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Bending of curved tubes: WILLIAM HOVGAARD. This paper is an abstract of reports on a series of tests with curved tubes, such as are used as expansion bends in steam piping. The theoretical investigation, the tests and their analysis were carried out by the author during the years 1925 to 1929. The study began with the development of formulas for determining the deflections and stresses in such pipes when they are subject to bending. Suppose, for instance, that a bending couple, tending to increase the curvature, is applied to a pipe bend. The stress forces will then cause a small deformation of the transverse circular section which takes the form of an oval with its minor axis in the plane of bending. Hereby the material farthest from the neutral axis is largely relieved of longitudinal stresses, and the maximum values of these stresses, instead of occurring at the top and bottom of the section, as in the bending of a solid bar, occur at points much nearer to the neutral axis. The result is that equilibrium between the external bending moments and the internal stress couples will not be established until the bend has taken an angular deflection much greater than in the absence of sectional deformation. It follows that also the linear displacement of the ends of the pipe is much greater, a point which is of great importance to the engineer in the bends used in steam pipes to provide for expansion due to a rise in temperature. In all, nine full-scale pipe bends were tested in the laboratories of the Massachusetts Institute of Technology, varying in diameter from 4½ inches to 14 inches, and with a radius of curvature from one and one half to six times the diameter. The thickness of the pipe wall covered a wide range, the pipes being designed for steam pressures varying from about 100 to 600 pounds per square inch. The analysis of the tests led to the following general conclusions: (1) The calculated values of the displacement of the ends of a bend relative to each other, as also of the sectional deformations, showed an excellent correspondence with the observed values. The calculated stresses, longitudinal as well as transverse, corresponded well with the stresses obtained by measurements so long as the material was within the elastic limit. (2) The elastic yielding capacity of the pipe bends seemed to be dominated by the magnitude of the longitudinal stresses. It was found that so long as these stresses did not exceed 20,000 pounds per square inch, there was no appreciable permanent set in a bend, although probably local overstrain existed at certain points. On the basis of these results it was recommended to design pipe bends for a calculated longitudinal stress of 16,000 pounds per square inch. A special study was made of the occurrence of plastic flow in the material, evidenced chiefly by the appearance of Lüders lines on the surface of the pipes, and indicated also by the measurements of the strain meters. The principal formulas used in the analysis are given in an appendix.

The effect of the annihilation of matter on the wave-length of light from the nebulae: RICHARD C. TOLMAN. The purpose of this paper is to examine the cause of the red-shift in the light from the extra-galactic nebulae, which has been found by Hubble and Humason to increase approximately linearly with the distance of the nebulae, and if interpreted as an ordinary Doppler effect would correspond to enormous velocities of recession for the more distant objects of this class. The method of attack is to investigate, on the basis of the principles of general relativity, what form of line element for the universe as a whole would correspond to the continuous transformation of matter into radiation which appears to be going on throughout the universe and then determine if this form of line element would have any effect on the wave-length of light from distant objects. Attention is first called to the fact that neither of the rival static line elements for the universe proposed by Einstein and by de Sitter gives a satisfactory explanation of the red-shift, and that previous work of the author has shown that these are the only *static* line elements which would agree with approximately uniform conditions throughout the universe. These static line elements, however, correspond in the Einstein case to a universe permanently filled with a constant distribution of matter and in the de Sitter case to a universe which is permanently empty. Hence if we accept the contemporary opinion of the astro-physicists that the universe is actually filled with a distribution of matter, which is continuously changing over into radiation, we must expect that the actual line element for the universe will be a non-static one corresponding to the non-static condition of the universe. By applying the requirements that conditions throughout the universe shall on the average be substantially uniform, and that particles (nebulae) which are at rest in the coordinates chosen shall remain so, as is necessary for the preservation of a stable distribution, the author is then able to obtain for the line element of the universe the expression

$$ds^2 = -\frac{e^{g(t)}}{\left(1+\frac{r^2}{4R^2}\right)^2}\,(dx^2+dy^2+dz^2)+dt^2 \qquad (1)$$

where R is a constant and g is a function of t which gives the dependence of the line element on the time. With the help of this form of line element, it is then possible to obtain an expression for the density of matter in the universe and to show that g must be changing with the time if a general transformation of matter into radiation is really taking place. Furthermore, if we apply the additional requirement that particles (nebulae) which are not exactly stationary in the coordinates chosen tend to become so, it can be shown that g must be increasing with the time, and this leads to a red-shift in the light from distant objects. Finally, assuming in the neighborhood of $t=0$ a simple linear dependence on time,

