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CONTENTS

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DOMESTIC ELECTRIC RATES AND CONSUMPTION

PRESIDENTIAL ADDRESS BY HOWARD M. TURNER*

BOSTON SOCIETY OF CIVIL ENGINEERS, MARCH 22, 1944

TEN years ago, the late Philip Cabot, then Professor of Public Utility Management at the Harvard Business School, suggested that it would be interesting to study what would be the effect on the consumption of electricity for domestic use if the utilities had to raise their rates to cover increasing taxes. I did not get very far on this particular question, but in studying it I came upon a relation between price and consumption of domestic electricity that seemed to be of considerable interest. That was in 1934. Three years later I continued the study using data up through 1937, and I have recently brought it up to date.

Up to about 1920 electricity for domestic use was sold generally on a flat rate, i.e., so much per Kw. hr. of consumption. Decreases in rate were made by simply decreasing this flat rate. The average consumption per customer was generally about 300 Kw. hrs. per year, used mostly for lighting. With the advent of various electrical appliances, the so-called promotional rate came into use, which gave to the customer the benefit of a lower average price per Kw. hr., the larger the use. This rate was founded, in general, on the principle of marginal cost, although exact figures are difficult to obtain, namely, that with the investment to provide service to each customer more

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or less fixed, the cost of providing additional Kw. hrs., once the service is installed, is not as great as that of the initial Kw. hrs.

With rates being thus reduced, the consumption per customer began to increase and the revenue per Kw. hr., i.e., the average price paid by the customer, to decrease, so that whereas in the year 1913 the average revenue per Kw. hr. for the country as a whole was 8.7¢, and the average Kw. hr. use by each customer was 264 Kw. hrs. per year, in 1942 the price had dropped to 3.67¢ and the Kw. hrs. had risen to an average of over 1,000 per customer.

A great tribute is due to the public utility industry as a whole for this remarkable job, that in a period when the cost of living has risen 70 per cent, it has continually been able to lower its residential rates. I think the advocates of public ownership, with their subsidized "yard sticks," do not give enough credit for the fact that this achievement was initiated by the private companies and has been carried through chiefly by them. It is a truly amazing performance.

In my investigation I found that there was a definite relation between the average price and consumption per customer, which held pretty generally all over this country and Canada, indicating a definite reaction of the customer to a reduction in price. The figures of average price and consumption for each year were plotted with the average revenue in cents per Kw. hr., as abscissa, and the average annual Kw. hr. consumption per customer, as ordinate. A sample of this plot for a New England company for the years 1921-1943 is shown in Fig. 1. On this figure there is also shown a curve, which I have called the "characteristic revenue-consumption curve," or the "characteristic curve" for that particular company. Plotting of similar data for many companies in different parts of the country, examples of which will follow, all show a similar form of characteristic curve.

Before considering these curves, the way this growth of load took place should be described. Fig. 2 gives a typical promotional rate, and the rate curve shows the average price per Kw. hr. that a customer would have to pay for a given amount at this rate. The dotted line to the left of this rate curve, called the revenue curve, gives the average revenue and consumption that a group of customers using this rate will obtain assuming different distributions, i.e., with

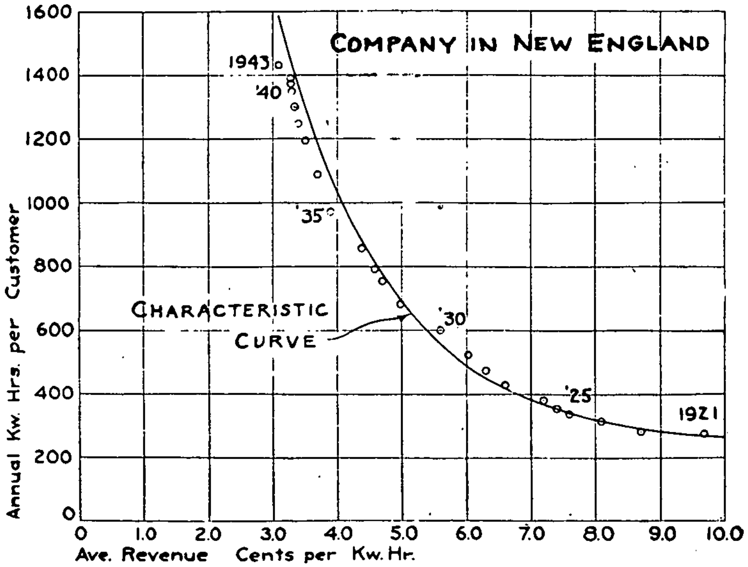

FIG. 1.—DOMESTIC CONSUMPTION AND REVENUE.

various numbers of customers using varying amounts. Unless all the customers use the same amount, the average revenue per Kw. hr. from a group will always be less than that from any one customer using that number of Kw. hrs. The revenue curve will thus be generally parallel to the rate curve, but at a lower average rate.

It has been argued, that the revenue-consumption curve, such as I have given on Fig. 1, is interesting, but only a plot of the use of the customers under the rate curve, that is, that the reduction in price is the *effect* of increased consumption under the promotional form of rate, rather than the increased consumption being caused by the lower price. That this is not the case is shown by Fig. 3, which shows, for a company in the Northeast, the average revenue per Kw. hr. and consumption per customer, and the rate curves in effect for the nineteen years from 1925 to 1943 and the "characteristic curve." From this it can be seen that the characteristic curve is *not* the same or even parallel to any of the rate curves, as the rate has been consistently lowered and the consumption has been increasing throughout the period. The net result has been a growth along the

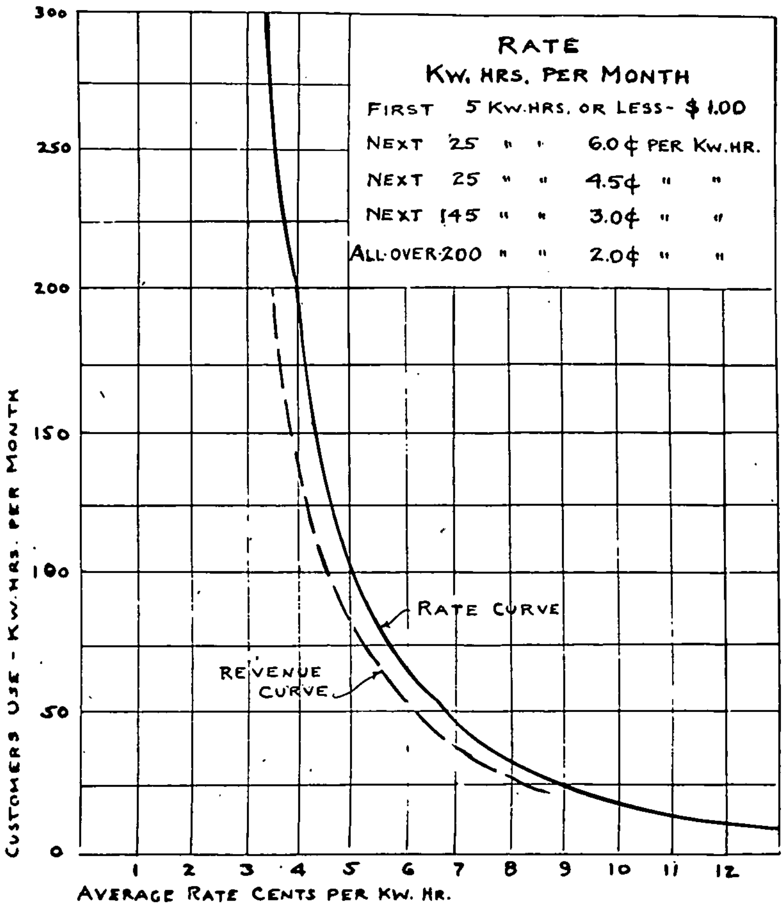

FIG. 2.—TYPICAL PROMOTIONAL RATE CURVE.

characteristic curve and not parallel to the rate curves. The former then may be taken to show result of the effect of lowering the price accomplished in this particular instance by a succession of decreasing rates of the promotional form. In other words, this characteristic curve would seem to show the experience which this company had in increasing consumption with lowering rates.

The following Figs. 4 to 8 show examples of the characteristic curves for companies in the New England States, in the Northeast,

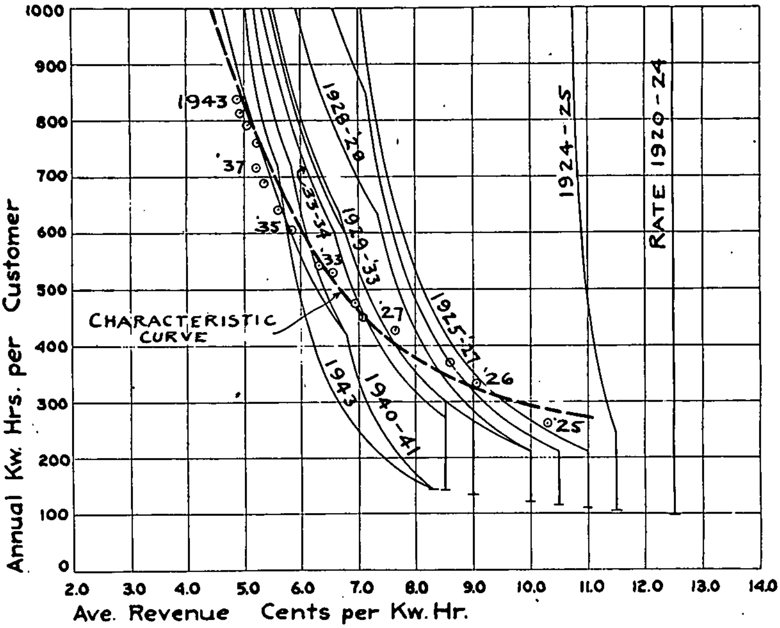

FIG. 3.—DOMESTIC RATE CURVES 1920 TO 1943 AND CHARACTERISTIC CURVE.

the Central Industrial district and the Pacific area and of the Hydro-Electric Power Commission of Ontario.

These characteristic curves are all of the same equation, but with a different constant, dependent on the revenue per Kw. hr. at the beginning of the increase in load. In this analysis I have chosen to use the same equation, i.e., to figure the curve using the constant which most nearly fits the given data, instead of finding in each case the equation of a separate curve which gives the best fit for each set of data, in order to show the comparative uniformity of the experience in different companies. The equation* of this curve is as follows:

*This was the revision of an original equation based on the average revenue, x_1, at the consumption of $y_1 = 265$.

$$y = 240 + \frac{25}{10^{\frac{3.135(x-x_1)}{x_1^{1.10}}}}.$$

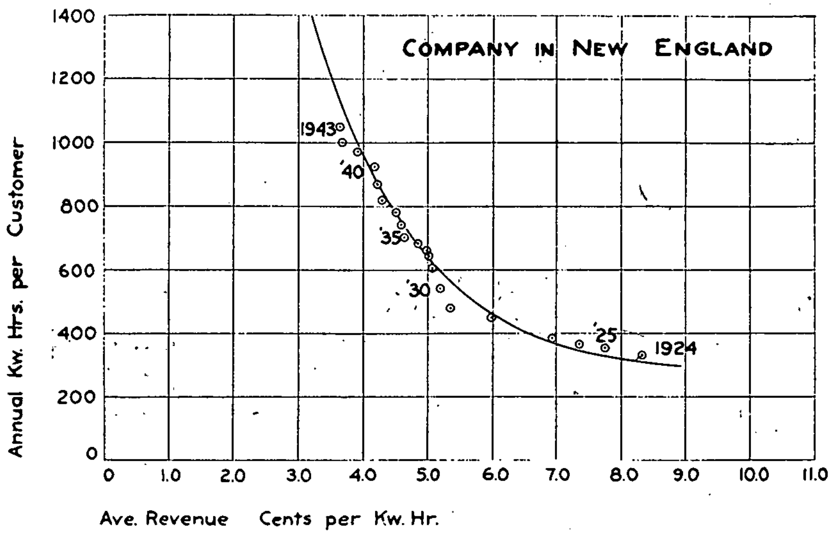

FIG. 4.—DOMESTIC CONSUMPTION AND REVENUE.

$$y = 240 + \frac{25}{10^{\frac{1.528x - 2.335\,(x_2 - 0.22)}{x_2 - 0.624}}}. \qquad (1)$$

Where y = the average consumption per customer per year.
x = the average revenue per Kw. hr.
x_2 = the average revenue per Kw. hr. when
$y = 400$, i.e. the constant fixing each curve.

It was found that this equation did not hold in the upper parts of the curves as it reaches a finite value of the consumption, y, when the average revenue, $x = 0$. The following equation was derived to cover the cases involving large consumption figures where x is greater than x_0.

$$x_0 = \frac{x_2 - 0.624}{1.955}$$

$$y = 240 + 0.166\,(y_0 - 240)\,10^{\frac{1.528\,x_0^2}{(x_2 - 0.624)\,x}} \qquad (2)$$

y_0 = the value of y when $x = x_0$.

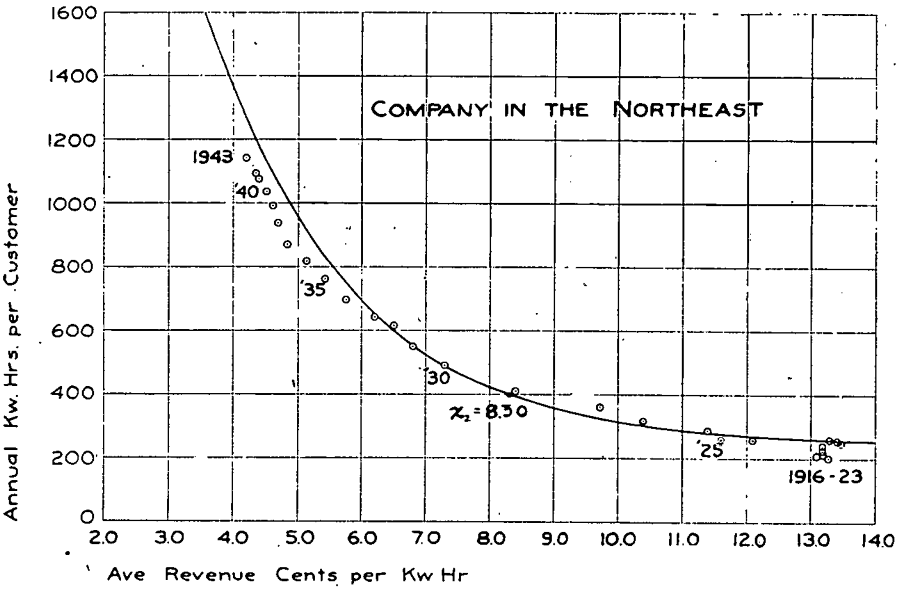

FIG. 5.—DOMESTIC CONSUMPTION AND REVENUE.

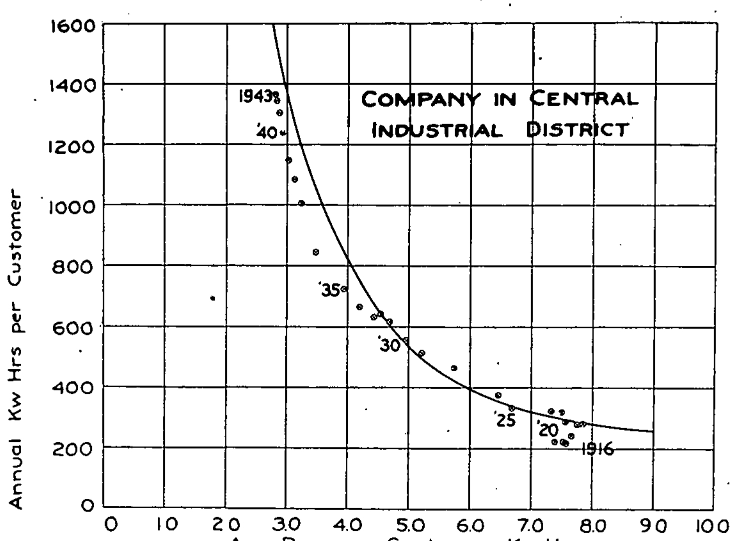

FIG. 6.—DOMESTIC CONSUMPTION AND REVENUE.

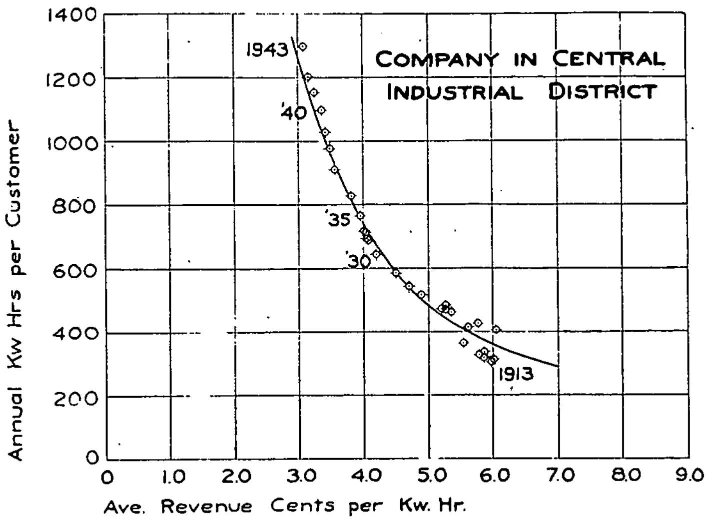

FIG. 7.—DOMESTIC CONSUMPTION AND REVENUE.

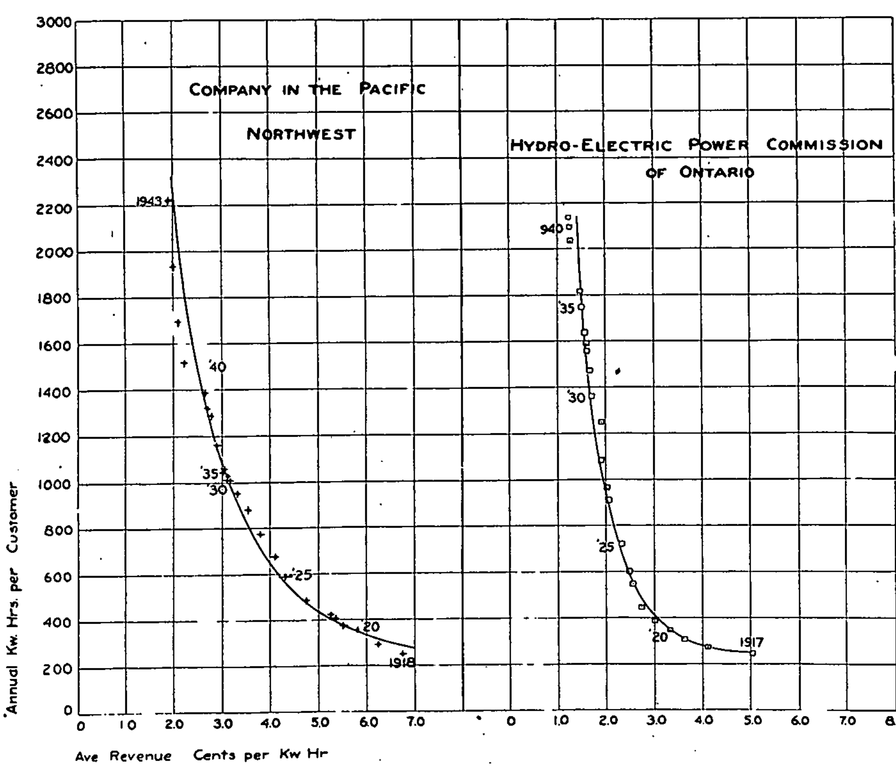

FIG. 8.—DOMESTIC CONSUMPTION AND REVENUE.

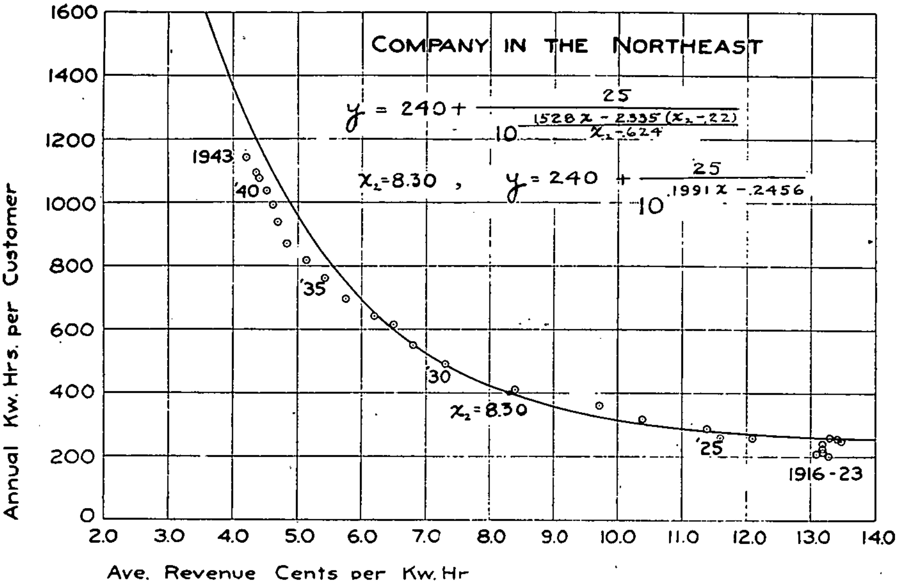

FIG. 9.—DOMESTIC CONSUMPTION AND REVENUE.

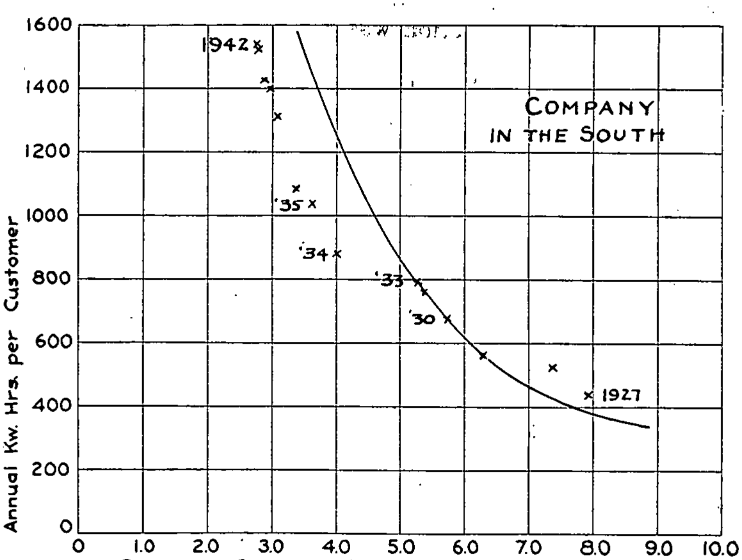

FIG. 10.—DOMESTIC CONSUMPTION AND REVENUE.

