There


are eight different ring positions (opening at top, bottom, left, right, or at 45° in between). In each vertical column the outside diameter of the rings diminishes from top to bottom according to a geometrical progression from 50 to 2.2. In each horizontal row the contrast diminishes from right to left according to an arithmetical progression from 0.94 to 0. The contrast is determined by the difference in luminance \( L_a - L_r \) between background and ring divided by the luminance \( L_a \): alternatively if background and ring receive equal amounts of light, the contrast is determined by the difference in reflective power \( \varrho_a - \varrho_r \) between background and ring divided by the reflective power \( \varrho_a \) of the background:

\[
C = \frac{L_a - L_r}{L_a} = \frac{\varrho_a - \varrho_r}{\varrho_a}.
\]

The visual acuity in this Landolt ring test is determined by the reciprocal value of the angle (expressed in minutes of arc) subtended by the aperture of the ring, in the case of the smallest ring whose position the observer is able to ascertain. If this angle be \( D_\theta \), then \( 1/D_\theta \) represents the visual acuity. The test supervisor indicates, by means of an arrow-head (see fig. 2), one ring at a time. Fig. 3 shows how the person under test responds by placing a rotatable ring into a position corresponding with that of the ring indicated on the panel. A correct answer is signalled electrically (by a white disc appearing in front of an aperture, visible only to the investigator).

Fig. 2 also shows how this signal is produced. The movement of the arrow-head is reproduced on a smaller scale by means of a parallelogram linkage to a pin moving across an insulating board with holes and to a needle moving across a sheet of paper.
in a holder. Both the insulating board and the sheet of paper are small-scale reproductions of the ring panel. Each hole contains a metal bush which is connected to one of the eight contacts under the rotatable ring manipulated by the person under test. As soon as the pin is pressed into the hole, a circuit is completed provided the position of the rotatable ring corresponds with that of the paper ring indicated by the arrow-head.

When the answer is correct, the examiner presses the needle in, thus punching a hole in the paper and recording the result (fig. 4).

The final result is then ten figures \(^3\) for each test person at various luminance values \(L_0\) (four in our case) of the field of vision, viz. the numbers of the last ring in the various columns for which a correct answer was given. The value of \(D_0\) was taken as the geometric mean of the angles relating to this last ring and the next smaller one. For each value of \(D_0\) there is an accompanying value of the contrast \(C_0\). Together \(I_0\), \(D_0\) and \(C_0\) are the factors determining what is termed the “threshold value”. In the investigation the various threshold values per test person were studied and compared individually.

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\(^3\) In the extreme left-hand column the contrast was zero (paper of rings same colour as background). This column was not taken into consideration in the tests.

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Test results

The average result of all persons tested can be represented by a three-dimensional diagram, where \(D_0\) is plotted as a function of \(C_0\) and \(L_0\) (fig. 5). It will be seen that \(D_0\) diminishes (and consequently the visual acuity increases) at a given luminance as the contrast increases, and at a given contrast value as the luminance increases.

The surface in fig. 5 can be expressed by the empirical formula:

\[
\log D_0 = 2.17 \frac{1.57 - \log C_0}{\log L_0 + 3.95} - 0.79;
\]

where \(\log D_0\) represents the average value of \(\log D_0\).
The influence of age

It appears that the visual power \( G \) bears a simple relationship to the age of the test person. The test persons were divided into age groups and the average value of \( \log G \) was calculated for each group. The mean value \( \bar{G} \) thus obtained has been plotted in fig. 6 against the average age \( \bar{A} \) of the group. It can be derived from this graph that

\[
G = 9 - 0.1 \bar{A} \quad \ldots \ldots \ldots \ldots \ldots \quad (2)
\]

in which \( \bar{A} \) is expressed in years.

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### Table I. Survey of visual types.