$$g = a + 2kt \qquad (2)$$

it is found that k is a quantity which is related on the one hand to the average rate at which matter is changing over into radiation and on the other hand to the known shift in wave-length with distance. By comparison with observational data it is then shown that the value of k necessary to account for the known red-shift falls close to the range of values which would correspond to the rates of transformation of matter into radiation for actual stars of different types, although considerably higher than that for an average star. In conclusion, it is pointed out that further information as to the exact dependence of the red-shift on distance and knowledge as to the concentration of dust in the universe and its rate of annihilation are very desirable. It is also emphasized that the simplification of the model used for the calculation and the assumptions, such as that of a linear dependence on time, make it necessary to regard the treatment given as not better than a first approximation to the correct theory.

The energy requirements of intense mental effort: FRANCIS G. BENEDICT and CORNELIA GOLAY BENEDICT. The popular tradition that fish is a brain food has given way to the idea that mental effort demands calories. The feeling of complete mental and physical exhaustion as an aftermath of intense, sustained mental effort has led to interest in the real dynamic effect of so-called "mental work." By measuring the changes in the heart rate, the respiration rate, the character of the respiration, the carbonic acid exhalation and especially the consumption of oxygen, definite evidence can be secured of the immediate results of intense mental effort. Studies made in earlier years on the influence of mental work upon heat production have shown either that the mental effort had no effect or a very pronounced effect. Further experiments have been made during the winter of 1930 at the Nutrition Laboratory of the Carnegie Institution of Washington, at Boston, in which the subjects (five men and one woman) were measured under three different conditions: first, during complete muscular and digestive repose and as nearly as possible in a state of mental vacuity; second, during "attention" or response to an electric signal, but with no active cerebral processes of a complex nature; third, during intense, sustained mental activity, as in the elaboration of mental arithmetic problems for an hour, at the end of which time each subject admitted that he was exhausted, at least mentally. The first series of observations with each subject represented the measurement of the now well-known "basal metabolism," a measurement made daily in the hospital, especially in suspected thyroid cases, and likewise used as evidence of the level of vital activity of normal persons. The problems, such as multiplying mentally 73 by 47, were given orally, and at the completion of each problem the subject touched a telegraph key. Problem followed problem as rapidly as solved, and with one subject a complexity represented by numbers such as 873 by 67 was reached successfully. The general picture of the effect of mental effort was the same with all subjects, a distinct increase in heart rate, a pronounced alteration in the general character of the respiration, a small increase in the carbonic acid exhalation and a slightly smaller increase in the oxygen consumption. In the periods of repose following the mental work all these factors immediately resumed their former level and nature. During the mental effort, lasting in some cases more than an hour, the different factors measured showed no increase from period to period during the four consecutive fifteen-minute periods. The response to mental effort is therefore immediate and not cumulative, at least when the mental effort is uniform in nature. From the slight increase in the carbonic acid exhalation and the oxygen consumption it is possible to calculate the extra heat produced during such mental effort, that is, the increase above the heat production during complete muscular, digestive and mental repose. From the standpoint of dynamics it is perhaps surprising that the extra caloric demands of mental effort are so small. The professor absorbed in intense mental effort for one hour has an extra demand for food or for calories during the entire hour not greater than the extra needs of the maid who dusts off his desk for five minutes. The cloistered scholar at his books may be surprised to learn that the extra calories needed for one hour of intense mental effort would be completely met by the eating of one oyster cracker or one half of a salted peanut.

The suppression of fluorescence in concentrated solutions: ERNEST MERRITT. In dilute solutions the "specific fluorescence" of a substance, *i.e.*, the fluorescent emission per molecule, has been found to be constant throughout a considerable range. But as the concentration is increased a point is finally reached at which the specific fluorescence suddenly begins to diminish exponentially with increasing concentration. Apparently when the molecules of the active substance are sufficiently close together some action occurs which inhibits the process of emission. It has been suggested that we have to do with collisions of the second kind or with some inductive action between the molecules which disturbs the conditions for radiation. Assuming that some action of this kind occurs when the distance between molecules is less than some specified distance, and assuming further that the active molecules are distributed at random, a law of variation of fluorescence with concentration has been derived for liquids by Perrin and for solids by Merritt. But this law indicates an exponential variation for *all* values of the concentration. In some cases the experimental results reported by Wawilow differ by as much as 50 per cent. from those computed by Perrin's formula. Abandoning the idea of random distribution the author assumes that the potential energy of the molecule of active material when at a distance from other similar molecules is less than its energy when near another active molecule. This makes it necessary to introduce the Boltzmann distribution law in computing the probable distribution and leads to a new expression for the specific fluorescence, F, namely:

$$F = \frac{F_0}{1 + (e^{\mu n} - 1) e^{Q/kT}}.$$

n = concentration; Q = energy (negative) required in bringing two active molecules together from a great distance; μ = a constant determined by the maximum distance apart at which one active molecule prevents radiation by the other. This expression represents the experimental results better than that derived on the assumption of random distribution. For large values of n the expression takes the form

$$F = F_0 e^{-\mu(n-n_0)},$$

which was given by Wawilow as best representing his results. The corresponding expression for the observed fluorescence in the case of a solid is also derived and is found to agree with the experimental results. The complicating effects of dissociation and the possible causes of the inhibiting action are discussed.

X-ray diffraction determinations of electron distributions in atoms: ARTHUR H. COMPTON. Work by Darwin, the author, the Braggs, Duane and others has made it possible to estimate from measurements of the intensity of X-ray diffraction by crystals the distribution of the electrons in the atoms of which the crystals are composed. Similar analysis now shows that the density of distribution of the electrons as a function of the distance from the center of an atom may be expressed as a Fourier integral, which can be evaluated from the observed intensities of the X-rays diffracted by amorphous substances. The theory, which is based on classical electrodynamics, is identical with the results of the quantum mechanics, except for a small correction which is to be applied when dealing with the diffraction of short waves at large angles. A comparison of the results obtained from the diffraction by gases with those calculated from the diffraction by crystals shows a close agreement in the general form of the electron distribution curves. The data from the gases show, however, a stronger concentration of the electrons near the center of the atom, a result which is doubtless due to the thermal agitation of the atoms in the crystal lattice, which gives to these atoms an apparent diffuseness. In fact, we are thus afforded an interference method of determining the amplitude of the atomic motions in a crystal lattice. The results are in qualitative accord with those to be expected from the usual kinetic theory.

Absorption spectra and the problem of the pyrones: R. C. GIBBS, J. R. JOHNSON and E. C. HUGHES (introduced by Ernest Merritt). Organic compounds that contain a pyrone ring exhibit certain unusual properties. Strictly chemical evidence as well as that of absorption spectra has led to conflicting suggestions regarding the structural formulas for the pyrones and their acid salts. Arguments have been advanced for the free substance chiefly in favor of either the ketonic structure with a quinoid-like nucleus or an inner salt formula, the nucleus of which is benzenoid. In forming an acid salt, the acid radical has been considered to be attached to either of the two oxygen atoms or to the carbon atom involved in the ketonic linkage thus producing either an oxonium or a carbonium salt. In seeking to secure crucial data that might serve to clarify the problem, the absorption spectra of gamma-pyrone, dimethyl pyrone, benzopyrone and xanthone in absolute alcohol and alcoholic HCl were carefully examined. Sulphuric acid solutions of two of these compounds were also examined. Whenever dissociation might conceivably occur and thus possibly modify the results, ether or dimethyl sulphate solutions were also measured. The absorption for the neutral solutions of gamma-pyrone and dimethyl pyrone is characteristic of that found for compounds known to have a ketonic linkage which, in these cases, involves a quinoid-like nucleus. Although the absorption in the case of neutral benzopyrone and xanthone is more complex due to the presence of benzene rings, the ketonic type of absorption also appears to be present in these compounds. The absorption curve for the acid solution of each of these four compounds resembles that for the corresponding neutral solution. It is therefore concluded that in forming an acid salt of these pyrones, the ketonic linkage is not broken and that an oxonium salt is produced through addition to the ketonic oxygen atom. The formation of a carbonium salt would have necessitated a rupturing of the ketonic linkage, thus producing a marked change in the nature of the absorption spectra. Furthermore the resemblance between the absorption of the free pyrones and that of their acid salts gives fairly conclusive evidence that these salts do not have an oxonium benzenoid structure, for such a structure would have yielded widely modified absorption spectra. Additional confirmation of these conclusions is obtained by comparing the absorption of 4-methoxy lutidine, a compound in which only the benzenoid structure is possible, with that of its ketonic isomer, N-methyl lutidone. The absorption spectrum of lutidone bears a close resemblance to that of pyrone, but that of lutidine is radically different, being similar in character to those for benzene and toluene.

BOOKS RECEIVED

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