Data for very large average consumptions are limited, but the upper part of the characteristic curves expressed in this equation appear to satisfy those now available. Equation 1 is easily applied, once the constant is fixed as shown in Fig. 9.

This equation is of the general form, $y = a + 10^{mx}$. For a given constant decrement in price, Δx, the increment in consumption, Δy, above 240 Kw. hrs. is geometrically progressive, that is, the increment Δy, for each unit of decrement, Δx, is a constant factor times the increment, Δy, for the previous one.

It has been interesting plotting the data up to date to see how well the curves drawn ten and six years ago still hold. In some cases they do not, for example, in Figs. 10 and 11, which are for two companies in the South. In both of these cases the rates were sharply reduced after the T.V.A. rates were established in the neighborhood. In some other companies, not shown here, the same thing occurred, i.e., drastic reductions in rates at about that time. If my theory is correct, eventually the consumption under these new rates should increase until the characteristic curve is reached, but it is too early to tell. In any event, this type of rate reduction was not inspired by economics only

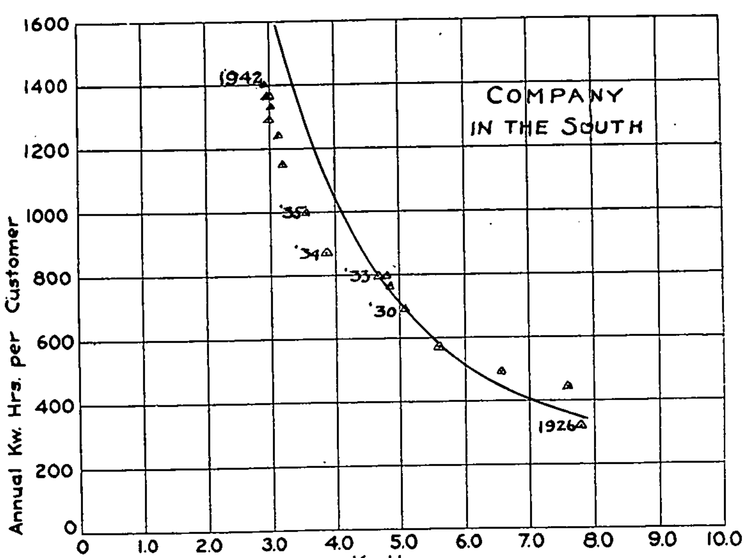

FIG. 11.—DOMESTIC CONSUMPTION AND REVENUE.

and perhaps could not be expected to conform. This same tendency is shown in the last few years by the country as a whole, shown on Fig. 12. These data contain all public utility companies, privately

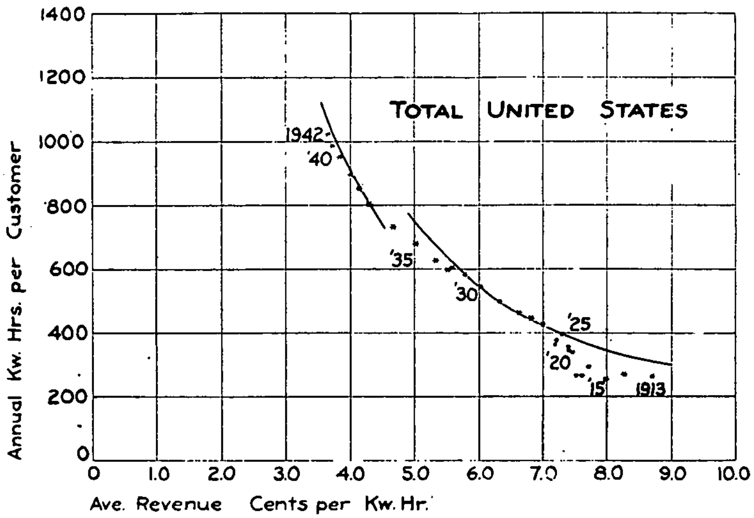

FIG. 12.—DOMESTIC CONSUMPTION AND REVENUE.

and publicly owned and I believe the step to the left on the curve, which is about 10 per cent, is due to the same type of rate reduction, and also to the growing proportion of low rate publicly owned systems; also the data since 1936 have been on a slightly different basis.

I have not made a study of all the records available and of course I have found some cases where the characteristic curve does not fit. One of these is shown on Fig. 13 for a New England company where the original 1934 curve does not hold at present. In analyzing about 60 sets of data of companies and subdivisions of companies, however, I have found comparatively few where the curve does not fit astonishingly well, except for those that made the drastic rate reductions in 1934, mentioned above. In general, there are few cases where, except for isolated points for a few years, differences from the characteristic curve are as much as 10 per cent and generally much less.

Fig. 14 shows several of these curves for this country and Ontario on the same chart. Apparently the reaction is the same, regardless

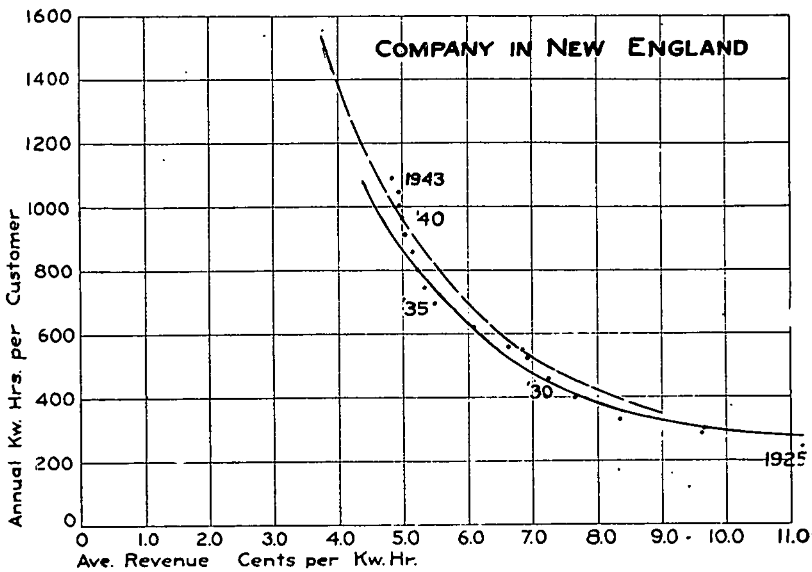

FIG. 13.—DOMESTIC CONSUMPTION AND REVENUE.

of whether it is in an area of high prices, such as the eastern seaboard, or of extremely low ones, like the Pacific coast or Canada, although in the lower rate cases the average consumption is generally greater; the reaction occurs also regardless of the years during which the growth took place.

There is some question as to the real significance of this. Even though these characteristic curves do not follow the usual promotional rate curves, it may be that the promotional rate curves are such that a continual decrease of any such rates would produce the characteristic curve. When one studies for each company the differences, not only in the rates themselves, but also in the dates when the rates are made, and in the scale of prices, it seems as if there were something more to it than this. Without attempting to develop any theory in regard to these facts, these curves do appear to chart the experience of these companies in obtaining greater consumption per customer by rate reduction. It should follow that to get the most economical result, that is, increased consumption with the greatest revenue, the rates should be made so that the growth is along the

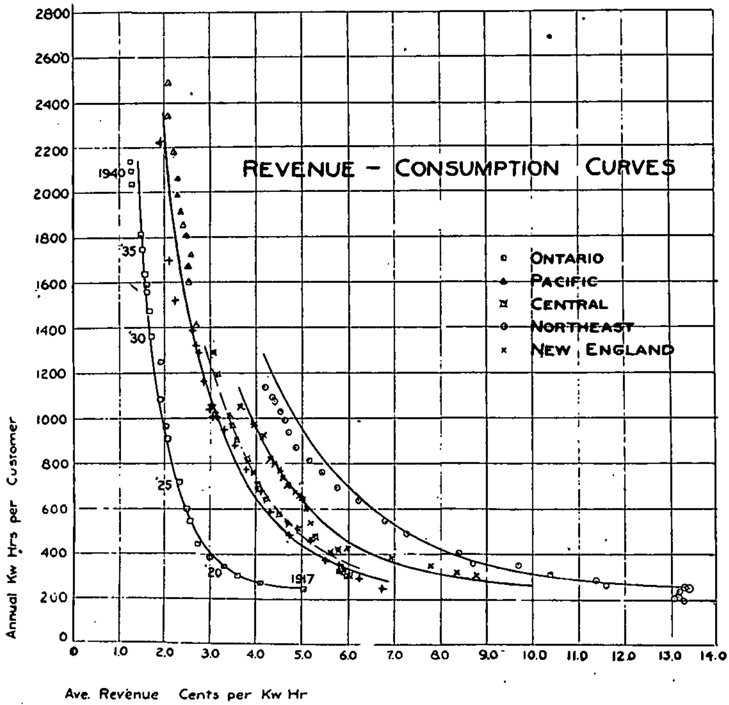

FIG. 14.—REVENUE CONSUMPTION CURVES.

characteristic curve. This does not mean that the rate curve should necessarily be parallel to the characteristic curve; that is immaterial, because the same thing can be accomplished by continual reduction of rates, which may have various advantages; but in order to have constant growth the rate or the succession of rates should be such as to permit the revenue and consumption to follow the characteristic curve.

An example of this is shown on Fig. 15 for a company in New England. The successive rate reductions and their effect on the consumption are clearly shown. It is always possible to make a large reduction in rates bringing the points to the left of the characteristic curve, as for example was the case in this company in 1929 to 1931, but the points came back to the curve in a few years and then it was necessary to reduce the rate again after 1935, during which year there was practically no growth.

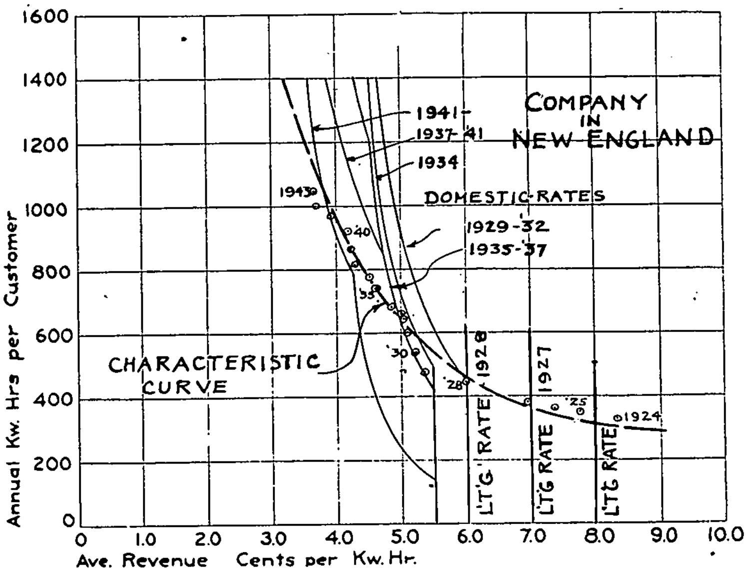

FIG. 15.—DOMESTIC CONSUMPTION AND REVENUE.

The rate is, of course, only one of the many elements which enter into the expansion of sales of domestic electricity. The development of new uses, general and local business conditions, competition with other fuels, the amount and range of customers' income and consequent ability to buy electricity and new equipment, the company's relations with its customers and particularly its sales effort, all are involved. These all affect the rapidity and quantity of the growth. The total progress will vary with different companies and apparently the section of the country in which they are located. The net result, however, appears to have general characteristics as shown by the curves.

I have attempted to apply this method of analysis of customers' reactions to reduced prices to other commodities for which there is, or was, a growing and presumably elastic market. It is difficult to find satisfactory data; one example is passenger automobiles. The data regarding retail sales and average retail prices are not available, but using the average wholesale value per car plotted against the number of cars manufactured, the curve, Fig. 16, shows

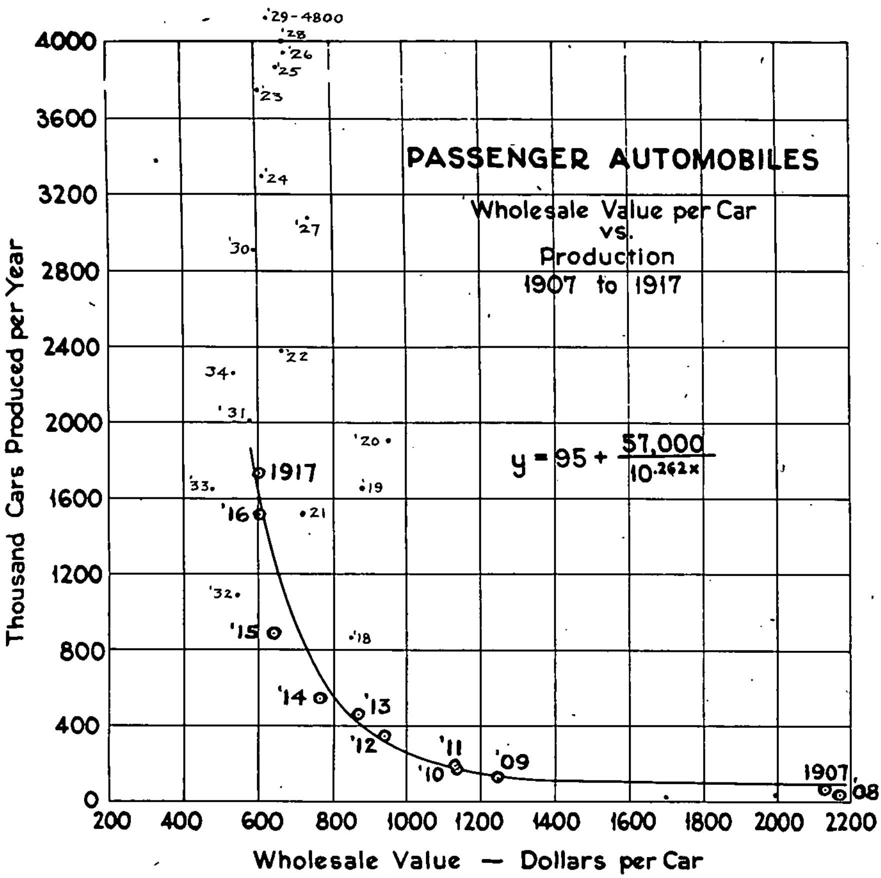

FIG. 16.—PASSENGER AUTOMOBILES.

generally the same form, i.e., it has the same form of equation, the number of cars produced increasing in geometric progression as the average wholesale value decreased during the ten years from 1907 to 1917, during which period the wholesale value per car dropped from \$2100 to \$600 and the annual production increased from 43,000 to 1,746,000. Then came the first World War, an increase in price and a drop in number, and after that the trend is not clear, although if corrections are made for the changes in the cost of living, the curves seem to continue up to the time of the depression. The significant

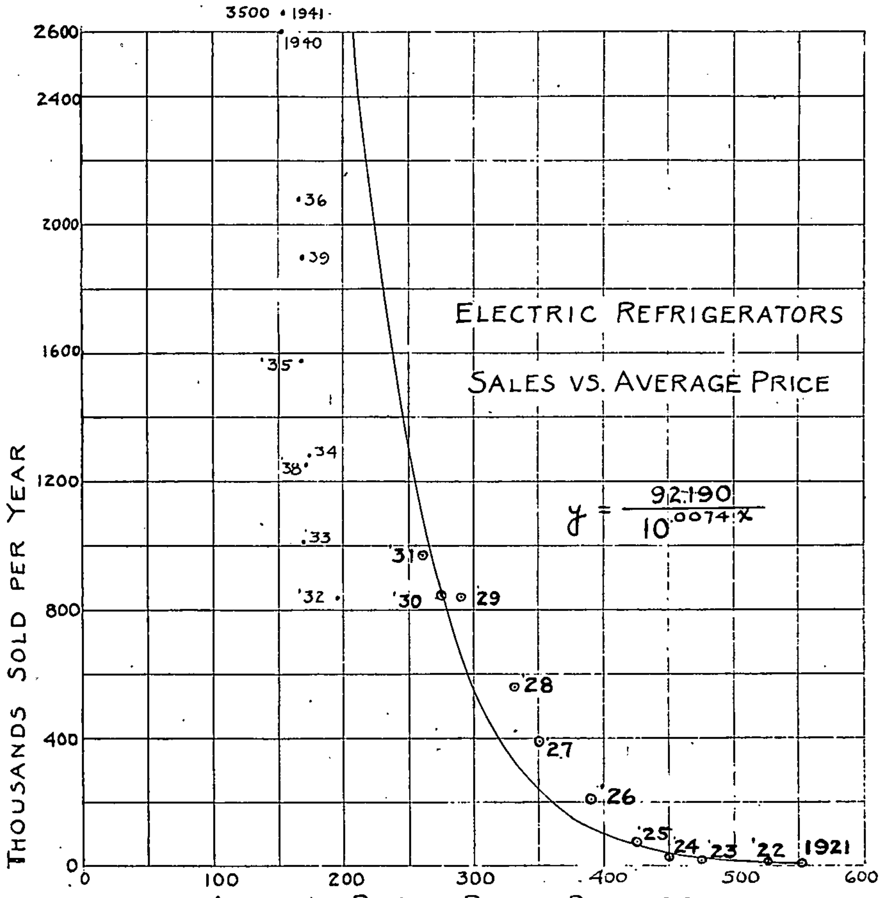

FIG. 17.—ELECTRIC REFRIGERATOR—SALES VS. AVERAGE PRICE.

thing is that the great growth in the consumption of automobiles took place along this same form of curve, when compared to the value.

The sales and price history of the electric refrigerator was similarly analyzed, Fig. 17. That too, shows the same form of increase in the number sold compared to the retail price, from the year of 1921, when the price was \$550 and the total sales were about 5,000, up to 1931, when the price was \$258 and the sales were 965,000. The great reduction in price, made during the depression, is shown on the left; the sales have not yet reached the original curve, and may not; but here again, during the period of great expansion, the increase progressed along this same type of curve.

As in the case of electric rates, these two curves seem to show that, during the development of the great expansion in use, up to a certain point, when other factors may enter into the sale, including probably near-saturation and price stabilization, the consumption of these two commodities appears to have increased in geometric progression as the price was reduced. If this is definite enough for practical use, perhaps it may help in estimating future sales to compare with future price reductions. Particularly in the case of electric rates it should be of assistance, though as the growth increases the normal rate curve and the characteristic curve tend to become more nearly parallel and other factors than price may be of more effect; in other words the period of development is passing. I shall have to confess that five years ago when I last took this up, I did not know of any public utility company making use of it, though most of them showed great interest.

Perhaps when the war is over, when we get back on to an economy which permits the laws of supply and demand to function, and new products are available, this study of the experience of the behavior of price reduction and the customers' consumption, may be of value.

SHEAR FAILURE OF ANISOTROPIC MATERIALS

By Dr. Arthur Casagrande, Member*
and
Dr. Nabor Carrillo†

Introduction

Mohr's[1] well known theory of failure of materials, may be stated in the following terms:

A material is said to "fail" when it reaches at a certain plane its ultimate strength or a more or less arbitrary yield point. In either case failure occurs when the shear component of stress in the given plane attains a maximum value, which is assumed to be a function of the normal component of stress and of the properties of the material.

The preceding statement, which is similar to Mohr's own statement, is expressed in a convenient equivalent form by means of Mohr's circles of stress. Referring to Fig. 1, the theory states that for each

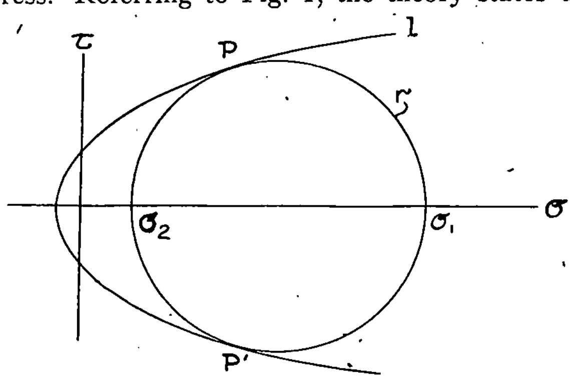

Fig. 1.

material the critical stress circles, such as r (defined by the major and minor principal stresses, σ_1, σ_2, producing failure), are all tangential to a characteristic curve, l, which is also the locus of points

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†University of Mexico, Mexico City, Mexico.
[1]Mohr, Otto, "Abhandlungen aus dem Gebiete der technischen Mechanik," 2d ed., W. Ernst u. Sohn, Berlin, 1914.

whose coordinates represent the combinations of stress components that will produce failure of the material. Thus, for each critical stress circle, such as r, the coordinates of the points of tangency (P and P') with the characteristic curve l, represent the stresses on the failure planes.

Experiments have shown that Mohr's theory of failure is accurate for brittle materials that are ruptured or rendered plastic by compressive stresses, and is satisfactory for ductile materials.‡

The purpose of this paper is to present an extension of Mohr's theory for non-isotropic materials. The subject of this presentation was suggested by the behavior of soil samples, and the paper is primarily intended as a contribution in the field of soil mechanics, although it is expected that certain phenomena observed in the failure of such materials as steel and concrete, and the faulting of rocks, may also be explained in the light of the following considerations.

Induced and Inherent Anisotropy. We shall distinguish between two different kinds of anisotropy in our discussion. If the anisotropic distribution of strength, exhibited by a material at failure, is due exclusively to the strain associated with the applied stresses, the material will be said to possess *induced anisotropy.* If, on the other hand, the non-isotropic behavior observed in a test is a physical characteristic inherent in the material, and entirely independent of the applied strains, the material will be said to possess *inherent anisotropy.* We can also conceive of a material whose inherent anisotropy would be affected to a certain extent by the applied strains, but this type of combined anisotropy will not be considered in this paper.

Cohesive and Cohesionless Materials. The investigations presented in this paper are limited to the restricted but important case for which the envelope of the critical stress circles consists of two straight lines; either parallel to the σ axis, Fig. 2(A), or else passing through the origin of the coordinate system, Fig. 2(B).

Fig. 2(A) corresponds to what is designated as a "perfectly cohesive material", of which mild steel is a satisfactory example; and Fig. 2(B) conforms to what is generally defined as a "cohesionless material" like a clean dry sand.