<table>
<thead>
<tr>
<th>Type</th>
<th>Dependence of ( G ) on ( \text{increasing luminance} )</th>
<th>( \text{increasing contrast} )</th>
<th>Numbers of persons (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>[ ]</td>
<td>[ ]</td>
<td>67</td>
</tr>
<tr>
<td>A</td>
<td>[ ]</td>
<td>[ ]</td>
<td>67</td>
</tr>
<tr>
<td>A(_2)</td>
<td>increase</td>
<td>[ ]</td>
<td>11</td>
</tr>
<tr>
<td>A(_3)</td>
<td>decrease</td>
<td>[ ]</td>
<td>5</td>
</tr>
<tr>
<td>B(_1)</td>
<td>[ ]</td>
<td>increase</td>
<td>11</td>
</tr>
<tr>
<td>B(_2)</td>
<td>[ ]</td>
<td>decrease</td>
<td>1</td>
</tr>
<tr>
<td>C(_1)</td>
<td>[ ]</td>
<td>increase</td>
<td>4</td>
</tr>
<tr>
<td>C(_2)</td>
<td>increase</td>
<td>increase</td>
<td>1</td>
</tr>
</tbody>
</table>

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4) Here \( D_0 \) is expressed in minutes and the luminance \( I_0 \) in nits (cd/m\(^2\)). In the articles mentioned in note 1 the brightness (\( B_0 \)) is expressed in millilamberts (1 mL = 3.18 nits).

5) The author has suggested the introduction for \( G \) of a unit called "snellen", in honour of the Dutch ophthalmologist Herman Snellen (1839-1918).
Naturally this empirical formula may be applied only within the age limits for which it has been derived, i.e. 10 to 60 years. It shows that visual acuity drops a by factor $\frac{1}{2}$ when going from the age of 10 to 50, and, after some slight extrapolation, by a further factor of $\frac{1}{2}$ from 50 to 70 years. That even considerable extrapolation does not lead to absurd results appears from the fact that according to formula (2) $G = 0$ for $A = 90$ years.

Of course there is a certain amount of dispersion for $G$ in each age group. This dispersion is shown by fig. 7. Figure 8 shows that in general the steep drop of $G$ with increasing age, as represented in fig. 6 and by equation (2), is only slightly affected by this dispersion. Here the percentage of test persons in a given age group whose $G$ value exceeds a given value is indicated. The figure proves that only the best 10% in the 55-64 years group ($A = 60$) and the poorest 10% in the 5-14 years group ($A = 10$) can see approximately as well as the average ones in the 35-44 year group ($A = 40$).

The variations of $D_0$

When reviewing once more the results of the whole test, one is struck by the fact that the value of $D_0$, the smallest detail observed, can vary so strongly according to conditions. Table II gives an idea of this. It contains the $D_0$ values calculated with formula (1) for various contrast and luminance values and for various values of visual power $G$, viz. for the average value of $G$ in the age groups 5 to 14 years, 25 to 34 years, and 45 to 54 years, and for the highest and lowest $G$ values found ($G = 14$, and $G = 1$ respectively).

Apart from this selection of numerical values, some graphic representations of formula (1) are given in figures 9 and 10, in order to illustrate the influence of the various variable quantities. In fig. 9a, b and c, three age groups (the same as in table II) are dealt with separately. When applying the result to an individual person, account must be taken of the fact that, owing to the dispersion, the effective age $A_{\text{eff}}$ of a person may differ from his real age.

In fig. 10, $I_0$ has been plotted against the effective age for three values of the contrast and for two values of $D_0$, viz. 1' and 10' (0.00027 and 0.0027 radians). It follows from this that, in order to discern the same detail with increasing age, the luminance must be more strongly increased for small details than for larger details. This explains why elderly people are inclined (erroneously) to forbid children to read in waning light, telling them

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Table II. The smallest perceptible detail $D_0$ (in minutes of arc) for three contrast values $C_0$ and four luminance values $I_0$ at a visual power $G = 1, 4, 6, 8$ and 15.

<table>
<thead>
<tr>
<th>$I_0$ (nit)</th>
<th>$C_0$</th>
<th>$G = 1$</th>
<th>$G = 4$</th>
<th>$G = 6$</th>
<th>$G = 8$</th>
<th>$G = 14$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.1</td>
<td>0.32</td>
<td>1.0</td>
<td>0.32</td>
<td>1.0</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>26</td>
<td>13.5</td>
<td>2.7</td>
<td>6.5</td>
<td>3.4</td>
<td>4.1</td>
</tr>
<tr>
<td>10</td>
<td>13.5</td>
<td>9.1</td>
<td>4.9</td>
<td>3.4</td>
<td>2.0</td>
<td>12.5</td>
</tr>
<tr>
<td>100</td>
<td>9.5</td>
<td>5.8</td>
<td>3.7</td>
<td>22.2</td>
<td>1.4</td>
<td>0.95</td>
</tr>
<tr>
<td>1000</td>
<td>6.3</td>
<td>4.5</td>
<td>3.1</td>
<td>1.6</td>
<td>1.1</td>
<td>0.8</td>
</tr>
</tbody>
</table>

By effective age $A_{\text{eff}}$ is understood the age a person should be in order to have the $G$ value following from formula (2) if $G$ were substituted by $G$, and $A$ by $A_{\text{eff}}$, thus $A_{\text{eff}} = 10(9 - G)$. For $G$ values over 9, $A_{\text{eff}}$ is negative.
**ERRATUM**

**VISUAL ACUITY IN CONNECTION WITH TELEVISION**

In the November-December issue of this Review (Vol. 16, p. 176), Table II of the article by G. J. Fortuin, Visual acuity in connection with television, has been badly misprinted. The editors tender their apologies and the table is here reprinted correctly in a form suitable for pasting over the previous table.

**Table II.** The smallest perceptible detail \( D_0 \) (in minutes of arc) for three contrast values \( C_0 \) and four luminance values \( L_0 \), at a visual power \( G = 1, 4, 6, 8 \) and 14.

<table>
<thead>
<tr>
<th>( L_0 ) (nit)</th>
<th>( C_0 = 0.1 )</th>
<th>( C_0 = 0.32 )</th>
<th>( C_0 = 1.0 )</th>
<th>( C_0 = 0.1 )</th>
<th>( C_0 = 0.32 )</th>
<th>( C_0 = 1.0 )</th>
<th>( C_0 = 0.1 )</th>
<th>( C_0 = 0.32 )</th>
<th>( C_0 = 1.0 )</th>
<th>( C_0 = 0.1 )</th>
<th>( C_0 = 0.32 )</th>
<th>( C_0 = 1.0 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>26</td>
<td>13.5</td>
<td>7.2</td>
<td>6.5</td>
<td>3.4</td>
<td>1.8</td>
<td>4.1</td>
<td>2.1</td>
<td>1.15</td>
<td>0.32</td>
<td>1.0</td>
<td>0.1</td>
</tr>
<tr>
<td>10</td>
<td>13.5</td>
<td>8.1</td>
<td>4.9</td>
<td>3.4</td>
<td>2.0</td>
<td>1.25</td>
<td>2.1</td>
<td>1.3</td>
<td>0.8</td>
<td>1.7</td>
<td>1.0</td>
<td>0.6</td>
</tr>
<tr>
<td>100</td>
<td>9.5</td>
<td>5.8</td>
<td>3.7</td>
<td>2.2</td>
<td>1.4</td>
<td>0.95</td>
<td>1.4</td>
<td>0.9</td>
<td>0.6</td>
<td>1.1</td>
<td>0.7</td>
<td>0.45</td>
</tr>
<tr>
<td>1000</td>
<td>6.3</td>
<td>4.5</td>
<td>3.1</td>
<td>1.6</td>
<td>1.1</td>
<td>0.8</td>
<td>1.0</td>
<td>0.7</td>
<td>0.5</td>
<td>0.8</td>
<td>0.55</td>
<td>0.4</td>
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</tbody>
</table>
that they are "spoiling their eyes", because they are no longer able themselves to discern small type under such conditions.