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‡Nadai, A., "Plasticity," McGraw-Hill, New York, 1931, pp. 63 to 68.

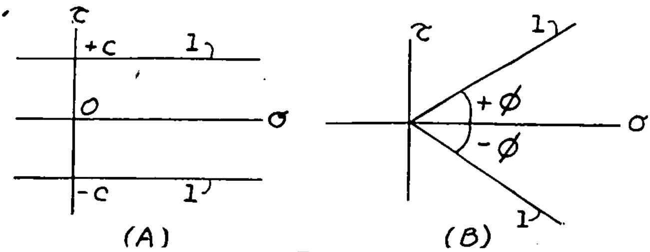

FIG. 2.

INDUCED ANISOTROPY

FAILURE OF A PURELY COHESIVE MATERIAL. Let us consider a purely cohesive material that develops at failure a non-isotropic distribution of shear strength. Let c_1 and c_2, in Fig 3, be the maximum

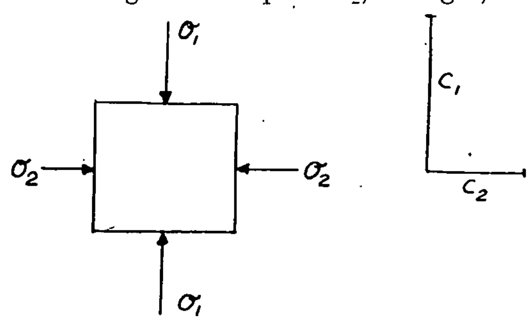

FIG. 3.

and minimum values of the shear strength, or vice versa. These value will be designated in what follows as the "principal strengths".

Since the anisotropy has been induced by the applied strains, it is justifiable to assume that the principal strengths develop in the planes of principal stress. Let us then choose c_1 and c_2 to represent the principal shear strengths in the directions of σ_1 and σ_2 respectively and let us propose to determine the radius of the critical stress circle under the assumption that the values c_1 and c_2 are known.

Since we do not know the strength distribution for planes inclined to the principal stresses, we must make an assumption. For example, it may be assumed that the curve c, Fig. 4, determined by the values of the strength taken from the origin O as vectors parallel to the corresponding planes, is an ellipse. By utilizing this assumption, or any other that may be found satisfactory, the radius of the critical stress circle can easily be determined by graphical trials as described in the following paragraph.

GRAPHICAL SOLUTION FOR A PURELY COHESIVE MATERIAL. Draw a tentative stress circle as r, Fig. 4, and then determine the cor-

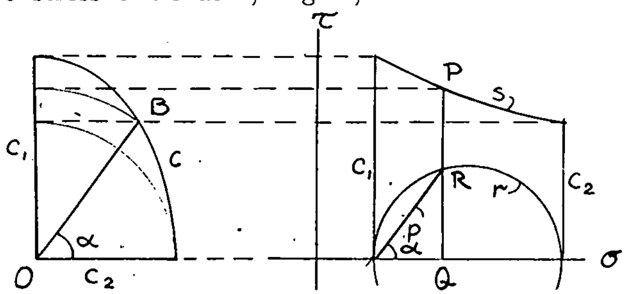

FIG. 4.

responding "strength line" s which gives for each point R of the circle the shear strength PQ in the corresponding plane p. The ordinate PQ of the strength line is obtained by drawing in the assumed ellipse the radius vector OB, parallel to the plane p.

The stress circle chosen in Fig. 4 is clearly not critical, since the strength exceeds the stress for every plane. Hence, another tentative circle must be tried and the procedure must be repeated until the strength line s is tangential to the stress circle r, as in Fig. 5.

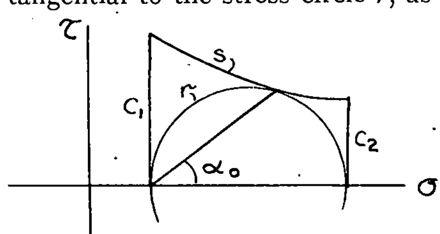

FIG. 5.

Since the values of the strength have been assumed independent of the applied stresses, the critical stress circles must all be equal, as shown in Fig. 6. It is apparent from Fig. 6 that line l, the envelope of the stress circles, does not coincide with the line l', locus of points representing the stress components on the planes of failure.

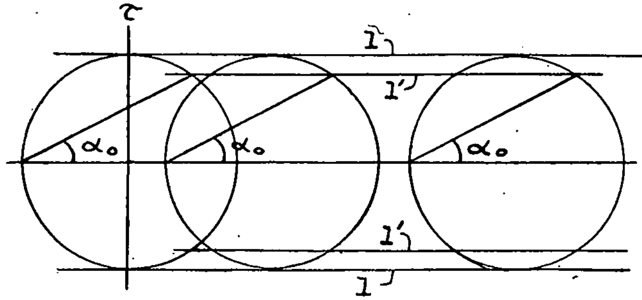

FIG. 6.

Furthermore, it is obvious from Fig. 5 that for $c_1 > c_2$, the angle α_0 between the plane of failure and the plane of major principal stress is *smaller* than 45°; and that for $c_1 < c_2$, the angle α_0 is *larger* than 45°.

ANALYTICAL[2] SOLUTION FOR PURELY COHESIVE MATERIAL. We may express the strength in the material by means of equation

$$c = f(\alpha) \tag{1}$$

wherein α is the angle between the plane of major principal stress and any other given plane, and c_α is the shear strength induced in the given plane. That is to say, equation (1) is the expression in polar coordinates of the curve c previously defined.

Now let us imagine a point A in the σ axis of Mohr's coordinate system, Fig. 7, and assume that the abscissa of A is the minor principal stress of the critical circle we intend to determine.

Consider curve c, Fig. 7, representing equation (1), drawn with

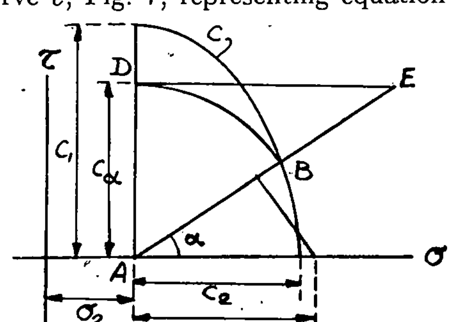

FIG. 7.

[2]In 1935 the senior author conceived the general approach and developed the graphical solutions. The analytical solutions presented in this paper were originated by the junior author in 1941.

point A as the origin of coordinates, and let AB be the value of the shear strength in the plane of failure. Draw the circular arc BD, with its center at A, and then draw through D a line parallel to the σ axis until it intersects line AB at point E. Then AE must be a chord of the critical stress circle, so that the radius r of the circle must satisfy the equation

$$r = \frac{c_\alpha}{\sin 2\alpha} \tag{2}$$

Furthermore, the strength line, s, previously defined, must be tangent to the stress circle; Fig. 5. Hence, the value of r defined by equation (2) must also satisfy the condition

$$\frac{dr}{d\alpha} = 0 \tag{3}$$

Equation (3) is equivalent to the following:

$$\frac{dc_\alpha}{d\alpha} = \frac{2c_\alpha}{\tan 2\alpha} \tag{4}$$

Therefore, the critical value of α is a root of the equation

$$f'(\alpha) = \frac{2f(\alpha)}{\tan 2\alpha} \tag{5}$$

obtained by substituting c_α from (1) and (4).

In order to utilize equation (5), we must know the law of strength represented by equation (1). In the absence of further information, it is believed that a satisfactory working hypothesis is the following:[3]

$$c_\alpha = c_2 + (c_1 - c_2) \sin^2\alpha \tag{6}$$

The preceding assumption leads to a very simple expression for the critical value of the angle α which will be designated by the letter α_0:

$$\tan \alpha_0 = \sqrt{\frac{c_2}{c_1}} \tag{7}$$

Thus the shear strength of the material in the failure plane is

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[3]Equation (6) is identical with the expression giving the unit extension in any direction in terms of the principal extensions. Cf. Timoshenko, S., "Theory of Elasticity," First Edition, McGraw-Hill, New York, 1934, p. 193.

$$c = \frac{2c_1c_2}{c_1 + c_2} \tag{8}$$

and the radius of the critical stress circle is, finally,

$$r = \sqrt{c_1c_2} \tag{9}$$

Equations (7), (8), (9) were utilized to compute the data for Plate I, which shows the value of α_0 and $\frac{c}{r}$ in terms of the ratio $\frac{c_1}{c_2}$.

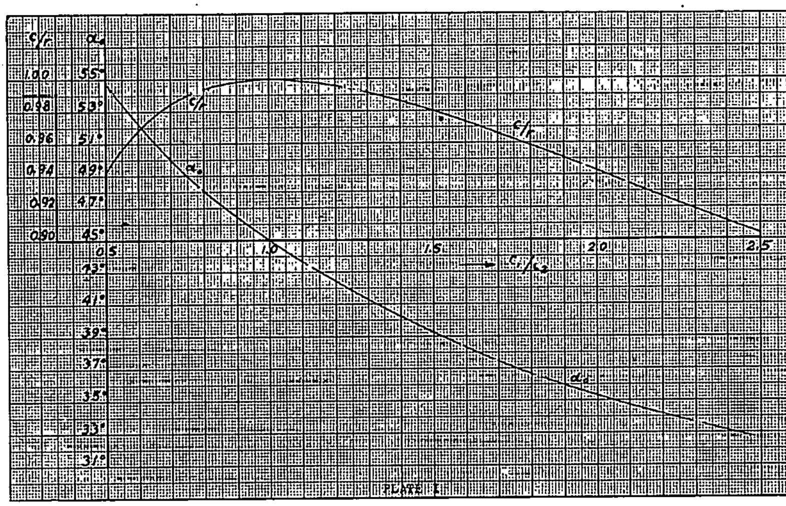

PLATE I.—PURELY COHESIVE MATERIAL WITH INDUCED ANISOTROPY EQUATIONS 7, 8 and 9.

FAILURE OF A COHESIONLESS MATERIAL. Let us imagine a clean sand which, because of a system of applied stresses, develops a non-isotropic distribution of shear strength. In other words, the rearrangement of the sand grains produced by the induced strain results in a variable angle of internal friction.

Since the anisotropy considered is induced by the applied stresses, we can assume that maximum and minimum values of the angle of internal friction, which we shall call the "principal angles of internal friction", occur on the planes of the principal stresses. Let us choose ϕ_1 and ϕ_2 to represent the principal angles in the directions of the major and minor principal stresses, respectively, and let us determine the radius of the critical stress circle and other pertinent quantities in terms of ϕ_1, ϕ_2 and the value of the minor principal stress σ_2.

GRAPHICAL SOLUTION FOR A COHESIONLESS MATERIAL. Let us plot point A in the σ axis of Mohr's coordinate system, Fig. 8, repre-

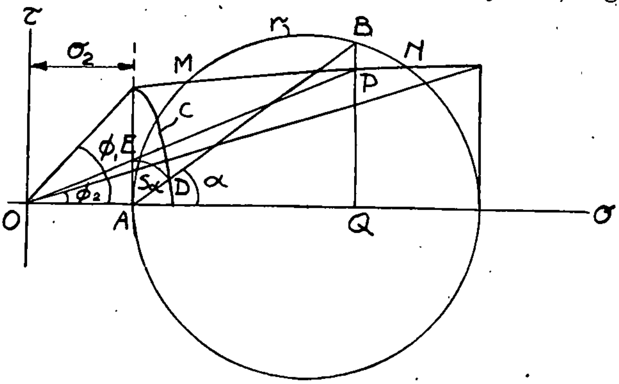

FIG. 8.

senting the value of the given minor principal stress. Then we draw curve c by taking from point A, in every direction, the value of the shear strength at constant normal stress σ_2. Any radius vector s_a of curve c represents the product σ_2 *tan* ϕ_a wherein ϕ_a is the angle of internal friction of the material in the plane inclined α to the plane of major principal stress. To construct curve c, we are compelled to make an assumption. For example, it may be assumed that curve c is an ellipse. With this assumption, we are now in a position to determine the radius of the critical stress circle and the orientation of the failure planes.

Draw a tentative stress circle such as r, Fig. 8. Then draw the corresponding strength line s as follows: for any plane AB, the ordinate PQ of the strength line is determined by drawing the circular arc DE, with its center at A, and then drawing the line OEP. The ordinate PQ is then equal to the product of the normal stress acting on plane AB, times the corresponding coefficient of internal friction ϕ_a. The stress circle chosen in Fig. 8 is evidently too large, since for all planes corresponding to the arc MN of the circle, the stress is greater than the strength. Therefore, another stress circle must be assumed and tried, and the procedure must be repeated until the strength line is tangential to the chosen circle, as in Fig. 9.

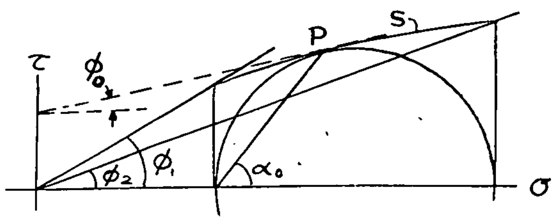

FIG. 9.

ANALYTICAL SOLUTION FOR A COHESIONLESS MATERIAL. Let us express the distribution of the shear strength in the material by means of the equation

$$tan\ \phi_a = f(\alpha) \tag{10}$$

wherein ϕ_a is the angle of internal friction in a plane inclined α to the plane of the major principal stress.

Consider point A, Fig. 10, representing the value of the given

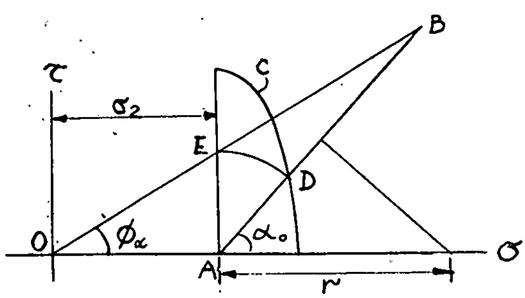

FIG. 10.

minor principal stress, and imagine curve c, drawn by plotting from A in any direction α the value of the product $\sigma_2\ tan\ \phi_a$. Let AB be the direction of the plane of failure. Draw the circular arc DE, with its center at A, and then find point B by intersecting AB and OE. AB must be a chord of the stress circle. Therefore, from the figure, the radius r of the stress circle is:

$$r = \frac{sin\ \phi}{cos\ \alpha\ sin(\alpha - \phi)} \cdot \frac{\sigma_2}{2} \tag{11}$$

Furthermore, since the strength line s, previously defined, must be tangential to the stress circle,

$$\frac{dr}{d\alpha} = O \tag{12}$$

Therefore, from (11) and (12),

$$\frac{d\phi}{d\alpha} = \frac{\sin \phi \cos(2\alpha - \phi)}{\sin \alpha \cos \alpha} \tag{13}$$

By substituting in (13) the value of ϕ in terms of α as given by (10), we obtain an equation from which the critical value of α is determined. The preceding exact solution, however, is cumbersome even if the function f is simple.

Instead of imposing an assumption on the curve c, as was done for the cohesive material, we assume that the strength line s is straight at failure. This assumption seems to be justified for the relatively small differences between ϕ_1 and ϕ_2 which are likely to be encountered.

Let us then consider the critical stress circle, Fig. 11, assuming that the strength line EG is straight.

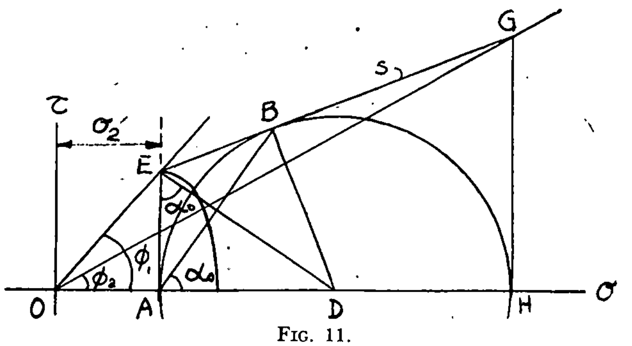

Fig. 11.

From Fig. 11, we have

$$OA = \sigma_2;\ AE = \sigma_2 \tan \phi_1;\ AH = 2r;\ HG = (\sigma_2 + 2r) \tan \phi_2 \tag{14}$$

These values must satisfy the equation

$$\begin{aligned} AH^2 + (GH - AE)^2 &= (EB + BG)^2 \\ &= (AE + HG)^2 \end{aligned} \tag{15}$$

Hence,

$$(2r)^2 + [(\sigma_2+2r)\ tan\ \phi_2 - \sigma_2\ tan\ \phi_1]^2 = \\ = [\sigma_2\ tan\ \phi_1 + (\sigma_2+2r)\ \tan\ \phi_2]^2 \qquad (16)$$

from which, solving for r:

$$r = \sigma_2\ tan\ \phi_1\ tan\ \phi_2 \left[1 + \sqrt{1 + \frac{1}{tan\phi_1\ tan\phi_2}} \right] \qquad (17)$$

Then,

$$\sigma_1 = \sigma_2 + 2r = \sigma_2 \left[1 + 2\ tan\phi_1\ tan\phi_2 \left(1 + \sqrt{1 + \frac{1}{tan\phi_1\ tan\phi_2}} \right) \right] \qquad (18)$$

Finally $$tan\ \alpha_0 = \frac{AD}{AE} = \frac{r}{\sigma_2\ tan\ \phi_1}$$

$$tan\ \alpha_0 = tan\ \phi_2 \left[1 + \sqrt{1 + \frac{1}{tan\phi_1\ tan\phi_2}} \right] \qquad (19)$$

Equations (17), (18), and (19) are valid not only when $\phi_1 > \phi_2$, as was assumed in drawing Fig. 11, but also when $\phi_1 < \phi_2$. That is, the same critical stress circle is obtained by interchanging ϕ_1 and ϕ_2, as can be seen from Fig. 12.

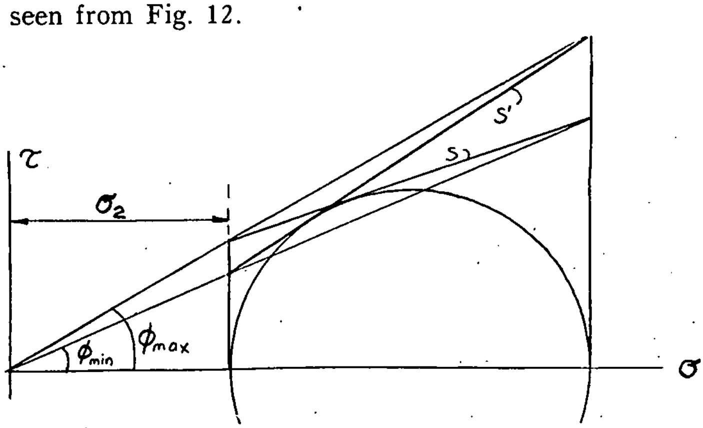

FIG. 12.

Equation (19) was utilized to compute the values plotted in Plate II, where the difference $(\phi_2 - \phi_0)$ is shown as a function of ϕ_1 and ϕ_2.

The results of the above analytical approach differ from those

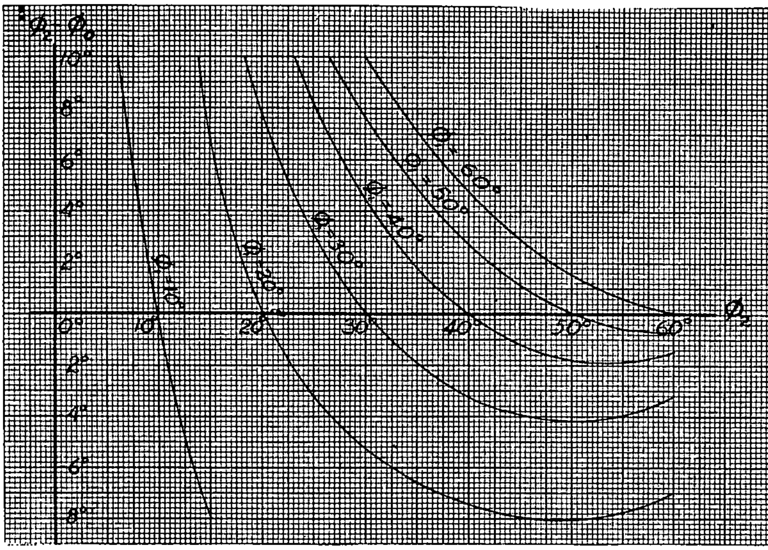

PLATE II.—COHESIONLESS MATERIAL WITH INDUCED ANISOTROPHY-ANALYTICAL SOLUTION.

obtained on the basis of elliptical distribution of the angle of internal friction. In Fig. 13 and Table I the results obtained from the analytical solution, equations (18) and (19) are compared with the graphical solutions using ellipses as distribution curves.

The analytical solution for $\phi_1 = \phi_{max.}$ corresponds to the distribution curve c_{III} which was obtained by reversing the graphical procedure. This curve does not differ much from the elliptical distribution c_I corresponding to $\phi_1 = \phi_{max.}$. Nevertheless we can see from Table I that the effective angles of internal friction ϕ_0 are substantially different.

Very much greater differences develop for the case $\phi_1 = \phi_{min.}$ for which case the elliptical distribution is represented by curve c_{II} and the analytical solution by curve c_{IV} which differs radically from the shape of an ellipse. As a result, the effective angles of internal friction ϕ_0 and the ratio of the principal stresses σ_1/σ_2 are also widely different. This example illustrates the importance of the shape of the distribution curve c. Systematic investigations are needed to determine its shape for various materials.

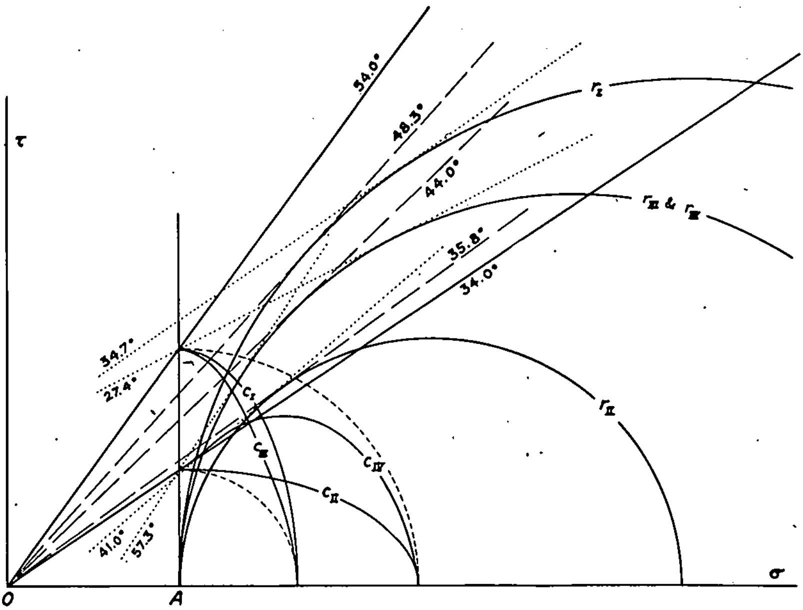

FIG. 13.

TABLE I

Symbol in Fig. 13	Assumption for Strength Distribution	Angles in Degrees ϕ_1	ϕ_2	a_0	ϕ_0	ϕ_c	$\frac{\sigma_{max.}}{\sigma_{min.}}$
I	Ellipse	54.0	34.0	62.4	34.7	48.3	6.86
II	Ellipse	34.0	54.0	65.5	41.0	35.8	3.82
III	Analytical Solution (Equations 18 and 19)	54.0	34.0	58.7	27.4	44.0	5.56
IV	Analytical Solution (Equations 18 and 19)	34.0	54.0	73.7	57.3	44.0	5.56
Isotropic Distribution $\phi_1=\phi_2=34°$				62	34	34	3.54
Isotropic Distribution $\phi_1=\phi_2=54°$				72	54	54	9.47

INHERENT ANISOTROPY

Let us now consider a purely cohesive material whose anisotropy is entirely independent of the applied strains. If the principal strengths coincide with the applied principal stresses, the problem is identical with that of a material with an induced anisotropy. We shall therefore assume that the principal strengths c_1 and c_2 are inclined β to the principal stresses, as shown in Fig. 14.

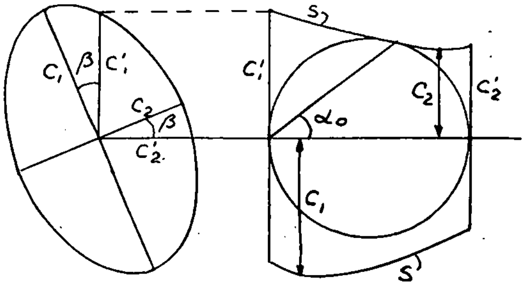

FIG. 14.

The first step is, as before, to assume a distribution curve c for the shear strength of the material, like the ellipse drawn in Fig. 14. Then the critical stress circle can be graphically determined by trying various circles until the one tangential to the strength line s is found. Analytically, the inclination α_0 of the failure plane can be computed by combining equation (5) with equation (6), with $(\alpha—\beta)$ written instead of α.

An important conclusion can readily be derived from an inspection of Fig. 14: unless the angle β is zero (that is, unless the directions of the principal strengths coincide with those of the principal stresses), there is *only one* orientation for the failure planes, instead of two. This interesting result is confirmed, for example, by observations of faulting in stratified rock.

The behavior of an inherently anisotropic cohesionless material can easily be understood on the basis of the preceding considerations and need not be described in detail. It is worth noting that, as for cohesive materials, *only one* orientation for the planes of failure can develop unless the maximum and minimum angles of internal friction occur on the planes of the principal stresses.

THE DEVELOPMENT AND FORECASTING OF AIRPORT REQUIREMENTS

BY EDWARD WARNER*

(Presented at a meeting of the Boston Society of Civil Engineers, held on March 22, 1944.)

THE subject of tonight's talk and the site loose a flood of personal memories. It was just over twenty years ago that Bostonians interested in aviation brought to the State House on Beacon Hill the revolutionary proposition that the airport facilities of a great commercial center were of more than selfishly private concern—or even of purely municipal interest—and urged that the State Legislature should appropriate $35,000 to cover the cost of grading some newly-filled land in East Boston and spreading cinders along two paths, thereby creating the Boston airport. The General Court took favorable action, and the airport came into being. I am told tonight that the amount that has been expended, or authorized for expenditure, now aggregates just over $12,000,000; and I think it very probable that there are more citizens of this community who now consider good airport facilities a bargain at $12,000,000 than it was possible to find to appraise the public value of an airport at as much as $35,000 in 1923.

There is nothing more dangerous for a speaker or writer than to declare that any particular event was the first of its kind. I make no claim to have performed any historical research on this point; but at least I can say that within the limits of my knowledge the construction of the Boston airport represented the first instance in the United States of contribution to the construction of a municipal airport by a governmental unit of more than municipal stature, excluding of course those cases in which such agencies of the Federal Government as the Post Office Department's air mail service shared in the development of airports for their own direct use.

We have come a long distance in these twenty years in our concept of the responsibilities of Government with respect to airport

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development, in our ideas of what an airport may be expected to cost, and in the views of experts on what constitutes a first-class airport. Our journey has not ended. We have attained no final convictions.

Airports are a problem for the civil engineer. They are a problem for the architect. They are a problem for the city planner, and for the operator of airlines, and for the distributor and the user of private aircraft, and for every civic organization, and for everyone who travels by air or ever expects to. They are a problem for the taxpayer. Those who deal with the matter professionally, and who have finally to take decisions, can rely on the close attention of a large and critical audience.

The Existing Airport Pattern

There are at the present time about 1,800 municipal and commercial airports open for public use in the United States—a total figure which has not changed appreciably in the last ten years. Very roughly, at the time of the airport survey of early 1939, 24 per cent of the area of the United States lay within 15 miles of some sort of permanently established airport, and 70 per cent of the population lived within the area so covered. A 15-mile standard is of course an arbitrary one, typically representing a maximum of 30 minutes of travel to reach an airport. Enthusiasts on the future use of private aircraft would consider such a standard as very modest, and indeed quite unsatisfactory. It would be more to their taste that the typical individual should find himself always within five miles of an airport; and to bring airport facilities to within five mles of 90 per cent of the population of the United States, and to within 20 miles of 99 per cent, would require that the total number of airports be increased approximately to 30,000.

The improvement in the quality of airports in recent years has been more significant than the increase in their number. At the end of 1938 only 231 airports in the United States had hard surfaced runways, and only 293 had boundary lights. At the present time the number of fields with runways has increased to 958, and the number with lighting to 652, increases of 315 per cent and 122 per cent, respectively. Five years ago there were 214 fields which had at least a 2,500-ft. runway, and generally adequate servicing facilities. Now there are 327 in that category—a 53 per cent increase.

The total numbers of airports now available, of any quality, are far short of the 30,000 that has been suggested as a rough measure of reasonably complete coverage for widespread private use of aircraft; and the discrepancy is a reminder of the wide variations that exist in airport form and function. The airport requirements of trunk-line or intercontinental air transportation are one thing; those of private flying are quite another; and I am going to talk particularly about the needs, as they appear to me, of the metropolitan areas which may expect to have frequent arrivals and departures of scheduled transport aircraft.

In speaking of this subject I ought to explain that I am trespassing on the special preserve of a neighbor in Washington; but our relations are so close, and our area of common interest so large, that I am sure I shall be forgiven for doing so. Civil airport development and advice on airport planning are the direct responsibility of the Civil Aeronautics Administration, to whom I am indebted for the figures that I have given on the present status. The Civil Aeronautics Board, of which I am a member, is less directly involved. Nevertheless we are very much interested, for the economic health of air transportation will be largely influenced by the nature of the terminal facilities that the airlines enjoy. Adequate airports, attractive in their provisions for the comfort and convenience of passengers, efficient in their provision for the expedited handling of traffic, with proper approaches for surface transportation from various directions, well located with respect to the major needs of their users, and capable of economical operation, can be of decisive benefit.

Airline Airports for Metropolitan Areas

The greatest problem of airport planning is that the life of an airport is, or should be, much longer than the life of an airplane. The operating plans of aircraft manufacturers and airline operators are made with reference to the aircraft that are now available and those that are immediately to succeed them. The plans of an airport commission must, on the other hand, take into account the characteristics of airplanes that will not even be designed for another ten or fifteen years, and they must be based on estimates of the total amount of traffic that will be moving by air fifteen or twenty years hence. The alternative will be a disconcertingly rapid obsolescence of ground facilities and the loading of fixed charges, whether borne directly by Governmental funds or ultimately by the airlines and their patrons, with uncomfortably heavy depreciation allowances. The planner of airports turns to designers of aircraft, to airline managements, and to the Civil Aeronautics Board and other Government agencies, and asks a projection of the course that aeronautics is to take throughout the life of a very expensive ground facility. It is impossible to give a wholly satisfactory answer; but it is also impossible to refrain from asking the question, and we must do the best that we can with it.

The resultant estimates must be presented with great diffidence. They are presented, however, in the conviction that some anticipation of the future is indispensable as a prelude to decisions that are immediately necessary, and that even a poor estimate, if it be the best that can be made, is far better than none.

In general, estimate for the purposes of airport planning should be kept deliberately on the liberal side. If an airport is made too large, a part of the capital expenditure will have been wasted. If it is too small, the whole amount may have been lost, and a fresh start become necessary under very difficult conditions. The objective is not to predict the most probable figure, but rather the largest figure that is reasonably likely to occur.

Aircraft Size and Airport Runway Loads

Let me take a relatively simple example, strictly in the domain of the civil engineer. The material, thickness, and foundation requirements of airport runways and taxiways, like the corresponding characteristics of highways, depend upon the loads that they are to carry. Five years ago there were only two aircraft in the United States which bore a maximum static load of more than 16,000 lbs. on any one wheel, and for those two the maximum did not exceed 35,000 lbs. Today there are thousands of machines in use for which the maximum static load per wheel is around 30,000 lbs., and at least one for which the unit load exceeds 60,000 lbs. Obvious military considerations prohibit discussion of the extent to which, if at all, those figures will be increased in the immediate future; but it is still possible to discuss the post-war probabilities in transport aircraft.

The major advantages of increase in aircraft size are aerodynamic and operational. The major disadvantages are structural. The increase in span of an airplane presents essentially the same problems as the increase in span of a bridge, except that in aircraft the progressive encroachment of structural weight on total load capacity can be fought off for a time by improved distribution of load and reduction of required load factor as size increases. In a small airplane, practically all of the load except the weight of the wing structure itself is carried in the body. As the size of the aircraft is increased, a progressively larger proportion of the total weight is distributed in the wings, where it will be directly balanced against the lift of the air on the wings in flight; and the proportion of the lift that has to be transmitted through the wing structure, as a beam extending along the span, is correspondingly reduced.

Manifestly there is a limit to the length to which that process can be carried. There is a limit also, and one that has already been reached, to the process of reducing load factors with increase of size. The loads imposed on the structure by the pilot's use of the controls may be expected to diminish in relative importance as aircraft grow larger, but the loads imposed by turbulent air are independent of size, and for most transport aircraft those are the loads that are critical. In short, the weapons that have heretofore served the structural engineer in his battle against increase of the ratio of structural weight to gross weight as the size of the aircraft increases begin to lose their effectiveness as the dimensions of aircraft grow larger and larger.

For that and other reasons, increase in size seems unlikely to continue indefinitely; but there is no reason to suppose that a ceiling has yet been reached. Much of the talk of aircraft of a million pounds gross weight or more has been ill-informed; but a leading American manufacturer has reported that serious study has been given to a machine designed to accommodate 400 passengers. Lord Beaverbrook, speaking for the British Government, has indicated that a transport now under order will have a gross weight of over 220,000 lbs. The "flying wing," which is beloved of artists illustrating dreams of the future world and which also possesses some very real merits, if its handicaps can be overcome, is limited by considerations of storage volume available in the wings to gross weights of at least 200,000 lbs., and more probably of 300,000 or more.

If airport planners ask for a projection of the future in this respect, it is my personal belief that we are likely, although by no means certain, to see aircraft of over 300,000 lbs. gross weight in use within the next 15 years; and that the maximum weight may reach 400,000 lbs., but probably will not go appreciably beyond that. Aircraft of more than about 150,000 lbs. gross weight are likely to be used only on services on which it is necessary to fly for distances of 1,500 miles or more without stopping for fuel, and possibly on a very small number of routes of exceptionally heavy traffic within the United States; and their use is accordingly likely to be limited to a relatively small number of landing areas. For the purposes of civil aeronautics, it would probably be sufficient to have twenty-five airports in the United States capable of handling airplanes of above 150,000 lbs. weight. Potential military uses, of course, may be more demanding.

With increase of size it becomes advantageous to spread the landing loads on the aircraft among a number of widely separate points of support. Aircraft of very large dimensions are quite likely to have at least four completely independent landing-gear units along the span. Taking account of that probability, I think it unlikely that the maximum static load on any wheel or closely associated group of wheels will be appreciably in excess of 100,000 lbs. for a number of years to come. Between the 12,000-lb. static wheel load of the present DC-3 and the hypothetical 100,000 lbs. of the future, however, there is still enough of a gap to provide plenty of problems for the designer of concrete slabs and for the drainage and foundation engineers who must provide the assurance that the runway slabs can remain true and evenly supported. There is plenty of need for further research on their behalf, and further study of just what type of loads an aircraft of a given large weight imposes on the surface on which it lands and takes off, along which it taxis, and which it scours with the concentrated blast from its propellers.

The determination of the airport capacity that will be needed for transport operations involves three main questions:

(1) How much transport traffic must metropolitan airport facilities be expected to handle in a reasonably near future?

(2) Is it inherently preferable that a metropolitan area have all its transport traffic concentrated on a single airport, or that several airports should be used?

(3) How long a runway is desirable for a metropolitan airport?

Let me say something on each of the three; and first on traffic prediction.

AIRPORT TRAFFIC VOLUME

It seems to me reasonable to expect, from all the data that I can assemble and from consideration of estimates made by others as well as of my own previous experiments in the same field, that within four or five years after the end of the war the general volume of air traffic may rise to as much as three or four times the highest pre-war level. I believe that it might double again in the next six or eight years.

The significance of those figures can best be appreciated in terms of their relation to existing traffic. They mean that at the maximum level that seems to me likely enough to be realized so that it should be taken into account in airport planning, the travel between Boston and New York by air a dozen years after the war would be a little more than the total travel between those cities by rail in the year 1933, whereas the total movement by air between Boston and the Pacific Coast would be about two and a half times the rail volume for 1933—that being the only year for which a comprehensive report of point-to-point railroad passenger movements exists.

In September 1940 the total number of passengers arriving or departing from Boston by air averaged 798 each day. The average number of transport landings and take-offs was 64 each day. Assuming that the traffic twelve years after the war will be ten times what it was in 1940 (which must be used as a base, since no similar survey for the summer of 1941 is available), and that the aircraft will carry an average revenue load of eighteen passengers each, the average number of take-offs and landings each day may then be about 450.

Since about 15 per cent of the take-offs for the 24 hours may be expected to be concentrated in the busiest hour of the afternoon, the expansion of traffic on Boston's main intercity connections may build up the number of transport take-offs to about 35 in the hour between 5:30 and 6:30 each afternoon, with about half that number of landings in the same time. That number might be increased by from 50 to 100 per cent by the operations of local routes serving areas not at present touched; and the total number of take-offs and landings during the busiest hour might thereby come close to 100. The rush-hour total would be unlikely to exceed 50 within the first five years after the war; but even 50 operations in an hour would be nearly double the highest figure so far attained on any airport in the world, and the need for the most efficient arrangement of facilities for the handling of traffic on the ground and in the air is correspondingly clear.

The total flow of passenger traffic into and out of New York in 1940 was roughly four times that for Boston. Six other cities also exceeded Boston's flow; but there were only 15 others, making 23 in all, that had a movement even half as heavy as Boston's. The problem of building airports for the utmost possible capacity is likely to remain the problem of a very small number of metropolitan areas. A city that averages as much as one scheduled transport take-off every two minutes, or one landing every three minutes, during the busiest part of its day, will be the exception; but it is in connection with those exceptions that the greatest expenditures are involved and that the greatest demands are made on the ingenuity of the designer.

The Physical Capacity of an Airport

The problem of designing for maximum capacity is one of balancing ground against air requirements. Ground capacity can be almost indefinitely increased by simple multiplication of the number of parallel or nearly parallel runways. The capacity of the air space is the problem; and I believe that in future we should determine the capacity of an airport primarily in terms of the rate at which aircraft can be brought in or taken out with safety in instrument weather. I believe there is general agreement on the undesirability of so scheduling operations that they can only be conducted as planned under virtually ideal conditions, with serious delays or diversion of the flights to alternate fields having to be anticipated whenever the clouds hang low. The capacity of airports under instrument conditions is now too low to be endured as a general limitation; but after the war we may hope for such improvement in methods of navigation and traffic control as will make it safe to bring aircraft much closer to one another, under conditions which prevent the pilot's seeing one another directly, than has so far been admissible.

At the present time an airport with four parallel runways might be able to handle 180 take-offs and 120 landings in an hour in good weather. With present methods the best that it would seem possible to expect from air traffic control in bad weather would be the safe handling of 20 take-offs and 15 landings in an hour; but the post-war improvements in radio technique of which we hold such bright hopes ought to increase those figures materially. The airline personnel who have been working on a proposed field layout and methods of operation for New York's new Idlewild airport are hopeful that the bad-weather capacity there can be raised to over 300 movements an hour. There is at least a good chance, if by no means a certainty, that the physical capacity of a single airport can be great enough to handle all of the transport traffic that even the greatest metropolitan centers will be receiving and dispatching in the course of at least the next ten years.

One Airline Terminal for Each Metropolitan District?

That is a more optimistic conclusion than would have been generally acceptable a couple of years ago. It was then the common assumption that each metropolitan area must have a number of transport air terminals. There has been a marked trend in more recent months towards the alternative of concentrating on a single site. The newborn optimism about the possibility of enormous increases in traffic-handling capacity under instrument conditions after the war, to which I have already referred, has brought the central airport back into the realm of physical possibility, even for the largest cities. Emphasis on the airport as an object of civic pride has favored a concentration of all the available resources on a single site developed to the highest possible standard. Considerations of operating convenience also favor such a concentration, with its elimination of short connecting flights and duplicated terminal organizations. The development of central airports so placed as to give service to two cities, each of which has in the past been a transport stop, is a particular evidence of the new trend.

Assuming that no physical necessity is to force the multiplication of metropolitan air terminals, the merits of central and multiple airports may be judged in terms of their respective effects upon the convenience of patrons of air transportation. One does not go far with such an examination without discovering that there is no single best answer. The answer depends upon the local conditions. To prove that with a single instance, suppose the case of a city which is a potential point of departure for non-stop transoceanic flight, but which also has a large volume of exchange of air traffic with a neighboring city a couple of hundred miles away. For reasons that I shall develop a bit later, the economic importance of runway length increases steadily with increasing length of flight. In the imaginary case that I have cited, suppose that an airport with 5,000-ft. runways can be constructed close into the center of the city, whereas it is physically impossible to find a site within fifteen or twenty miles with such dimensions as to permit an 8,000-ft. run. It would be a manifest folly to burden every short-distance air traveler with an extra twenty or thirty minutes of surface travel, or an extra connecting flight, to reach an all-purpose airport, when thousands of passengers could have been saved that loss of time by segregation of the long-haul and short-haul operations. Certainly the ideal to be sought is that all transport aircraft should take off and land in the most convenient location possible; but if it is necessary for some part of air transport's patrons to travel on the ground for three-quarters of an hour or more to reach their point of take-off, the transoceanic traveler will be better able to tolerate that preliminary trip than will the commuter; and it would be better for a minor part of the passengers to have their ground journey protracted than for all of them to do so.

There is real danger that emphasis on airports of enormous size will lead to the adoption of terminal sites farther and farther out into the country, with a resultant loss in ground time for short-haul passengers that will more than offset any saving in air time that is made by increases in the cruising speed of aircraft.

There are on the other hand some cases in which a single site is so outstanding in its excellence, both in convenience to the center of the city and in capacity for physical expansion, as to make it absurd to consider any alternative or any subdivision.

At best the airports will be far enough from the homes and places of business of many of their users to make the speed of surface transportation a matter of major importance. An airline distance of eight miles may take twelve minutes to cover or forty, depending on the circuity of the highways and upon traffic conditions and whether there is a reserved right of way free of traffic crossings. The first rule is to get the airport as close in as is compatible with having a site of proper size. The second is to recognize that a really good system of express highways connecting the airport with strategic points in the metropolitan area, and perhaps supplemented by subways or other rail communications, is a necessary adjunct to the airport and a proper element of its cost.

A third factor in airport location is that if the placing of the airport at a substantial distance from the center of the city proves inescapable, it is best, other things being anywhere near equal, to locate it on the side from which the greatest part of the air transport traffic comes. The speed of aircraft is high, but not so high as to make the distance flown a matter of complete indifference. The difference between using an airport ten miles on the near side of the center of the city and using one ten miles on the far side will be nearly ten minutes in flight time, and about a dollar, at present rates, in the reasonable fare for the trip. Boston's airport is very close in to the center of the city in terms of airline distance; but obviously if a choice had had to be made between potential sites to the north of Boston and to the south, it would have saved both time and expense for a majority of the passengers if the southern site had been chosen. This does not happen to be a practical problem for Boston, but there are other metropolitan districts in which the analogous problem is of very real and immediate importance.

Even where there is no need for building two different airports, close in with short runways and far out with long ones, for local and long-range traffic respectively, there may be occasion for building two or more fields in different locations.

The justification for a second airport depends upon the proportion of the total traveling public who would save time by its use, and upon whether the aggregate of potential saving and the aggregate of new traffic created as a result are sufficient to justify the increase of expense and complication in airline operations. To give the problem specific form, suppose that a second airline airport about ten or twelve miles to the southwest of the present site were under consideration for the Boston area. Such a location would save about three minutes in flying time to New York, and I suppose another half-hour in ground travel time for passengers who wished to go to the airplane from a starting-point in the suburban towns well to the west or south of Boston.

Whether the area that would be substantially benefited by such a hypothetical secondary terminal actually initiates any very considerable proportion of the Boston-New York traffic is a matter upon which my badly out-of-date local information would hardly permit me to have a firm opinion. I do not suppose that anyone would really know at the present time, at all exactly, what proportion of actual or potential airline passengers start from the various residential and commercial areas within the metropolitan district. That is the sort of problem of which there has been far too little serious investigation. Real research on the distribution of air traffic among the various parts of a metropolitan area, as well as a really thorough and objective study of the time normally required to move by highway between the various parts of the district and the various airport sites that are under consideration, are necessary features of intelligent airport planning. It is surprising how often one finds that the only information on normal driving time to an airport either comes from obviously interested parties, and is quoted to prove a point, or is based on obviously inadequate experience.