If, on the other hand, the luminance is a given value, then fig. 9 gives the answer to the value of $D_0$ for the various age groups. The latter conforms with the situation met in television. In television the brightness of the picture can be adjusted to a certain extent by turning a knob, but there is an upper limit to this because, owing to the discontinuity of the image, flicker may occur, and because, even if the other conditions remain unchanged, the critical flicker frequency (i.e. the frequency above which no flicker is seen) is higher as the brightness is greater. With the fluorescent materials commonly used in Europe and at a mains frequency of 50 c/s, the maximum permissible screen luminance can be taken at 100 nits (100 cd/m²)\(^7\).

As the tests described above were carried out with the aid of Landolt rings and the details observed in a television image are of a different kind (brightness variations along the lines of the image) one cannot simply apply formula (1) to television. On the other hand the perception of details does not depend strongly on the nature of the detail. It is therefore still admissible to use formula (1) to get at least an impression of the variations in perception and their dependence on the various factors which affect them.


From Table II it can be seen that if $C_0 = 0.1$ and $L_0 = 100$ nits, $D_0$ may vary from 2.2' ($G = 4$, $A_{\text{eff}} = 50$ years) to 1.1' ($G = 8$, $A_{\text{eff}} = 10$ years), and in extreme cases even from 9.5 ' to 0.6'. If we assume that formula (1) may be applied quantitatively to the case in question, this means that the distance $a$ between the screen and the eye at which practically all details can be seen, varies from 1.5 metres ($A_{\text{eff}} = 10$ years) to 0.8 metre ($A_{\text{eff}} = 50$ years), and that in extreme cases $a$ may even vary from 3.4 to 0.18 metres!

The above conclusions can also be applied, mutatis mutandis, to the observation of a projected image (lantern slides, cinema projection). Here, too, with a view to the visibility of the details, it will be desirable to raise the luminance as much as possible, although here too there is an upper limit, this time set by the capacity of projector and lamp and the distance between projector and screen (in the case of cinema projection special measures are taken to avoid the inconvenience of flicker of the image\(^8\)). It is a well-known fact that in general a screen lighting of 100 lux (screen luminance 20 to 100 nits, according to the reflection properties of the screen) is considered satisfactory. If we assume that the smallest details on a $4 \times 3$ m screen are 2.5 mm in size (this depends on the grain size of the negative with which the exposure was made and on the sharpness of the optical system of the camera) we

\(^8\) This is explained on p. 161 of the article by J. Kotte, A professional cine projector for 16 mm film, in this issue.
find that the optimum distance between observer and screen varies from 4 to 8 metres according to the observer’s age, and from 1 to 18 metres if allowance is made for extreme cases.

We may conclude by pointing out that formula (1) should be used with some care for calculating lighting standards. In the first place the tests refer to threshold values, indicating a minimum which in practice should always be exceeded. It is difficult to say to what extent the minimum should be surpassed, because apart from perception the comfort of the subject plays also a part. Furthermore, the formula is the outcome of laboratory experiments, where time is not included as a factor. It will be clear, therefore, that conclusions drawn from such experiments should be applied to cases involving movement and rapidity of perception with great caution.