In Boston's case, however, I have not only found plenty of data available from actual tests on driving time, but I have just been given a personal demonstration of the remarkable convenience of the airport to the business district. Nine minutes to reach the center of the financial district from the airport administration building under normal midday driving conditions, and a total of only 20 minutes to reach Harvard Square, represents a degree of convenience that few cities of anywhere near Boston's population are fortunate enough to approach.

General formulas are dangerous in application to so complex a problem; but I believe that it would be a fair rule to consider the establishment of two terminal airports in place of a single one as justifiable only if the introduction of the second terminal will save time for at least a third of the total number of travelers on a particular route, and save them an average of at least 20 minutes each. Even then, the use of co-terminals would be justified only on routes which will support at least 20 schedules a day in each direction. If the number of flights were less than that, a still more stringent standard should be met before the division of the schedules among two different terminal airports would be justified.

An obvious corollary of the suggested standard is that it is practically never justifiable to put two co-terminal fields within 30 minutes' ground travel time of one another. That, I believe, is actually a sound rule. Of course there may be cases in which fields will be placed closer together than that and connected by shuttle service by airplane or helicopter; but unless they are at least 30 minutes apart by highway, or some ten to twenty miles' airline distance, the benefit derived from splitting the service on a particular route, and starting some of the through schedules from one terminal field and some from another, could hardly be great enough to offset the inconvenience and expense of the duplicated facility.

Certainly it will rarely be possible to justify the use of two co-terminals within the same metropolitan area, or less than one hour apart by highway, unless they are nearly enough balanced in value so that each of them can expect to be the preference of at least a quarter of the total number of passengers. If in any such case there is a large difference in the numbers of passengers who would naturally prefer the two fields, the position is unstable; for the airport having the better geographical situation will naturally enjoy the greater frequency. By that very fact, it will draw more and more traffic away from the area that might normally have been expected to be tributary to the other field, a considerable part of the passengers accepting the extra ground travel time in order to secure the greater convenience of schedule. To cite a particular instance, again, a field to the southwest of Boston would be somewhat easier for residents of the suburbs in that area to reach from their homes than the present Boston airport; but if 20 schedules a day ran to New York from the present airport, and only four or five from the new one, a large proportion even of the travelers from the immediate neighborhood of the new site would presumably choose the busier field, to keep to a minimum the average extent of the dislocation of their desired travel schedule that would be necessary to fit it to the schedules of airline departure.

I do not want to point out individual local situations, but from what I know of a certain number of them I would estimate that under the standards that I have suggested here there are not less than four cities in the United States, and probably not more than twelve, which are spread over such a geographical area and are otherwise of such characteristics as to justify the use of two co-terminal fields for air transport within the next ten years.

The duplication of airports is often objected to on account of the inconvenience occasioned in the making of connections. The objection has some force; but less than is often claimed for it. Its force is limited by the very limited number of passengers who in fact change from one airplane to another. Of the 23,000 passengers who touched the Boston airport in September 1940, more than 96 per cent were beginning or ending their journeys in Boston, and less than four per cent were making connection with another plane. In New York, in the same month, only eight per cent of all passengers were either making connections or going straight through New York on the same plane on which they arrived, more than 90 per cent making New York the terminus of their journeys. If the use of two or more airports as co-terminals were actually to offer substantial savings in ground transportation time to a large part of the travelers to and from the area, the fact that one or two per cent of the total number of passengers might have to come in on an airplane at one airport and leave by another plane from another, traveling between the two either by ground transportation or by inter-airport aircraft shuttle, would be no sufficient reason for denying the benefits of a divided terminal to a much larger number.

Runway Length and the Economics of Air Transport

I come now to the last of the technical problems, and the gravest. For twenty years the appeal to governmental authorities for a fixed specification of the desirable length of airport runways has been incessant. Those of us who have dealt with such matters have been the objects of repeated reproach for having allowed, and even encouraged, communities to build airports which within a few years thereafter were being criticized as obsolete.

The development of our ideas on runway length, from the time when the infield of a half-mile racetrack seemed to serve nicely to the present, when our talk is of runways of 6,000, 8,000, or even 10,000 or 12,000-ft. length, has been the product in part of higher standards of safety in aircraft operation; but even more largely the result of changes in the characteristics of the aircraft themselves.

There is a widely prevalent misapprehension that larger and larger airports are needed because of increases in aircraft size. In truth, the size of the airplanes is virtually without direct effect upon the needed runway length. Given constant ratios among weight, power, and wing area, and the same number of engines in each case, a 100,000-lb. airplane needs no more space for take-off than one of 20,000 lbs. weight, and relatively little more for landing. The primary factors influencing airport requirements since 1918 have been the steady tendency to increase of wing loading, or weight supported for each square foot of wing area, and the increase in inherent aerodynamic efficiency of the aircraft.

It may seem very odd that a progressive increase in efficiency, and increasing perfection of aerodynamic form of the airplane, should require progressive enlargement of airports. It is of course true that if we were inflexibly limited to runways 2,500 ft. in length, like those of which we were once so proud at the Boston airport, aircraft could now be designed which would operate both more safely and more economically from such runways than any aircraft that existed when the Boston airport was built. But it is also true that whereas at that time a 2,500-ft. length appeared quite liberal, the designer is now able to offer a further large improvement in economy and performance if he can be assured that his aircraft will have a materially greater runway length from which to take off and to which to return.

Like other engineering problems, this one permits analysis. We can determine the runway length required to operate any particular aircraft, at any particular weight. We can also study the subject in more general terms, with relation to large families of hypothetical aircraft differing from one another in particular design variables, and so arrive at general conclusions. I have been doing a little work on such a study.

In presenting its results, I must of course issue a warning against the assignment of undue significance to the exact figures that they embody. It is the nature of such studies that the results will not be strictly applicable to any individual aircraft. They fulfill their purpose if they succeed in showing general trends, and the general nature and magnitude of the effects of particular changes either in airport or in airplane characteristics.

My basic assumptions in the present analysis have roughly corresponded to the present requirements of the Civil Air Regulations, although with some modifications and with the omission of certain of the regulatory provisions which would otherwise have limited the scope of the study. I have assumed that critical obstacles, both of which must be cleared in straight flight after the take-off, are 50 ft. high and 2,000 ft. beyond the end of the runway, and 200 ft. high and 11,000 ft. beyond the end of the runway, respectively. It is further assumed that the retraction of the landing-gear will be completed twelve seconds after leaving the ground, and that in the event of an engine failure the feathering of the propeller will be completed 30 seconds after the failure.

I have assumed that the total effects of departures from standard in atmospheric conditions, in the mechanical condition of the aircraft and its engine, and in piloting technique, are such as to increase the length of the take-off run on the ground to 20 per cent more than the minimum distance measured in tests, and to reduce the slope of the flight path thereafter by 1/50, amounting to an assumed loss of from 180 to 300 ft. per minute in rate of climb as compared with the rates of climb observed in the certification tests of the aircraft.

The general level of aerodynamic efficiency that has been assumed in the computations is intended to be representative of good present-day practice, although not the very best that is possible.

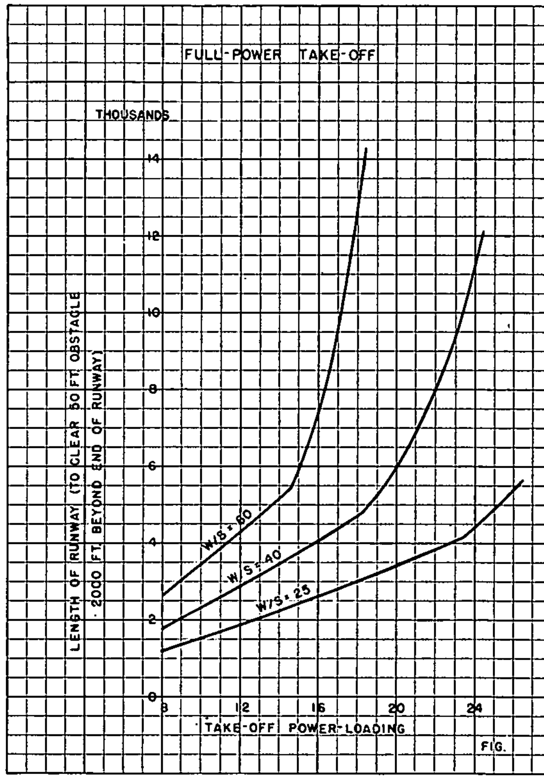

Fig. 1.

The three illustrations that follow (Figs. 1, 2, 3) show the lengths of runway required for take-off under the conditions assumed. Each of the charts contains three curves, corresponding to three different wing loadings, and shows how the required runway length would increase with increases of power loading, or number of pounds carried for every rated horsepower of the engine. The first of the three represents runway length needed on the assumption that all engines continue to run properly throughout the take-off. Analysis on those terms is primarily of military interest; for the rare incident of an engine failure during take-off is accepted as a normal hazard of military operation, but in transport service standards of safety are

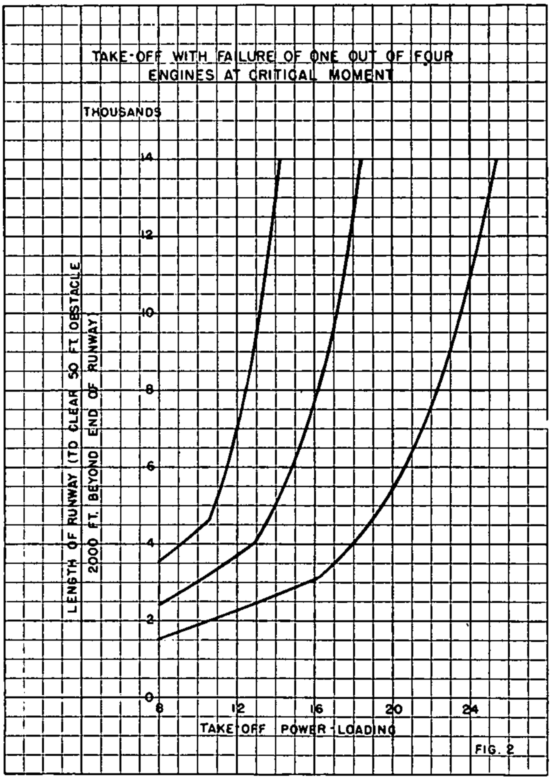

Fig. 2.

so high as to require that the consequences of such a failure during take-offs must be foreseen and fully provided against. The next two figures accordingly show the relations, for twin-engine and four-engine aircraft respectively, of the power loading and the runway length required to insure safety in event of the sudden stoppage of one engine at the most critical instant of the take-off, or at the last instant at which it would be possible for the pilot to bring the take-off attempt safely to an end by shutting off all power and stopping the airplane within the confines of the runway.

The break which appears in a number of the curves corresponds to the point along the curve at which the presence of a 50-ft. obstacle

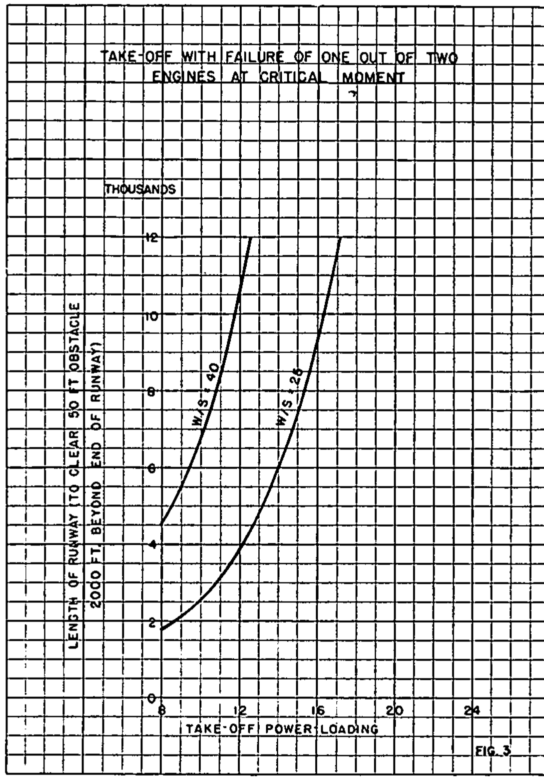

FIG. 3.

2,000 ft. from the end of the runway becomes critical. The less steeply-sloped portions of the curves, to the left of the break in each case, represent the variation of runway length with power loading for hypothetical aircraft which would have so steep a climb, even with one engine inoperative, that they could reach a 50-ft. height in less than 2,000 ft. The more steeply-sloped portions, to the right of the break, cover conditions in which the 50-ft. climb would require more than 2,000 ft.

A striking feature of the curves is the extreme steepness of their upper portions, indicative of a rapid diminution in the rate of return from additional increments of runway length as the basic length increases. Thus for a twin-engined aircraft with a wing loading of 25 lbs. per sq. ft., or almost exactly the wing loading of the familiar Douglas DC-3, an increase of runway length from 4,000 to 6,000 ft. would make it possible, if there were no other considerations, to reduce the total engine power for an aircraft of given weight by about fourteen per cent. The addition of a similar increment of length on an 8,000-ft. runway, however, bringing it to 10,000 ft., would only permit a seven per cent reduction in power.

A reduction in power of course has other effects than to increase required runway lengths. Other things being equal, it reduces the speed of the aircraft; it reduces the rate of climb; and it increases the pay-load, because of the reduction of powerplant weight. The last effect is favorable; the first two are not. To show how all these changes fit together, I have made computations for a number of hypothetical aircraft varying in wing loading and in the runway length required for take-off, but all designed to carry the same payload over a 500-mile distance. The gross weight of the aircraft required to carry such a load, their required take-off power, their cruising speed at an altitude of 10,000 ft., and their rate of climb with one engine stopped have been included in the tabulation. The two tables relate, respectively, to a group of four-engined aircraft designed to carry a 20,000-lb. payload over a 500-mile distance and a group of twin-engined aircraft similarly designed for a 10,000-lb. payload.

Any one of the columns in the table can be taken as basic for purposes of comparison among various alternative cases. Rate of climb, for example, may be taken as the basic factor. I believe it can be stated as a general rule that a four-engined aircraft which is to be used in short-range passenger transport operations, with comparatively frequent landings and take-offs, ought to have enough power to give it a rate of climb with one engine stopped of at least 300 ft. per minute with a wing loading of 25 lbs. per square foot, 400 ft. per minute, with a loading of 40 lbs., and 500 ft. per minute with a 60-lb. loading. It is evident from the tabulations that the runway lengths corresponding to those rates of climb for the three wing loadings would be approximately 6,000, 7,200 and 8,000 ft. respectively. A four-engined airplane with a 40-lb. wing loading which needed more than a

CHARACTERISTICS OF ALTERNATIVE 4-ENGINED AIRCRAFT ALL DESIGNED FOR 20,000-LB. PAYLOAD OVER A 500-MI. DISTANCE

Required Runway Length (ft.)	Power Loading	Gross Weight (lbs.)	Total Power (Take-off Rating)	Cruising Speed at 10,000 (m.p.h.)	Rate of Climb, One Engine Inoperative, Take-off Power on Remainder, Landing Gear Retracted, Idle Propeller Windmilling (ft. per min.)
Wing Loading—25 Lbs. Per Sq. Ft.					
3,000	15.3	69,000	4,500	173	600
4,000	17.8	63,200	3,550	159	440
6,000	20.6	59,300	2,880	143	300
8,000	22.4	57,200	2,550	133	240
10,000	23.7	56,200	2,370	126	200
12,000	24.5	55,600	2,270	121	170
Wing Loading—40 Lbs. Per Sq. Ft.					
3,000	10.2	78,000	7,650	218	1,000
4,000	13.0	65,100	5,000	190	630
6,000	14.9	60,000	4,030	172	460
8,000	16.2	58,000	3,580	161	370
10,000	17.2	56,900	3,310	152	300
12,000	17.9	56,300	3,150	145	270
Wing Loading—60 Lbs. Per Sq. Ft.					
3,000	6.9	94,000	13,600	260	1,600
4,000	9.0	79,000	8,800	233	1,020
6,000	11.5	69,000	6,000	196	610
8,000	12.4	66,700	5,380	184	500
10,000	13.1	65,000	4,960	174	420
12,000	13.7	63,600	4,640	166	370

CHARACTERISTICS OF ALTERNATIVE 2-ENGINED AIRCRAFT ALL DESIGNED FOR 10,000-LB. PAYLOAD OVER A 500-MI. DISTANCE

REQUIRED RUNWAY LENGTH (FT.)	POWER LOADING	GROSS WEIGHT (LBS.)	TOTAL POWER (TAKE-OFF RATING)	CRUISING SPEED AT 10,000 (M.P.H.)	RATE OF CLIMB, ONE ENGINE INOPERATIVE, TAKE-OFF POWER ON REMAINDER, LANDING GEAR RETRACTED, IDLE PROPELLER WINDMILLING (FT. PER MIN.)
		WING LOADING—25 LBS. PER SQ. FT.			
2,000	8.7	63,000	7,200	219	670
3,000	10.7	48,000	4,500	203	440
4,000	11.9	43,000	3,600	195	330
6,000	13.9	37,400	2,620	182	190
8,000	15.3	34,700	2,270	173	110
10,000	16.3	33,300	2,040	167	60
		WING LOADING—40 LBS. PER SQ. FT.			
2,000	3.7*	—	—	—	—
3,000	5.5	95,000	17,000	275	1,200
4,000	7.1	58,000	8,200	204	790
6,000	9.5	41,600	4,400	222	390
8,000	10.9	37,200	3,400	208	230
10,000	11.9	34,600	2,890	201	140

*The characteristics for this case have not been included, as it would be impossible in the present state of the art to build a transport plane with so light a power loading.

7,200-ft. runway wouldn't have enough climb to be really safe without dumping fuel in case an engine stopped after it was in the air.

If speed be taken as a criterion, three cases which happen to show almost exactly the same speed can be compared—those for four-engined aircraft with a wing loading of 25 lbs. per square foot and designed to use a 3,000-ft. runway, with a 40-lb. wing loading and designed for a 6,000-ft. runway, and with a 60-lb. wing loading and requiring a 10,000-ft. runway. The effect of the increase of the wing loading of 25 to 40 lbs. per square foot, while keeping the same speed, would be to double the runway length and to reduce the gross weight of the aircraft by about 13 per cent and the total power required by about 10 per cent, but at the price of losing about 140 feet per minute of climb (from 600 to 460). A further increase of wing loading to 60 lbs. per square foot, still keeping approximately the same speed, would increase the gross weight of the aircraft by about eight per cent and the engine power required by more than 20 per cent, while requiring another 4,000 ft. of runway length and losing another 40 feet per minute of climb. As among those alternatives, the increase of wing loading from 25 to 40 lbs. per square foot would permit a substantial increase in the economy of operation. The further increase of wing loading from 40 lbs. to 60, requiring a further extension of runways to 10,000 ft., would on the other hand be a bad bargain from every point of view, both that of the air transport operator and that of the city planner. For that particular set of conditions, it is probable that the longest runway that could actually be justified by improvement in the economic characteristics of the aircraft which it would be possible to operate would be about 6,000 ft.

I made that comparison for an assumed cruising speed of about 170 miles an hour, which is of course far lower than normal transport practice, because it gave me a point corresponding to each of the three wing loadings. If a cruising speed of 200 miles an hour at 10,000 ft. were to be taken as the fundamental specification, on the other hand, it would be practically impossible to produce a four-engined aircraft of the general efficiency and the propeller characteristics assumed here that would require more than a 5,000-ft. runway, under the conditions that have here been assumed to determine runway length, unless its wing loading at take-off were to be in excess of 50 lbs. per square foot, or well beyond present limits. Even if the wing loading were increased to 60 lbs per square foot, only about a 6;000-ft. runway should be needed for a four-engined aircraft with a cruising speed of 200 miles an hour.

It would appear, in summary, that there is little to be gained in short-range operations from the use of four-engined aircraft which would require more than a 6,000-ft. runway for take-off.

A similar comparison for twin-engined aircraft shows that if the minimum allowable rate of climb with one engine stopped and the remaining engine operating at take-off power, with the landing gear retracted and the idle propeller windmilling, is to be taken as 200 ft. per minute at a 25-lb. wing loading and 300 ft. per minute at a 40-lb. loading (which seem, quite independently of the terms of present regulations, to be about the minimum reasonable figures), the greatest runway lengths that aircraft should be designed to require with the two wing loadings would be approximately 6,000 and 7,000 ft. respectively. Again, as in the four-engined case, there seems to be little to be gained by designing medium-range transport aircraft to make use of more than a 6,000-ft. runway for take-off (including the proper allowance for safety in the event of an engine failure), and practically no gain at all from designing for more than 7,000 ft.

The DC-3, on which very thorough tests on take-off performance have been made by the Civil Aeronautics Administration, would require a runway length of approximately 4,600 ft. to meet the specification laid down herein with respect to the margins of safety that should exist in the event of an engine failure at the critical instant of the take-off. (The assumptions made in the present study are therefore substantially more conservative, at least in that case, than the existing regulatory requirements, which call for an approximate 4,000-ft. runway for DC-3 take-off at full load.) The take-off power loading of the DC-3 at a take-off weight of 25,200 lbs., for which the distance of 4,600 ft. was calculated, is 10.5 lbs. per horsepower; and the wing loading at that weight is 25.6 lbs. per square foot. The cruising speed at 10,000 ft. is approximately 185 m.p.h.; and the rate of climb with one engine inoperative, take-off power on the remainder, the landing gear retracted and the idle propeller windmilling, is about 260 ft. per minute by the Civil Aeronautics Administration tests, the corresponding values obtained by interpolation from the generalized tabulation that I have given for twin-engined aircraft, for a required runway length of 4,600 ft., would be a power loading of 12.5 lbs. per horsepower, a cruising speed of 191 miles per hour, and a rate of climb of 280 ft. per minute. The present study therefore concludes that the advances in the art in the ten years since the DC-3 was designed should make it possible to secure take-off characteristics equal to those of the DC-3 in an aircraft with the same wing loading as the DC-3 and about 16 per cent less power. The differences between the speed and the climb of the DC-3 and those read from the generalized tables for an hypothetical future aircraft requiring the same runway length are not large. They can be presented in the alternative form of a statement that a twin-engined aircraft now designed to have the same wing loading as the DC-3 and the same cruising speed would require about a 5,500-ft. runway instead of 4,600 ft.; and that a machine now designed to have the same rate of climb as the DC-3, again with the same wing loading, would require a runway lengthened from 4,600 ft. to 5,000. The comparison is a concrete illustration of the sometimes surprising point that the effect of increase in the efficiency of aircraft has been to make a modern aircraft require a longer take-off run than would have been required by a much less efficient machine with the same speed or rate of climb.