Summary. In the observation of a television (or projection) image, the visual acuity of the observer is of importance. A measure for this is the smallest detail $D_0$ which can be discerned at a given contrast and a given luminance of the object. Tests carried out with Landolt rings on 228 persons in ages varying from 7 to 64 years revealed that the product $GD_0$ is a general function of contrast and luminosity, $G$ being an individual constant (the visual power) for each observer, whose value, apart from a certain statistical variation depends on the age $A$ of the observer in the following way: $G = 9 - 0.1 A$. A description is given of the manner in which this average result has been obtained, and the restrictions are mentioned that must be taken into account, when applying it to an individual observer. The meaning of the relationship thus found is illustrated by a table and several graphs. It appears that the visual acuity increases by a factor of roughly 2, if a) the luminance increases by a factor 100, or b) the contrast increases by a factor 5. Under equal conditions the visual acuity of persons 50 years old is half that of a ten-year old child, while that of persons 70 years old is only one quarter. Although in the case of details of different kinds it is not permissible to draw quantitative conclusions from the relationship found, it still helps to give an impression of the extent to which the need for light increases with age and of the extent to which, at a given luminance and contrast, the perception of details is better with young persons than with old.


The reciprocal relaxation time of conduction electrons due to polar interaction with piezoelectrically active acoustical vibration modes is calculated for two-atomic regular crystals. It is found to be proportional to $T^{-1}$. It is shown for the case of ZnS (sphalerite) that below 150 °K the numerical value of this reciprocal relaxation time is comparable with the reciprocal relaxation time due to polar interaction with optical vibration modes. In crystals with sodium chloride structure the mass difference of the ions may in principle be responsible for polar scattering by acoustical modes. The corresponding reciprocal relaxation time is proportional to $T^0$. In the special case of LiF it becomes equal to polar scattering by optical modes at about 200 °K.

The impurity levels in the energy diagram of a zinc sulphide phosphor are considered to be localized S²⁻ levels lifted above the filled S²⁻ band due to the presence of monovalent positive or trivalent negative activator ions in the lattice. Electron traps are formed similarly by the substitution of S²⁻ ions by monovalent negative ions or of Zn²⁺ ions by trivalent positive ions. The energy produced when electrons recombine with trapped holes or when holes recombine with trapped electrons is either emitted directly as light or is first transferred to impurity ions. The elements of the iron group give rise to electron traps. The killing action of these elements is explained by assuming that the energy liberated by recombination between holes and electrons in these traps is transferred to the killer ions. The excited ions return to the ground state without radiation, because of the presence of many electronic levels between the excited and the ground state. The effect of heat and infrared radiation on the luminescence is discussed. It is shown that, in a phosphor, energy may be transferred by electrons through the conduction band or by holes through the occupied S²⁻ band.


A method described by Pfeil and Schroth for the quantitative determination of formaldehyde appears to be applicable in the presence of phenols and phenol alcohols.

2102*: P. Cornelius: L'électricité selon le système Giorgi rationalisé (Ed. Dunod, Paris 1953, 116 pp.). (Electromagnetism according to the rationalised Giorgi system: in French.)

French translation of Dutch text (see these abstracts, No. 1803). The author has extended and altered the text at a few points. The generator (dynamo) is treated from the viewpoint of an observer moving with the rotor (alternating flux) as well as from that of an observer at rest (Lorentz force on electrons in wire). The case of a b-scan of electrons in a magnetic field is considered. In the final chapter the author explains why he avoided discussions on quantity equations. (The equations in Giorgi units as given in the text may be considered either as numerical or as quantity equations.)

2103: H. Bremmer: Eine einfache Näherungsformel für die Feldverteilung längs der Achse magnetischer Elektronenlinsern mit unge- sättigten Polschuhen (Optik 10, 1-4, 1953, No. 1). (A simple approximate formula for the field along the axis of magnetic electron lenses with unsaturated pole-pieces; in German.)

For the field \( H(z) \) along the axis of a rotationally symmetrical magnetic electron lens with unsaturated pole-pieces, the formula

\[
H = (0.4 \pi N) \left[ \varphi \left( \frac{z}{b} + \frac{s}{2b} \right) - \varphi \left( \frac{z}{b} - \frac{s}{2b} \right) \right] \frac{1}{s}
\]

is given, in which \( s \) is the width of the slit, \( b \) the diameter of the bore, and \( \varphi(x) \) a function which, depending on the value of \( x \), can be expanded in a series in different ways. A table of \( \varphi(x) \) for \( 0 < x < \infty \) is given. The results are in agreement with a (less simple) theory of Lenz.