A similar analysis could be made for long-range operation, with the comparison of various alternative aircraft in terms of the payloads that they would carry over a distance of two or three thousand miles rather than over one of only five hundred. I have not actually prepared such a tabulation, but its general effect would be to increase the importance of the column of gross weights in the tabulations already given. It is likely to take about as large an aircraft to carry 6,000 lbs. between Boston and London without stop as to carry a 20,000-lb. load between Boston and Washington; and variations in the ratio of payload to gross weight which might have but little economic importance on the short haul would become critically important on the Atlantic flight. It will be observed from the tabulation that the general tendency is for the gross weight required to handle a given payload to decrease steadily, though more and more slowly, as the required runway length increases. The law of diminishing returns is again in evidence. In very round numbers it appears that the effect of increasing runway length from 4,000 ft. to 6,000 would be to increase by about 30 per cent the amount of payload that could be carried in a non-stop trans-Atlantic operation with a four-engined aircraft of a given gross weight. Further increases in the runway length for which the aircraft was designed from 6,000 ft. to 8,000, 10,000 and 12,000, respectively, would increase the payload by further increments of approximately 10, 5, and 2.5 per cent. Each additional 2,000-ft. increment would show approximately one-half as much beneficial effect on payload as the similar increment immediately preceding.

Summarizing again, it appears that from the point of view of take-off requirements alone there is likely to be a pronounced advantage in transport economy and transport performance from increase of runway length up to about 6,000 ft. for medium-range operations, and about 8,000 ft. for long range; and that there is a diminishing but still quite appreciable gain from further increases up to about 7,000 and 10,000 ft., respectively. I will at least offer those figures, and the methods by which they have been derived, as the target of criticism and the possible starting-point of further analysis.

I have omitted any consideration of mechanical assistance to the take-off, to accelerate the airplane up to flying speed and get it off the ground in a shorter distance. The general use of such aids for long flights, to make it possible to operate from a runway of 6,000 to 7,000 ft. length with aircraft so loaded that they would otherwise need 10,000 ft, or more, is at least a substantial possibility of the future; but I would hardly think it wise at present to count on their routine use on all transport flights as reducing the desirable runway length to below the figures that I have suggested.

Runway Requirements for Landing

Landing distance, assuming that the aircraft designer uses his full resources in securing braking efficiency, is almost exclusively dependent on wing loading. In the next figure (Fig. 4) I have plotted the length of runway likely to be required for landing in accordance with existing transport regulations, which require that the length of runway be 67 per cent greater than the distance actually used in

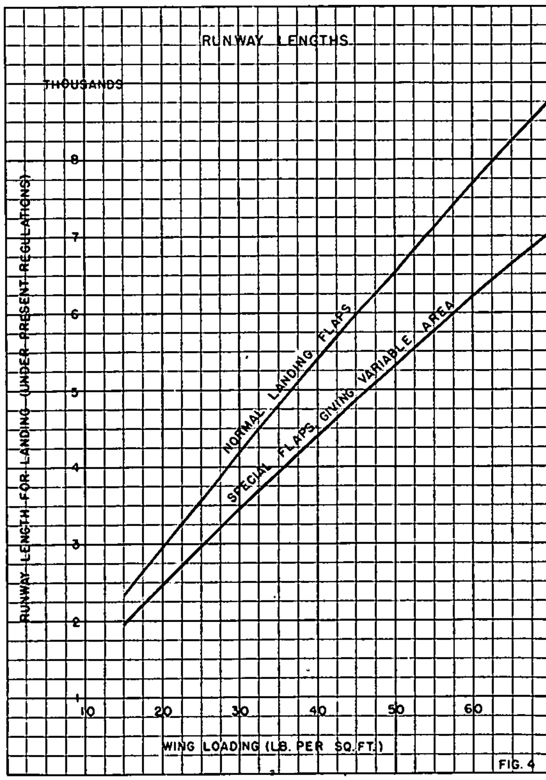

FIG. 4.

bringing the aircraft to rest in a test, assuming the airplane to cross the end of the runway in its approach at an altitude of 50 ft. and at a speed 30 per cent greater than the stalling speed. In plotting the curves it has been assumed that enough power is used during the approach to keep the rate of descent at constant air speed from exceeding 600 ft. per minute. Although the rate so assumed is conservatively representative of normal practice, it is a steeper rate of descent than is likely to be used in connection with instrument landing devices, and to be safely prepared to meet instrument-landing requirements as they now seem most likely to develop the runway lengths plotted in the curves should be increased by about another 1,000 ft.

The maximum wing loading allowable for landing under the regulations which now limit the stalling speed of transport aircraft is approximately 38 lbs. per square foot with ordinary flaps, and 48 lbs. with special or variable-area flaps. The corresponding length of runway required for landing, as shown by the curves, would be about 5,100 ft. in each case. To allow for the probable development of instrument-landing requirements, the figure ought to be raised to about 6,000.

It would, however, be foolish to rely on present stalling speed requirements remaining in force throughout the life of airports now being planned. It is altogether likely that future improvements both in aircraft and in navigational and traffic control methods will make it safe to approach a field and land at a higher speed than now appears permissible. It is hard to set a maximum limit to the possibilities in that respect, since they will depend so largely upon unpredictable invention in the radio art; but I think it would probably be reasonable at least to anticipate the possibility of a 20 per cent increase in stalling speed within the next ten or fifteen years. If that materializes, the extreme runway length necessary will be increased to approximately 7,000 ft. for landings under contact conditions and 8,000 ft. for instrument landings. Such increases may be offset in part by the use of reversible propellers for braking; and I should think it safe to count on 7,000-ft. runway as meeting all probable landing requirements for a number of years to come, if not for the entire fifteen-year period after the war.

I do not want to overstress the importance of these very long runways. Lengths up to about 7,000 ft. for operations over moderate ranges and up to 10,000 ft. for very long range seem to present distinct advantages where they can be obtained. I have no doubt that we shall have aircraft in operation along major routes within the next ten years which can make good use of runways of 7,000 ft. in length, or even somewhat more, or in the case of the trans-oceanic routes up to 10,000 ft.; I hope that the typical metropolitan airline airport will provide such runways, and I believe that the city which is unable to provide at least a 6,500-ft. runway will be at some disadvantage in seeking a place on the main trunk routes where the aircraft of highest performance are used; but I also have no doubt that as of ten years from this date there will be many aircraft in regular transport use, even though they may be limited to secondary services, which can operate with safety and with good payloads from runways of 4,500 ft. or less.

Of General Interest

PRIZES AWARDED AT ANNUAL MEETING ON MARCH 22, 1944

The Desmond FitzGerald Medal

To Ralph W. Horne, Member

Presentation made by President Howard M. Turner

Mr. Karl R. Kennison, Chairman of the Committee on Award of the Desmond FitzGerald Award, consisting of Karl R. Kennison, Donald W. Taylor and George A. Sampson, outlined the purpose of this prize which was instituted and endowed in 1910 by the late Desmond FitzGerald, a Past President and Honorary Member of this Society. This Medal is awarded annually for a paper presented by a member and published during the year which is adjudged worthy of special commendation for its merit. The paper selected by this committee and recommended to the Board of Government for the Award was that by Ralph W. Horne, Member, entitled "Cranston, Rhode Island, Builds Complete New Sewerage Works for 53,000 People", presented at a Joint Meeting with the Sanitary Section held on January 27, 1943, and published in the April, 1943, Journal.

President Turner on behalf of the Board of Government presented the Desmond FitzGerald medal to Mr. Ralph W. Horne, who accepted this award with appropriate remarks.

The Hydraulics Section Prize

To Prof. Thomas R. Camp, Member

Presentation made by President Howard M. Turner

Mr. George A. Sampson, Chairman of the Hydraulics Section Prize Award Committee, consisting of George A. Sampson, Harry P. Burden and C. Frederick Joy, outlined the purpose of the Hydraulics Section Prize which was authorized by the Board of Government in 1924 to be given for a worthy paper given in a Section by a member of the Section.

The paper selected was entitled "Velocity Gradients and Internal Work in Fluid Motion", by Prof. Thomas R. Camp and P. Charles Stein (Co-authors) members, presented at a Joint Meeting with the Sanitary and Hydraulics Sections, held on May 19, 1943, and published in the October, 1943, Journal. The prize consisted of the following books:

"The Collected Works of J. Willard Gibbs", Vol. 1 and 2

"Pumps", by F. A. Kristal and F. A. Annett

"Fluid Mechanics", by R. A. Dodge and M. J. Thompson

Clemens Herschel Award

To Prof. William C. White

Presentation made by President Howard M. Turner

Mr. Karl R. Kennison outlined the purpose of the Clemens Herschel Award which was established by a gift from the late Clemens Herschel, a Past President and Honorary Member of the Society, and is awarded for a paper which has been particularly useful and commendable and worthy of recognition. This year the prize was awarded to Prof. William C. White, for his paper on "Engineering Education—Yesterday, Today and Tomorrow", presented at the Annual Meeting of the Society held on March 17, 1943, and published in the April, 1943, Journal. The prize consisted of the following books:

"The Birds of America", by J. J. Audubon

"Growth of the American Republic", by Morison & Commager.

ACTIVITIES OF MEMBERS

Thomas R. Camp, Member, has resigned from the faculty of the Massachusetts Institute of Technology to open offices for full-time practice as a consulting engineer. He will specialize in water works, sewage works, municipal and industrial wastes, stream sanitation and flood control.

Mr. Camp is a graduate of Texas A. & M. College, Class of 1916, and received a master's degree from M.I.T. in 1925. For twenty-five years he has specialized in hydraulic and sanitary engineering, and for the past 15 years has been in charge of sanitary engineering at M.I.T. He is the author of 35 scientific and technical papers and discussions, including three sections in Davis' "Handbook of Applied Hydraulics", dealing with water supplies, water distribution and water treatment. He is active in research and development work, being the holder of five patents in the field of water and sewage treatment. He holds membership in numerous engineering and technical societies, and is active in committee work. He was the first recipient of the Karl Emil Hilgard Hydraulic Prize of the American Society of Civil Engineers, and has received both the Hydraulics Section and Sanitary Section prizes of the Boston Society of Civil Engineers.

PROCEEDINGS OF THE SOCIETY

MINUTES OF MEETINGS

Boston Society of Civil Engineers

January 26, 1944.—A regular meeting of the Boston Society of Civil Engineers was held this evening at the Auditorium, New Building, Northeastern University and was called to order by the President, Howard M. Turner. This was a Joint Meeting with the Designers Section B.S.C.E. One hundred members attended the meeting and eighty-nine attended the dinner.

President Turner announced the

death of the following members:

Edward P. Adams, who was elected a member October 17, 1883, and who died December 24, 1943.

George M. Warren, who was elected a member February 17, 1897, and who died December 12, 1943.

Prof. John W. Howard, who was elected a member September 16, 1914, and who died January 25, 1944.

President Turner announced that the February meeting would be held at the Boston City Club, the speaker to be Brigadier General C. L. Sturdevant, Assistant Chief of Engineers for War Planning, Washington, D. C.

President Turner called upon Mr. Herman G. Protze, Chairman of Designers Section, to carry on any necessary business for that section.

President Turner then introduced the speaker of the evening, Mr. Joseph Townsend, Hull Superintendent of Bethlehem - Hingham Shipyard, who gave a particularly interesting talk on "Modern Ship Construction". The talk was illustrated with numerous lantern slides indicating the layout of various features of the shipbuilding plant as the means for securing quantity production.

The speaker was given a rising vote of thanks.

Adjourned at 9:00 P.M.

EVERETT N. HUTCHINS, *Secretary*

FEBRUARY 16, 1944.—A regular meeting of the Boston Society of Civil Engineers was held this evening in the Auditorium, Boston City Club, 14 Somerset Street, Boston, and was called to order by President Howard M. Turner. Two hundred twenty members and guests attended this meeting. Two hundred three persons attended the dinner preceding the meeting.

The American Society of Military Engineers, Boston Post, were extended an invitation to attend this meeting.

President Turner announced the death of the following members:

Roland N. Cutter, who was elected a member February 15, 1893, and who died January 28, 1944.

Daniel P. Kelley, who was elected a member October 20, 1909, and who died December 29, 1943.

David A. Harrington, who was elected a member March 19, 1890, and who died January 31, 1944.

The Secretary announced the election of the following members on this date:

Grade of Member: Albert A. Adelman, Warren S. Daniels, John L. Doherty, Leo E. Gaudette, Edwin M. Howard, William W. Lundgren, Roye A. Mulholland.

Grade of Junior: Robert H. Brown*, Richard M. Burbank*, Paul W. Cameron*, Ernest A. DeVeuve*, George B. Fay*, Richard P. Heffernan*, John G. Jarnis*, Esa M. Khoury*, Joseph C. Lawler*, Joseph W. Lavin*, Edward F. Lobacz*, Richard A. Morse*, William C. Petterson*, John W. Wiita*.

President Turner stated that with the approval of the Board of Government the date of the Annual Meeting has been changed from March 15, 1944 to March 22, 1944, to accommodate the speaker, Dr. Edward P. Warner.

The President introduced the speaker of the evening, Brigadier General C. L. Sturdevant, Assistant Chief of Engineers for War Planning, Washington, D. C., who gave an extremely interesting talk on "Construction in Overseas Theatres". The talk was illustrated by slides and also movies.

A rising vote of thanks was given the speaker.

Adjourned at 8:45 P.M.

EVERETT N. HUTCHINS, *Secretary*

*Transfer from Grade of Student.

MARCH 22, 1944.—The ninety-sixth annual meeting of the Boston Society of Civil Engineers was held today at the Boston City Club, Auditorium, and was called to order at 4:30 P.M., by the President, Howard M. Turner.

President Turner announced the death of the following members:

Paul L. Bean, who was elected a member February 20, 1925, and who died January 29, 1944.

Albert F. Sargent, who was elected a member March 21, 1894, and who died January 1, 1944.

The minutes of all previous meetings of the current fiscal year which have been printed in the various issues of the JOURNAL were approved as printed.

The Secretary reported the election of the following members on this date:

Grade of Student: R. H. Olney, S. J. Pattison, I. A. Benjamin, E. J. Galten, G. H. Searles, W. N. Maravell, R. J. Markell, A. M. Clericuzio, A. Hebert, M. M. Kay, E. W. Murphy, R. Wooldridge, R. H. Jones, J. M. Campbell, J. Sikora, B. F. Colton, N. Kopsiaftis, A. J. Urban, B. Kolner, J. A. Johnson, E. Schwartz.

The Annual Reports of the Board of Government, Treasurer, Secretary, and Auditors were presented. Reports were also made by the following committees: Social Activities, Subsoils of Boston, Welfare, Library, and John R. Freeman Fund.

VOTED that the reports be accepted with thanks and placed on file, and that they be printed in the April, 1944, JOURNAL.

VOTED that the incoming Board of Government be authorized to appoint such Committees as it deems desirable.

The report of the Tellers of Election, Charles C. McDonald and Ralph M. Soule, was presented and in accordance therewith the President declared the following had been elected officers for the ensuing year.

President—Samuel M. Ellsworth
Vice-President (for one year)—Harry P. Burden
Vice-President (for two years)—Carroll A. Farwell
Secretary (for one year)—Everett N. Hutchins
Treasurer (for one year)—Chester J. Ginder
Directors (for two years)—Albert E. Kleinert, Henry A. Mohr
Nominating Committee (for two years)—Raymond W. Coburn, Lawrence M. Gentleman, Donald W. Taylor.

The retiring President, Howard H. Turner, then gave his address on "Domestic Electric Rates".

Sixty members attended this part of the meeting.

The meeting adjourned to assemble at 7:45 P.M., the Annual Dinner being held during the interim.

The President then called the meeting to order.

New Honorary Member

President Turner announced that Honorary Membership in the Society had been conferred on one of the Society's distinguished members, by vote of the Board of Government on January 26, 1944, to Mr. Arthur T. Safford, who became a member on December 21, 1892, and was President of the Society, 1934-35.

Presentation of the certificate of Honorary Membership was made by President Turner. The certificate reads as follows:

BOSTON SOCIETY OF CIVIL ENGINEERS

ARTHUR TRUMAN SAFFORD

for many years engineer for the water power at Lowell where he ably upheld a great hydraulic tradition, a consulting hydraulic engineer whose advice is widely sought on much important work has been duly elected an

HONORARY MEMBER

By direction of the Board of Government

January 26, 1944

(Seal)

Everett N. Hutchins, Secretary
Howard M. Turner, President

Presentation of Prizes

President Turner requested Past President Karl R. Kennison, Chairman of the Committee on the Award of the Desmond FitzGerald Medal to outline the purpose of this award and to present the candidate for the award. President Turner then on behalf of the Society made the presentation of the medal to Ralph W. Horne, Past President, for his paper on "Cranston, Rhode Island, Builds Complete New Sewerage Works for 53,000 People", presented at a Joint Meeting of the Society with the Sanitary Section held on January 27, 1943, and published in the April, 1943, JOURNAL.

The President requested Mr. George A. Sampson, Chairman of Hydraulics Section Prize Award Committee to outline the purpose of the Section Prize. The President then on behalf of the Society presented to Prof. Thomas R. Camp, Member, the Hydraulics Section Prize, which consisted of books as follows:

"The Collected Works of J. Willard Gibbs". Vols. I and II.
"Pumps", by F. A. Kristal and F. A. Annett.
"Fluid Mechanics", by R. A. Dodge and M. J. Thompson.

The President requested Karl R. Kennison to outline the purpose of the Clemens Herschel Prize. The President then presented the Herschel Prize to William C. White, for his paper on "Engineering Education—Yesterday, Today and Tomorrow" presented at a meeting of the Society held on March 17, 1943, and published in the April, 1943, JOURNAL. The prize consisted of books as follows:

"Growth of the American Republic", by Morison & Commager.
"Birds of America", by J. J. Audubon.

President Turner then introduced the guest speaker, Dr. Edward P. Warner, Vice-Chairman, Civil Aeronautics Board, Washington, D. C.

Dr. Edward P. Warner—Harvard, A.B. 1916; Massachusetts Institute of Technology, B.S., 1917, and M.S., in 1919; Professor Aeronautical Engineering, M. I. T., 1920-26; Assistant Secretary of the Navy for Aeronautics, 1926-29; Vice-Chairman, Federal Aviation Commission, 1934-35; Vice-Chairman, Civil Aeronautics Board since 1940; Honorary Fellow, Royal Aeronautics Society, London.

Dr. Warner's address, "The Development and Forecasting of Airport Requirements", dealt with the considerations that have controlled, and will control, the size of airports, and with the relations of airport planning to city planning and to traffic requirements, as well as to considerations of operational economy and efficiency. Al though the address covered primarily airports for transport aircraft, the prospective needs of other types of flying were described. The talk was illustrated by stereopticon slides and was especially interesting.

At the conclusion of this address, President Turner introduced the newly elected President, Samuel M. Ellsworth, who then assumed the chair and adjourned the meeting at 9:30 P.M.

Two hundred thirty-two members and guests attended the dinner. Among the guests were Mr. George W. Schryver, Associate Commissioner, Massachusetts Department of Public Works; Mr. Arthur Tully, Director, Massachusetts Aeronautics Commission.

Meeting adjourned at 9:30 P.M.

EVERETT N. HUTCHINS, *Secretary*

SANITARY SECTION

DECEMBER 15, 1943.—The Sanitary Section met jointly with the Boston Society of Civil Engineers at the Twentieth Century Club on December 15, 1943. Dinner was served at 6:30 P.M. and the meeting began at about 7:45 P.M. Following the business meeting of the main society the Sanitary Section conducted a business meeting, the results of which were as follows:

It was voted to accept the resignations of Messrs, Edwin B. Cobb and Kenneth Knowlton, dated November 9 and 7, 1943, respectively. Mr. Cobb had resigned to enter the United States Naval Reserve and Mr. Knowlton to enter the United States Army. It was voted that the chairman should appoint a nominating committee to recommend candidates for the office of Vice-Chairman of the Section, formerly filled by Mr. Cobb, and of clerk, formerly filled by Mr. Knowlton. The chairman appointed a nominating committee as follows:

Ralph M. Soule, Chairman
C. F. Joy, Jr.
G. W. Coffin
C. O. Baird

Mr. C. F. Joy reported for the nominating committee as follows:

Mr. Murray H. Mellish for Vice-Chairman
Mr. George C. Houser, for Clerk

It was voted that nominations be closed and then it was voted that the chairman should cast one ballot for the two nominees.

The principal speaker, Mr. Seth G. Hess, Director and Chief Engineer of the Interstate Sanitation Commission (for New York, New Jersey and Connecticut) delivered a paper entitled "Interstate Agreements for Pollution Abatements". Mr. Hess described the formation and functioning of the Interstate Sanitation Commission and of other similar commissions. The paper was discussed principally by a guest of the Society, Mr. Warren Scott, Chief Engineer of the Department of Health of the state of Connecticut. Following a considerable general discussion, the meeting adjourned at about 9 o'clock. Thirty members were in attendance.

W. L. HYLAND, *Chairman*

FEBRUARY 10, 1944.—A meeting of the Sanitary Section was held at the Society Rooms at 7 p.m., following an informal dinner gathering at Patten's Restaurant. Twenty-seven persons attended the meeting, with seventeen at the dinner.

It was voted that the Chairman should appoint a Nominating Committee to recommend candidates for officers of the Section and members of the Executive Committee for the year beginning March 1, 1944.

The speaker of the evening was Mr. George W. Coffin, Engineer, Boston, who presented a paper entitled "Water Supply and Sewage Disposal at Certain Outlying Airfields in Southern New England". After a considerable general discussion, the meeting adjourned about 8:35 p.m.

GEORGE C. HOUSER, *Clerk*

MARCH 1, 1944.—A meeting of the Sanitary Section was held this evening at the Society Rooms at 7:35 p.m., following an informal dinner gathering at Patten's Restaurant. Thirty-one persons attended the meeting with twenty-seven at the dinner.

The Chairman read the report of the Nominating Committee, consisting of R. M. Soule, Chairman, C. O. Baird, G. W. Coffin and C. F. Joy, submitting the following nominations for officers for the ensuing year:

Chairman—Frederick S. Gibbs
Vice-Chairman—Murray H. Mellish
Clerk—George C. Houser
Executive Committee—
George F. Brousseau
Allen J. Burdoin
William L. Hyland

Upon motion duly made and seconded, it was voted that the Clerk cast one ballot for the list of nominees submitted by the Nominating Committee.

The speaker of the evening was Mr. Philip B. Streander, Consulting Sanitary Engineer, who is associated with Stone & Webster Engineering Corporation. Mr. Streander presented a paper entitled "Some Interesting Features of Sewage Plant Design". Mr. Streander spoke about many of the appurtenances which are usually overlooked in a paper on sewage treatment works, but which are nevertheless important features of the plant. Among the subjects discussed were the following: operation of constant-speed and variable-speed pumps, methods of withdrawal of grease from settling tanks, and the maintenance and operation of effluent filters. After a considerable general discussion, the speaker was given a rising vote of thanks and the meeting adjourned about 9 p.m.

GEORGE C. HOUSER, *Clerk*

DESIGNERS' SECTION

JANUARY 26, 1944.—A joint meeting with the main Society, preceded by a dinner, was held at Northeastern University this evening, President Howard M. Turner presiding. Chairman Herman G. Protze transacted the business of the Designers' Section. It was voted to authorize the Chairman to appoint a Nominating Committee to prepare a slate of officers for the ensuing year. The Chairman thereupon appointed Emil A. Gramstorff, John B. Wilbur, and Kimball R. Garland to constitute such a committee and requested that a report be submitted at the next regular meeting.

The scheduled speaker for the evening was unable to attend and in his place Mr. Townsend, Superintendent of the Hull Division of the Bethlehem-Hingham Shipyard gave an illustrated talk on "Modern Ship Construction."

The attendance was 100 members and guests.

The meeting adjourned at 8:45 P.M.

EUGENE MIRABELLI, *Clerk*

FEBRUARY 9, 1944.—A regular monthly meeting of the Designers Section was held in the Society Rooms this evening starting at 6:45 P.M., with Chairman Herman G. Protze presiding. The minutes of the two previous meetings were approved as read.

The nominating committee submitted the following slate of officers for the coming year:

Chairman—Lawrence M. Gentlemen
Vice-Chairman—Eugene Mirabelli
Clerk—Frank L. Lincoln
Executive Committee—
Earl R. Baker
Dean Peabody, Jr.
Henry I. Wyner

These nominations were accepted by the Chairman and placed on file for further action.

The speaker for the evening was Mr. Eric P. Muntz of Montreal, Canada, who gave an illustrated talk on "Prestressed Concrete Structures."

There was an attendance of 80 members and guests.

The meeting adjourned at 10:00 P.M.

EUGENE MIRABELLI, *Clerk*

MARCH 8, 1944.—The Annual Meeting of the Designers Section was held in the Society Rooms on March 8, 1944, starting at 6:45 P.M. with Chairman Herman G. Protze presiding. The report of the previous meeting was approved as read. The report of the Executive Committee covering the activities of the Section for the past year was read and approved.

The Nominating Committee submitted a final report and the following officers were elected for the ensuing year:

Chairman—Lawrence M. Gentleman
Vice-Chairman—Eugene Mirabelli
Clerk—Frank L. Lincoln
Executive Committee—
Earl R. Baker
Dean Peabody
Henry I. Wyner

The speaker for the evening was Mr. F. L. Lawton, Assistant Chief Engineer, Aluminum Co. of Canada, who gave an illustrated talk on the "Design and Construction of the Shipshaw Hydroelectric Development".

There was an attendance of 60 members and guests.

The meeting adjourned at 9:00 P.M.

FRANK L. LINCOLN, *Clerk*

HIGHWAY SECTION

FEBRUARY 23, 1944.—A meeting of the Highway Section of the Boston Society of Civil Engineers was held in the Society rooms, 715 Tremont Temple, Boston, Mass.

The meeting was called to order by the Chairman, Mr. Edgar F. Copell, at 7:10 P.M. The Chairman called for the report of the nominating committee as the first business of the evening. The clerk then read this report which submitted the names of the following members as candidates for office for the coming year:

Chairman—Charles O. Baird, Jr.
Vice-Chairman—
William C. Paxton, Jr.
Clerk—George W. Hankinson
Executive Committee—
Thomas C. Coleman
Francis J. Crandall
Hermon S. Swartz

Further nominations were asked for and there being none it was moved, seconded, and carried unanimously that the clerk cast one ballot for the above officers who were thereupon declared elected.

The general subject of the meeting, "The Alaska Highway," was introduced with a showing of sound moving pictures by Mr. C. E. Copp, of the B. F. Goodrich Co., who furnished the pictures and the projector.

The Chairman then introduced the speaker of the evening, Mr. Hans E. Bernt, General Manager of the David Nassif Company, who held one of the contracts on the project. Mr. Bernt gave an intimate account of his experiences in connection with this project, illustrating his account with colored moving pictures taken during the work showing portions of the road and the rugged and primitive nature of the terrain which it traversed.

Following the talk, additional sound moving pictures were shown by Mr. John R. Perkins. These pictures illustrated construction work on the Alaska Highway Project and also the Alcan-Canol Project, incidentally depicting the versatility of heavy earth moving equipment in construction work of this type.

The meeting closed with a rising vote of thanks to the speaker of the evening and those who furnished the pictures and equipment.

The meeting adjourned at 9:50 P.M. Attendance 67.

THOMAS C. COLEMAN,
Acting Clerk

HYDRAULICS SECTION

FEBRUARY 2, 1944.—A meeting of the Hydraulics Section was held at the Society Rooms today. During the business meeting, conducted by Chairman William F. Covil, the following officers were elected to serve during the next year:

Chairman—Allen J. Burdoin
Vice-Chairman—
Charles C. McDonald
Executive Committee—
Kenneth C. Reynolds
Julian H. White
John G. W. Thomas
Clerk—Harold A. Thomas, Jr.

The speaker was Mr. Allen J. Burdoin of Metcalf and Eddy, who presented a paper prepared by Lt. Edwin B. Cobb, U.S.N.R., entitled "Flow of Water in Network Piping Systems". In the paper the Hardy Cross method for the solution of the flow of water in distribution systems was reviewed. Of the various means of facilitating the solution, the most significant was the use of the Darcy-Weisbach formula. Extensive tables and curves of friction factors were presented and analyzed.

In a prepared discussion, Mr. Burdoin extended and amplified some of the salient points by the author.

After a period of discussion the meeting was adjourned.

Twenty-four members and guests attended.

HAROLD A. THOMAS, *Clerk*

NORTHEASTERN UNIVERSITY SECTION

JANUARY 26, 1944.—A Joint Meeting of the Northeastern University Section, Boston Society of Civil Engineers, with the Boston Society of Civil Engineers and the Designers Section of B.S.C.E. was held this evening.

Dinner was served in the University Commons at 6:00 P.M. Seventeen students were present as hosts to the Boston Society of Civil Engineers and the Designers Section of B.S.C.E. After dinner, the meeting was adjourned to Room 228, New Building at 7:15 P.M.

The business meeting of the Boston Society of Civil Engineers was conducted by President, Howard M. Turner. Mr. Turner then turned the meeting over to Mr. Herman G. Protze, Chairman of the Designers Section of the B.S.C.E., for Section business.

Mr. Turner introduced the speaker for the evening, Mr. Townsend, superintendent of hulls at Bethlehem-Hingham Shipyards, who spoke in place of Mr. Samuel M. Wakeman, general manager of Bethlehem-Hingham Shipyards, who was unable to attend the meeting. His subject was "Modern Ship Construction."

Mr. Townsend gave a general description of the design and construction of prefabricated hulls. The discussion centered around the steel mill where all the prefabrication takes place. Slides were shown illustrating the arrangement of the machinery and jigs in the steel mills. Additional slides showed the general yard layout and the laying of the keel and launching of D.E. 3091. After his illustrated lecture of hull construction and ship building, questions were asked by the members of the Society.

The meeting adjourned at 8:45 P.M.

PHILIP A. FRIZZELL, *Secretary*

MARCH 16, 1944.—Dinner was held at the Lobster Claw at 6:00 p.m. Eighteen persons were present, including six guests and faculty members. After dinner the meeting adjourned to Room 228, New Building.

The meeting was opened at 7:00 p.m., by the President, Henry J. Bishop who conducted the business of the meeting. Mr. Bishop then introduced the speaker for the evening, Mr. Hans Bernt, General Manager of the David Massif Construction Company, who gave an illustrated lecture on "The Alaskan Military Highway".

Mr. Bernt gave some of the highlights of the construction of the Alaskan Military Highway, stressing the hardships which the men had to endure. After a short speech, movies were shown. The first reel illustrated the connection of the highway with the bombing of Pearl Harbor and the results that were hoped to be obtained. Subsequent reels gave a picture of the construction and showed much of the scenic beauty of the Yukon country. The meeting was informal and the audience was free to ask questions at any time.

The meeting adjourned at 9:30 p.m. Seventy persons attended the meeting.

Respectfully submitted,

PHILIP A. FRIZZELL, *Secretary*

APPLICATIONS FOR MEMBERSHIP

[March 20, 1944]

The By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of fifteen (15) days from the date given.

For Admission

RALPH J. CODE, Roxbury, Mass. (b. February 12, 1892, North Dakota.) University of Minnesota, 1915; Lowell Institute, 1932; surveying; Massachusetts Nautical Training School 1919-20, navigation; 1926-1927, general contracting, 1332 Tremont Street; 1927-1942, Public Works Administration, field engineer in charge of organization and activities of engineering field parties in Massachusetts, triangulation, airport layout, topographical map surveys and making hydrographic surveys and precise leveling; 1942, Platt Contracting Company, Inc., Newport, Rhode Island, chief of party, naval construction layout; 1943, Walsh Construction Company, Providence, R. I., docks, buildings and earth stabilization. Refers to *J. D. Guertin, D. Moore, H. G. Protze, R. S. Slayter. H. M. Turner.*

Malachy T. Coughlan, Charlestown, Mass. (b. August 1, 1915, Harborgrace, Newfoundland). Attended Lowell Institute, M. I. T. receiving certificate. Experience, 1936-1938, instrumentman with the Works Progress Administration under Army Engineers; 1938-1939, Civil Engineering Aid with the Metropolitan District Water Supply Commission; 1939-1944, inspector of engineering materials (Senior) with Navy Department. Refers to *J. Cavazzoni, W. F. Condon, 3rd, S. M. Dore, G. Hyland.*

Norman D. Hall, Greenwood, Mass. (b. October 14, 1905, Greenwood, Mass.) Graduated from Medford High School in 1926. Took drafting course at Massachusetts Institute of Technology in 1942. Experience, August 1926 to December, 1926, Commonwealth of Massachusetts, Department of Public Health, rodman, land and topography surveys. January, 1927, to present date, Commonwealth of Massachusetts, Metropolitan District Water Supply Commission,—January, 1927, to September, 1928, rodman, land and topography surveys; Quabbin Reservoir Area, Enfield, Mass; instrumentman, September, 1928, to September, 1936,—chemical laboratories, Springfield and Enfield, Mass., in charge of sampling boat and the collecting of river samples from the Connecticut River and tributaries within the State of Massachusetts. Also assisting with sanitary surveys in the field and chemical analyses in the laboratory. October, 1926, to December, 1941, soil testing laboratories, Enfield and Belchertown, Mass. October, 1936, to June, 1938, Senior Engineering Aid. June, 1938, to present date, Junior Civil Engineer. Work consisted of mechanical soil analyses, Winsor Dam and the testing of concrete aggregates. January, 1942, to present date, Boston Office, General engineering and laboratory work. Refers to *W. F. Covil, S. M. Dore, C. J. Ginder, F. Griffin, K. R. Kennison.*

William G. Horton, Belmont, Mass. (b. October 21, 1890, Chicago, Illinois.) Received degree, Bachelor of Mechancal Engineering, University of Arkansas, Fayetteville, Arkansas, in 1916. Experience, 1917-1921, General Electric Company, Lynn, Mass., turbine test and service engineer; 1921-1922, Chicago Pneumatic Tool Company, Franklin, Pa., service engineer; 1922-1924, Harvard Engineering School, instructor in mechanical engineering; 1924-1929, Boston Edison Company, in charge of mechanical and structural drafting; 1930-1931, Merrimac Chemical Company, Everett, Mass., assistant designing engineer on general program of plant expansion; 1932-1935, work on engineering report on which litigation involving a claim for damages to the Barre Wool Combing Company, caused by diversion of water from the Ware River, was based. During the same period did electrical design work for D. P. Eames, Consulting Engineer; 1935, Metcalf & Eddy, Boston, design of heating system for Lawrence Water Works Buildings; 1935-1936, Jackson & Moreland, Boston, design of steam distribution for Old Harbor Village; 1937, Westcott & Mapes, New Haven, Conn., report on future development of plant of United Illuminating Company, New Haven and Bridgeport; 1937-1938, Jackson & Moreland, reports; 1938-1939, Alfred Kellogg, Boston, Heating and Ventilating design. 1929-1941, Westcott & Mapes, power plant design; 1931-1943, Fay, Spofford & Thorndike, Boston, design of mechanical facilities for Newfoundland Army Base. Refers to *D. M. Brown, E. S. Chase, G. C. Douglas, K. R. Garland, W. L. Hyland.*

James N. Priest, Brookline, Mass. (b. December 14, 1903, Nelson, N. H.) Kimball Union Academy, Northeastern University Evening Polytechnic (1 year), Lowell Institute (M.I.T.), Tufts College, specializing in structural design and detail; Tufts College, specializing timber and concrete design. Experience, New Hampshire State Highway, survey, June to September, 1920 and 1921; New York, New Haven and Hartford Railroad Division Engineers Office, field and office, 1922-1925; Detroit Steel Products Co., 1925-1927, layout and detail estimating, construction engineer; 1927-1941, business for self, sales engineer, engineering and detail service for Architects and Manufacturers Representative for Groisser & Shlager, February, 1941 - October, 1941, layout and detail of structural steel for fabrication and erection, Lyon's Iron Works Inc., October, 1941-September, 1942, design, layout and detail of structural steel; Chas. T. Main, Inc., September, 1942 - April, 1943, structural computor and detail of reinforced concrete. April, 1943 to date, Shreve, Lamb & Harmon, Fay, Spofford & Thorndike, field engineer. Refers to *C. N. Cann, L. M. Gentlemen, F. L. Heaney, W. L. Hyland, M. H. Mellish.*

FRANK K. PERKINS, Newton, Mass. (b. October 6, 1891, Brooklyn, New York.) Graduate Civil Engineer, Cornell University, Class of 1912. LaSalle Extension University, course in higher accounting, completed, 1921; Massachusetts Institute of Technology, Special Naval Architecture War Course, 1943. Experience, 1912-1914, on Construction of New York, Westchester & Boston Railroad, main office, New York City, Civil engineer in office and field and some design, but mostly supervision of construction; 1912-1919, Junior engineer on construction of New York subways, principal assistant in field, and some office work; 1917-1919, Officer in U. S. Army Engineers; 1919-1923, Head of Perkins and Kuzmier, Civil Engineers, small general practice involving design and supervision of construction, surveys, etc. Since 1923 have been out of straight engineering work, although for most of the time was in semi-technical work in the truck business as transportation engineer and manager of various branch offices. For last ten years have been running a rather unique business of my own, doing newspaper columns and writing and lecturing on contract bridge and other games. Home paper is Boston *Herald-Traveler.* At present at Boston Navy Yard as naval architect. Refers to *T. R. Camp, E. N. Hutchins, H. M. Turner.*

JOHN F. SHEA, Framingham, Mass. (b. September 18, 1913, Mattapan, Mass.) Graduated from Northeastern University in 1937, received B.S. degree in Civil Engineering. Experience, September, 1937, to April, 1941, with Hardware Mutual Casualty Company, Boston, Mass. At this time called into active duty in the Officers' Reserve Corps of the U. S. Army, stationed at Camp Edwards as Assistant Post Engineer from April, 1941 to July, 1943, and was then transferred to Headquarters First Service Command, Office of the Service Command Engineer for duty as Assistant in Repairs and Utilities Work. Was transferred to the Cushing General Hospital, Framingham, Mass., in September 1943. At present, Post Engineer at the Cushing General Hospital, Framingham, Mass. Refers to *C. O. Baird, A. E. Everett, E. A. Gramstorff.*

Transfer from Grade of Junior

CHARLES G. HUNT, JR., Plainfield, N. J. (b. September 6, 1915, Newton, Mass.) Graduated from Northeastern University in 1939, with degree of B.S. in Civil Engineering. Experience, 1935-1938, City of Newton Engineering Department, as rodman and instrumentman; 1939, Junior engineering aid for Metropolitan District Commission (Sewer Division). After graduation employed by Metropolitan District Water Supply Commission as transitman on construction of tunnel section of New Aqueduct in Southborough; 1940-1943, employed by The Austin Company, Engineers & Builders, as construction engineer on Industrial Building projects in Pennsylvania, New Jersey, New York and Rhode Island. Assistant construction superintendent on large industrial construction project in New Jersey. 1943 to present employed as Plant Engineer by Diehl Mfg. Company, Somerville, N. J., in charge of complete plant maintenance, planning and directing plant alterations and new construction. Refers to *C. O. Baird, A. E. Everett, E. A. Gramstorff, J. J. Vertic.*

Transfer from Grade of Student

GEORGE W. HANKINSON, Boston, Mass. (b. September 13, 1915, Weymouth, Nova Scotia.) 1933-1937, Mount Allison University, New Brunswick, Pre-medical, B.A.; 1937-1938, Dalhousie University, Nova Scotia, medicine; 1938-1943, Northeastern University, B.S. degree in Civil Engineering. Experience, November, 1940 to February, 1941, with New York, New Haven and Hartford Railroad as chainman; June, 1941 to September, 1941, with same company as chainman and rodman; December, 1941 to February, 1942 and April, 1942 to July, 1942, with same company as inspector; September, 1942 to November, 1942, U. S. Army Engineers; November, 1942 to June, 1943, instructor in Physics and Mathematics at Northeastern University; June, 1943 to present time instructor in Civil Engineering at Northeastern University. Refers to *C. O. Baird, A. E. Everett, E. A. Gramstorff.*

JOHN F. HEANEY, JR., Lexington, Mass. (b. December 24, 1919, Lexington, Mass.) Graduated from Cambridge School of Liberal Arts in 1939 and Northeastern University in 1943. Attended U. S. Naval Academy, North Carolina State College and General Motors Institute under Navy Program. Experience, June, 1941 to September, 1941, instrument man with U. S. Engineer Department at Blackwater Dam; September, 1941 to November, 1941, Chief of Party and Inspector with U. S. E. D., relocating cemeteries at Franklin Falls Dam; January, 1942, to April, 1942, and June, 1942, to September, 1942, and November, 1942 to February, 1943, with U. S. E. D. at Castle Island as an aide to office engineer preparing survey computations and estimates. Junior member of American Society of Civil Engineers. At present, Engineering Officer aboard U.S.S. L.S.T. 1006. Refers to *C. O. Baird, A. E. Everett, E. A. Gramstorff, A. E. Sanderson.*

GEORGE O. HUSE, Newton, Mass. (b. March 31, 1921, Franklinton, New York.) Entered Northeastern University in September, 1938, and was drafted out June 25, 1943. At present a student at Rose Polytechnic Institute under Army Specialized Training Program. Refers to *C. O. Baird, A. E. Everett, E. A. Gramstorff.*

JOHN W. IRELAND, Lynn, Mass. (b. December 13, 1921, Lynn, Mass.) Graduated from Lynn Classical High School in 1933. Received B.S. degree in Civil Engineering from Northeastern University in 1943. Experience, April, 1941, to June, 1942, with William S. Crocker, as rodman and transitman on construction work and surveys; September, 1942, to September, 1943, with Thompson & Lichtner Company, Inc., as laboratory assistant and as part-time field inspector on concrete quality control. Work consisted of inspection and testing of building materials such as concrete, steel, brick and asphalt. The major part of this experience consisted of inspection and control of the quality of concrete, as to its strength, workability and resistance to wear and to the elements. At present doing part-time work as transitman with William S. Crocker, Civil Engineer, Boston. Refers to *C. O. Baird, L. A. Chase, M. N. Clair, W. S. Crocker, E. A. Gramstorff.*

FREDERICK B. JACKSON, Auburndale, Mass. (b. August 16, 1917, Beverly, Mass.) Graduated from Newton High School, June, 1936. Attended two years at Lowell Institute, Massachusetts Institute of Technology, structural engineering course. B.S. degree in Civil Engineering from Northeastern University, November, 1943. Experience, November, 1940, to January, 1941, Newton Engineering Department, Newton, Mass., chainman, rodman, and draftsman on street surveys; January, 1940, to June 1942, Lally Column Co., Cambridge, Mass., template draftsman and steel construction detailer for the manufacture of steel shaft concrete filled columns; September, 1942, to November, 1942, U. S. Engineer Dept., Boston District, Bedford Airport, Bedford, Mass., computing and checking airport construction layouts including runways, roads, sewerage system, water system, and estimating quantities; February, 1943, to April, 1943, Fay, Spofford & Thorndike, Boston, Mass., detailer of structural, reinforced concrete, plumbing and heating layouts, estimated quantities for airport construction; June, 1943, to September, 1943, Turner Construction Company, Framingham General Hospital, Framingham, Mass., as chief of party and instrumentman, work consisted of staking building lines, setting batters, grading piers, taking profiles and cross sections, and inspector in pile driving. At present stationed at U.S.N.R. Midshipmen's School, Notre Dame, Indiana. Refers to *C. O. Baird, A. E. Everett, E. A. Gramstorff.*

CARL G. JOHNSON, JR., Arlington, Mass. (b. September 16, 1920, Cambridge, Mass.) Graduated from Northeastern University in 1943, with degree in Civil Engineering. Experience, co-operative work, six months with Underground Steam Construction Company as timekeeper and resident engineer on underground pipe lines; eight months with Bethlehem-Hingham Shipyard, as a transitman on construction of the new shipyard, also three months with General Electric Company in Lynn, as transitman and draftsman on new installations of buildings and machines. Entered Armed Forces, April, 1943. Had basic training with the engineers at Fort Belvoir, Virginia. At present assigned to the combat engineers of the U. S. Army. Refers to *C. O. Baird, A. E. Everett, E. A. Gramstorff, A. E. Sanderson.*