The stress components in the material of a corrugated diaphragm are determined, approximately, by replacing the diaphragm by a fictitious flat plate of similar properties as described in a previous paper. From the most unfavourable combination of these stress components that is ever possible, formulae for the maximum stresses were derived. These formulae were tested in a special case for which the stresses have been worked out in full by Grover and Bell, and are found to be in good agreement. Thus these formulae may be useful for design purposes.


Experiments were carried out regarding the conversion of n-type germanium into p-type by heat treatment at 800 °C. The results indicate that the conversion is due to the presence of acceptor impurities on the Ge surface prior to heating. As long as the surface is clean, its roughness seems to have no influence on the conversion. Experiments with pieces of Ge saturated by diffusion with Cu at 800 °C show that the Cu can be inactivated by heat treatment at 500 °C but that it remains present in some form throughout the material. A similar effect was found with Ni.

Continuation of R 213 and R 214. The recording methods leading to a linear relationship between the input signal and the recorded magnetization are discussed. Special attention is paid to the a.c. biasing method and its relation to ideal magnetization. This discussion is based on magnetic measurements in homogeneous fields. A magnetic model explaining the linearizing effect of the a.c. biasing field is discussed.

Next follows the calculation of the magnetic field that exists in and around a sinusoidally magnetized tape, the cases of longitudinal and perpendicular magnetization being treated separately. When the permeability of the tape is greater than unity, the demagnetizing field in the tape effects a decrease of the recorded magnetization. The flux in an ideal reproducing head is calculated for this case. It is shown that longitudinal and perpendicular magnetization produce the same flux in the head only when the permeability of the tape is equal to 1.

R 218: J. L. Meijering: Interface area, edge length, and number of vertices in crystal aggregates with random nucleation (Philips Res. Rep. 8, 270-290, 1953, No. 4).

The interface area, edge length, and numbers of faces, edges and vertices in an aggregate consisting of a large number of crystals are calculated for two models. In the first ("cell model") the crystals start to grow simultaneously and isotropically from nuclei distributed at random. In the second ("Johnson-Mehl" model) the nuclei appear at different moments, the rate of nucleation being constant. Corresponding calculations are made for plane sections of the aggregates and for two-dimensional aggregates. For the one-dimensional case the size-distribution curves are calculated. From a discussion of the results it is concluded that in the two- and three-dimensional cell models, the crystals are less equiaxial than in the corresponding Johnson-Mehl models.


It is shown that the current definition of monochromatic intensity ($I_{\lambda}$) contains an arbitrary element. Other definitions are considered, based on a logarithmic wavelength scale ($I_{\lambda}$) or on a frequency scale ($I_{\nu}$). For black-body radiation the maxima of these intensities occur at different places in the spectrum, giving rise to three different constants in Wien's law. The question arises which scale should be used. It appears that the use of $I_{\lambda}$ is a matter of convention only. There are logical arguments for using $I_{\nu}$, the corresponding Wien constant being 0.3668 cm °K.


From X-ray measurements on simple and complicated spinels, regularities in the ionic distribution and lattice constants have been investigated. These regularities have been explained partly by general methods (Madelung potential, geometrical considerations) and partly by also taking into account the individual properties of the ions that are correlated with the distribution of electrons within the ion. The calculated correlation between the ionic distribution and the oxygen parameter $u$ was found to be confirmed by experiment. The ultimate choice of the distribution, however, is governed by the individual properties of the ions, partly by their dimensions and partly by the distribution of electrons. Some physical properties of the compounds investigated have been correlated with the ionic distribution.