PAUL D. KILLAM, Salem, Mass. (b. May 1, 1920, Salem, Mass.) Graduated from Northeastern University in 1943. Co-operative work while at school was at the Essex County Engineers Office. At present in the United States Army Air Force. Refers to *C. O. Baird, C. C. Barker, J. H. Harmaala, E. A. Gramstorff.*

Henry A. Kingsbury, Medfield, Mass. (b. April 26, 1921, Medfield, Mass.). Northeastern University, B.S. degree in Civil Engineering, November, 1943. Experience, June, 1937, to August, 1940, with Whitman & Howard, rodman, transitman, draftsman on sewerage and water systems; April, 1941, to June, 1942, with Fay, Spofford & Thorndike, draftsman and designer on construction plans for storm drainage systems for army base; Northeastern University on survey and record plans of drainage and sewerage systems; September, 1942, to November, 1943, Metcalf & Eddy, as designer of drainage layout for airfield, Wilmington, N. C.; January, 1943, to April, 1943, U. S. Navy, assistant engineer on design and layout of water supply system for airfields at Martha's Vineyard, Mass., Westerly, R. I., and Charlestown, R. I. Refers to *E. A. Gramstorff, C. O. Baird, F. H. Kingsbury.*

RALPH L. METCALF, Bridgewater, Mass. (b. October 19, 1922, Brockton, Mass.) Graduated from Northeastern University, November, 1943, with B.S. degree in Civil Engineering. Co-operative work, with Willcox Construction Company, Inc., government building project in Bridgeport, Conn.; slum-clearance project in Hartford, Conn.; factory expansion job in New Brunswick, New Jersey. With Samuel M. Ellsworth on Airport construction at Camp Edwards, Mass. With J. Slotnik Company, Inc., government housing project in Portland, Maine. Turner Construction Company on Army hospital at Framingham, Mass. At present in the U.S.N.R. Refers to *C. O. Baird, A. E. Everett, E. A. Gramstorff.*

PVT. RICHARD J. SPENCER, JR., Saugus, Mass. (b. October 26, 1921, Saugus, Mass.) Attended Northeastern University 4½ years. Joined Army Reserve on July 4, 1942. Called to active duty September, 1943. Co-operative experience, February, 1942 to April, 1942, with William S. Crocker, Civil Engineer, Boston, as transitman, city surveying, lines and grades, profiles and cross sections, general drafting and computing; June, 1942 to September, 1942, November, 1942 to January, 1943, chainman for New York, New Haven and Hartford R.R. Company, New Haven, Connecticut, lines and grades, profiles and cross sections, railroad curves, general drafting and computing, compilation of yearly reports, blueprinting; June, 1943 to September, 1943, chainman for Boston and Albany R.R. Company, South Station, Boston, Mass. Establishment of property lines, lines and grades, staking of spiral easement curves, profiles and cross sections, general drafting. Refers to *C. O. Baird, L. Chase, A. E. Everett, E. A. Gramstorff.*

LOUIS P. VUONA, Quantico, Virginia. (b. August 14, 1919, Worcester, Mass.) A student at Northeastern University for 4½ years. September, 1939 to July, 1943, co-operative work as follows, E. J. Cross, Inc., Worcester, Mass., engineers and contractors; H. R. Robinson, Engineer, Worcester, Mass., Vuona Bros., sub-contractors, Worcester, Mass. Refers to *C. O. Baird, E. A. Gramstorff.*

ADDITIONS

Members

WILLARD A. WALLACE, 114 Wildwood Avenue, Arlington 74, Mass.

EDWIN M. HOWARD, 2 Elmwood Court, Winthrop, Mass.

ROYE A. MULHOLLAND, 1006 Harper Lane, Austin 22, Texas

JOHN L. DOHERTY, 137 Highland Avenue, Winchester, Mass.

ALBERT ADELMAN, 41 Wallis Road, Brookline, Mass.

WILLIAM W. LUNDGREN, 18 Putnam Street, Beverly, Mass.

WARREN S. DANIELS, 15 Regent Road, Malden 48, Mass.

Students

RICHARD H. OLNEY, R.F.D. 2, Woonsocket, Rhode Island.

SAMUEL J. PATTISON, JR., 122 East Side Parkway, Newton 58, Mass.

Irwin A. Benjamin, 8 Fowler Street, Dorchester 21, Mass.

Edward J. Galten, 151-11th Street, Wood-Ridge, New Jersey

Gordon H. Searles, 16 Benefit Street, Worcester, Mass.

William N. Maravell, 192 Beacon Street, Boston 16, Mass.

Robert J. Markell, 92 Waumbeck Street, Roxbury 21, Mass.

Alfred M. Clericuzio, 349½ Meridian Street, East Boston 28, Mass.

Arthur Hebert, 337 Mt. Pleasant St., Fall River, Mass.

Millard M. Kay, 24 Calder Street, Dorchester 24, Mass.

Edward W. Murphy, 647 E. Third Street, South Boston 27, Mass.

Roy Wooldridge, 14 Talman Street, Dorchester 22, Mass.

Ralph H. Jones, Jr., 52 Paul Gore Street, Jamaica Plain 30, Mass.

John M. Campbell, 23 High Street, Marlboro, Mass.

John Sikora, 120 Hemenway Street, Boston 15, Mass.

Benjamin F. Colton, 120 Hemenway Street, Boston 15, Mass.

Nicholas Kopsiaftis, 3 West Street, Fitchburg, Mass.

Alfred J. Urban, 60 Holmes Avenue Dorchester 22, Mass.

Bennett Kolner, 91 Bowdoin Avenue Dorchester 21, Mass.

James A. Johnson, 813 Tremont St. Boston 18, Mass.

Ephriam Schwartz, 88 Gainsboro St., Boston 15, Mass.

DEATHS

George M. Warren, Dec. 12, 1943.
Edward P. Adams, Dec. 24, 1943.
Daniel P. Kelley, Dec. 29, 1943.
Prof. John W. Howard, Jan. 25, 1944.
Paul L. Bean, Jan. 29, 1944.
David A. Harrington, Jan. 31, 1944.
Albert F. Sargent, Jan. 31, 1944.
Arthur J. Maynard, January 3, 1944.
Franklin H. Robbins, March 12, 1944.

ANNUAL REPORTS

REPORT OF THE BOARD OF GOVERNMENT FOR THE YEAR 1943-1944

Boston, Mass., March 22, 1944

To the Boston Society of Civil Engineers:

Pursuant to the requirement of the By-Laws, the Board of Government presents its report for the year ending March 22, 1944.

Membership

Eighteen new members, 2 juniors, and 27 students have been added during the year, and 9 members, 1 junior and 1 student have been reinstated, making a total addition of 58 members.

During the year 14 members have died, 6 have resigned, 2 members have been dropped for non-payment of dues, and 3 juniors have been dropped for failure to transfer, and 51 students are not now in college, making a total deduction of 76.

The present net membership of the Society consists of 6 honorary members, 612 members, 46 juniors, 23 students, 7 associates, making a total membership of 694, a net loss for the year of 18.

The honorary membership list is as follows:

Dr. Karl T. Compton, elected February 17, 1932
Prof. C. Frank Allen, elected March 16, 1932
Charles M. Allen, elected January 14, 1942
Arthur W. Dean, elected January 14, 1942
Charles R. Gow, elected January 14, 1942
Arthur T. Safford, elected January 26, 1943

Deaths

Members:

Joseph R. Worcester, May 9, 1943
S. Stanley Kent, May 16, 1943
Maurice F. Brown, May 21, 1943
Everett E. Stone, May 26, 1943
Robert Spurr Weston, July 30, 1943
Herbert T. Gerrish, September 6, 1943
George M. Warren, December 12, 1943
Edward P. Adams, December 24, 1943
Daniel P. Kelley, December 29, 1943
John W. Howard, January 25, 1944
Roland N. Cutter, January 28, 1944
Paul L. Bean, January 29, 1944
David A. Harrington, January 31, 1944
Albert F. Sargent, January 31, 1944

Remission of Dues and Extension of Time

During this year the Board of Government has granted a number of members an extension of time for payment of dues and has remitted the dues of other members. With much regret the Board voted this year to drop from membership two who had not paid their 1943 dues, for which an extension had been granted. In the case of 2 members, dues for the year ending March 22, 1944, have been remitted. Forty-one members of various grades are in the Armed Services and one member is recorded as a prisoner in the Philippines.

Exemption of Dues

Eighty-four members are now exempt from dues in accordance with By-Laws 8, which provided that "a member of any grade who has paid dues for forty years, or who has reached the age of seventy years and has paid dues for thirty years, shall be exempt from further dues."

Meetings of the Society

Eight regular meetings, since the Annual, have been held during the year.

The September meeting was the Annual Student Night, attended by Student Chapters, American Society of Civil Engineers, at Harvard University, Massachusetts Institute of Technology, Tufts, Brown University, University of Connecticut, University of Maine, Worcester Polytechnic Institute and the Northeastern University Section of the Boston Society of Civil Engineers.

The total attendance at all meetings was 1,161 persons; the largest attendance was 300 and the smallest 28. Suppers have been a feature at all the meetings and they were well attended, a total for the year of 1,039.

The papers and addresses given were as follows:

March 17, 1943. Annual Meeting. Address of retiring President, Athole B. Edwards, "A Civil Engineer's Comments on Planning", followed by dinner and entertainment.

April 21, 1943. Joint Meeting. American Society of Civil Engineers, Northeastern Section, and Boston Society of Civil Engineers. "Looking Backward Over 50 years of Engineering Experience", by Charles R. Gow, President, Warren Brothers Company, Cambridge, Mass.

May 19, 1943. "Velocity Gradients and Internal Work in Fluid Motion", by Prof. Thomas R. Camp, Prof. of Sanitary Engineering, Mass. Institute of Technology, and Mr. P. Charles Stein, Instructor in Sanitary Engineering, Mass. Institute of Technology.

September 22, 1943. Student Night. Joint Meeting. Boston Society of Civil Engineers and American Society of Civil Engineers, Northeastern Section and Student Chapters ASCE and Northeastern University Section and Highway Section BSCE. "Building the Inter-American Highway", by Mr. A. N. Carter, Assistant Editor of *Engineering News-Record.*

October 27, 1943. "Engineering Studies and Problems in Connection with the Normandie", by Mr. A. C. E. Siecke, Consulting Engineer, Merritt-Chapman & Scott Corporation.

November 17, 1943. Joint Meeting. Boston Society of Civil Engineers and Hydraulics Section BSCE. "T.V.A. Engineering", by Prof. Theodore B. Parker, Head of Department of Civil and Sanitary Engineering, Mass. Institute of Technology.

December 15, 1943. Joint Meeting. Boston Society of Civil Engineers and Sanitary Section BSCE. "Interstate Agreements for Pollution Abatement", by Mr. Seth G. Hess, Director and Chief Engineer of the Interstate Sanitation Commission. (New York, New Jersey and Connecticut.)

January 26, 1944. Joint Meeting. Boston Society of Civil Engineers and Designers Section BSCE. "Modern Ship Construction", by Mr. Joseph Townsend, Hull Superintendent of Bethleham-Hingham Shipyard.

February 16, 1944. "Construction in Overseas Theatres", by Brigadier General C. L. Sturdevant, Assistant Chief of Engineers for War Planning, Washington, D. C.

Sections

Twenty-five meetings were held by the Sections of the Society during the year. These meetings of the Sections, offering opportunity for less formal discussion, have continued to demonstrate their value to their members and to the Society. The variety of subjects presented has made an appeal to the members, as indicated by the general attendance at these meetings.

Sanitary Section Meetings. The Sanitary Section has held 5 meetings during the year, with an average attendance of 40. The papers and meetings are listed in the report of the Executive Committee.

Designers Section Meetings. The Designers Section has held 8 meetings during the year, with an average attendance of 61. The papers and meetings during the year are listed in the report of the Executive Committee.

Highway Section Meetings. The Highway Section has held 4 meetings during the year, with an average attendance of 132. The papers and meetings are listed in the report of the Executive Committee.

Hydraulics Section Meetings. The Hydraulics Section has held 3 meetings during the year, with an average attendance of 55. The papers and meetings are listed in the report of the Executive Committee.

Northeastern University Section Meetings. The Northeastern University Section held 5 meetings and excursions during the year, with an average attendance of 42. The present membership includes now in attendance in the University. The meetings held are listed in the report of the Executive Committee.

Journal

The complete report of the Editor of the JOURNAL for the calendar year 1943 will be printed in the April, 1944, JOURPAL.

*Funds of the Society**

Permanent Fund. The Permanent Fund of the Society has a present value of about $62.000. The Board of Government authorized the use of as much as necessary of the current income of this fund in payment of current expenses.

John R. Freeman Fund. In 1925 the late John R. Freeman, a Past President and Honorary member of the Society, made a gift to the Society of securities which was established as the John R. Freeman Fund, the income from which

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*Details regarding the values and income of these funds are given in the Treasurer's Report.

was about $935. The income from this fund is to be particularly devoted to the encouragement of young engineers. Mr. Freeman suggested several uses. such as the payment of expenses for experiments and compilations to be reported before the Society; for underwriting meritorious books or publications pertaining to hydraulic science or art; or a portion to be devoted to a yearly prize for the most useful paper relating to hydraulics contributed to this Society; or establishing a traveling scholarship every third year open to members of the Society for visiting engineering works, reports of which would be presented to the Society. No additional scholarship was authorized during the year.

Edmund K. Turner Fund. In 1916 the Society received 1,105 books from the library of the late Edmund K. Turner, and a bequest of $1,000, "the income of which is to be used for library purposes". The Board voted to use $35 of the income for the purchase of books, for the library.

Alexis H. French Fund. The Alexis H. French Fund. a bequest amounting to $1,000, was received in 1931 from the late Alexis H. French of Brookline, a former Past President of the Society. The income of this fund is "to be devoted to the Library of the Society". The Board voted to use $35 of the available income for the purchase of books for the library.

Tinkham Memorial Fund. The "Samuel E. Tinkham Fund", established in 1921, at the Massachusetts Institute of Technology by the Society "to assist some worthy student of high standing to continue his studies in Civil Engineering". had a value of $2,409.11 on June 30, 1943. Henry Martyne Paynter, Jr., of Peekskill New York, a senior student in Civil Engineering has been awarded this scholarship for the year 1943-1944.

Desmond FitzGerald Fund. The Desmond FitzGerald Fund, established as a bequest from the late Desmond FitzGerald, a Past President and Honorary member of the Society, provided that the income from this fund shall "be used for charitable and educational purposes". The Board voted on April 13, 1943, to appropriate from the income of this fund the sum of $60, to be known as the Boston Society of Civil Engineers Scholarship in memory of Desmond FitzGerald, and to be given to a student of Northeastern University. Presentation of this Scholarship was made by President Howard M. Turner, at a student mass meeting at the University on March 31, 1943, to Irving T. Berkland, of Norwood, Mass., a senior student in Civil Engineering. The Board also voted on September 22, 1943, to appropriate the sum of $50 as the Boston Society of Civil Engineers Scholarship in Memory of Desmond FitzGerald, to be given to a student at Northeastern University. Presentation of this scholarship was made by President Howard M. Turner, at a student mass meeting held in Jordan Hall on November 3, 1943, to Joseph C. Lawler, of Lynn, Mass., a senior student in Civil Engineering.

Clemens Herschel Fund. This fund was established in 1931, by a bequest from the late Clemens Herschel, a former Past President and Honorary member of the Society. The income from this fund is to be used for the presentation of prizes for particularly useful and commendable papers presented at a meeting of the Society. The present value of this fund is about $1,200. The expenditure made during the year from this fund was for prizes.

Edward W. Howe Fund. This fund, a bequest of $1,000, was received December 2, 1933, from the late Edward W. Howe, a former Past President of the Society. No restrictions were placed upon the use of this money, but the recommendation of the Board of Government is that the fund be kept intact, and that the income be used for the benefit of the Society or its members. No expenditure from this fund was made during the year.

Prize Awards

Desmond Fitzgerald Medal. The Desmond Fitzgerald Medal (bronze) was provided for in 1910 as an endowed prize by the late Desmond FitzGerald, a former Past President and Honorary member of the Society. The prize is awarded annually to a member who presents an original paper to the Society which is published in the JOURNAL for the current year.

In accordance with the recommendation of the Committee on Awards, the Board of Government voted to award a Desmond FitzGerald Medal to Ralph W. Horne, Member, for his paper on "Cranston, Rhode Island, Builds Complete New Sewerage Works for 53,000 People", presented at a Joint Meeting with the Sanitary Section held on January 27, 1943, and published in the April, 1943, issue of the JOURNAL.

Section Prizes

The Board of Government voted on April 12, 1924, to present a prize for a worthy paper given in each section by a member of that section. "This award to consist of books suitably inscribed".

Hydraulics Section Prize. The Board adopted the recommendation of the Hydraulics Section Prize Award Committee and voted that the Hydraulics Section Prize be awarded to Prof. Thomas R. Camp and P. Charles Stein (Co-authors) Members, for their paper on "Velocity Gradients and Internal Work in Fluid Motion", presented at a Joint Meeting of the Society with the Sanitary and Hydraulics Sections, held on May 19, 1943, and published in the October, 1943, issue of the JOURNAL. The prize consisted of the following books:

"The Collected Works of J. Willard Gibbs", Vols. 1 & 2.
"Pumps", by F. A. Kristal and F. A. Annett.
"Fluid Mechanics", by R. A. Dodge and M. J. Thompson.

Clemens Herschel Award

The late Clemens Herschel, a former past President and Honorary Member made a bequest to the Society which would provide for the presentation of prizes for papers presented at meetings of the Society which have been particularly useful and worthy of grateful acknowledgment. On recommendation of the Committee on Awards, the Board voted to award the Clemens Herschel prize to William C. White, for his paper on "Engineering Education, Yesterday, Today and Tomorrow", presented at the Annual Meeting of the Society held on March 17, 1943, and published in the April, 1943, issue of the JOURNAL. The prize consisted of the following books:

"The Birds of America", by J. J. Audubon.
"Growth of the American Republic", by Morison & Commager.

Amendment to By-Laws

The Society voted to adopt an amendment to the By-Laws relative to the matter of fees of student and junior members transferring to other grades, action on which was taken at the November 17 and December 15, 1943, meeting of the

Society. This amendment eliminated the direct payment of a transfer fee in such cases, but provided that there shall be paid into the Permanent Fund the equivalent of this fee from the first year's dues subsequent to such transfers.

Meetings

The two meetings last spring were held at the Engineers Club as has been the custom during the last few years. This fall and winter three of the meetings have been held at the Twentieth Century Association, one at the Boston City Club and student night at Northeastern University.

Library

The report of the Committee on Library contains a complete account of the library activities during the past year.

Society Activities

The usual special committees dealing with the activities and conduct of the Society have included the following: Program, Publication, Library, Social Activities, Relations of Sections to the Main Society, Welfare, Investment, subsoils of Boston, John R. Freeman Fund, the Committees on the various Society Awards. Other special committees for the study of various questions arising during the year were appointed as follows and reported to the Board of Government:

A Committee on Meetings to study the whole general question of the attendance at meetings. This committee made a general study which included not only the question of meetings but other possible factors affecting the general membership of the Society. This Committee recommended the change in the By-Laws regarding membership transfer fees noted above.

A Committee appointed to study the Kilgore-Patman Bill drew up resolutions expressing the objections of the Board to this bill which were adopted and forwarded to Washington. This same committee also reported that no change in the Constitution regarding Society action on public questions was desirable at this time.

Other special committees were as follows:

1. A committee to study and report on the membership and activities of the ESNE.
2. A committee to study the establishment of student chapters.
3. A committee on Post-War Planning.
4. A committee to study the adequacy of the proposed Federal Aid for State Highways.
5. A committee to study the Cannons of Ethics proposed by the Engineering Council for Professional Development.
6. A committee to follow the situation existing with regard to the present recent building and safety laws, regulations and administration.

The Society has coöperated with the Engineering Societies of New England, and members of the Society have served on Engineering Societies Council and Committees.

Your Board, in conclusion, wishes to express its appreciation of the excellent work done by the officers of the Sections and by the Committees of the Society.

HOWARD M. TURNER, *President*

REPORT OF THE TREASURER

Boston, Mass., March 22, 1944

To the Boston Society of Civil Engineers:

The financial standing of the Society on March 6, 1944, at the end of the accounting period, is shown in the following:

Table 1.—Distribution of Funds—Receipts and Expenditures.

Table 2.—Record of Investments.

The receipts from dues this year amounted to $4,676, which is $127 less than the average amount received from this source during the past five years. However, in view of the dislocations due to war conditions and the remittances of dues of members in the Armed Forces, the receipts from dues have held up very well.

The income to the Current Fund has been insufficient to meet expenditures for current expenses and a transfer of $1,409.61 from the income of the Permanent Fund to the Current Fund has been necessary to meet this deficit.

This transfer amounts to 62% of the income from the Permanent Fund equalling a similar transfer amounting to 62% for the previous year. One item which contributed to the excess in current expenses over current income and which has not occurred in previous years was the payment of Social Security Tax charges amounting to $263.49. By letter from the Treasury Department dated December 21, 1943, it was ruled by the Department of Internal Revenue that the Society is subject to the requirements of Section 101 (6) of the Internal Revenue Code with the result that Federal Social Security payments would have to be made in connection with the salaries of employees of the Society. Taxes, interest and fines totalling $263.49 were paid during the year. Following an appeal against the Treasury Department's ruling of December 21, 1943, and the presentation of additional evidence concerning the purposes and activities of the Society, the Department of Internal Revenue reconsidered our status for Federal Income Tax purposes and ruled on February 23, 1944, that the Society is not subject to the requirements of Section 101 (6) of the Internal Revenue Code. Application for refund of taxes, interest and fines paid, are pending.

In other respects the expenses of the Society have been maintained fairly close to the prearranged budget for the year.

The amounts transferred from the Permanent Fund to Current Fund during the last five years are shown in the following:

	1939-40	1940-41	1941-42	1942-43	1943-44
Receipts to Current Fund					
Dues	$4853	$4961	$4876	$4653	$4676
Other than Dues	1756	3632	2860	2180	3161
Total Receipts to Current Fund	$6609	$8593	$7736	$6833	$7837
Current Fund Expenditure	7616	8977	8738	8243	9246
Deficit: Transferred from Permanent Fund	$1007	$384	$1002	$1410	$1409

The records of Current Income and Current Expenditures are kept separate from those applicable to other accounts. The total of income and profits from all sources during the past year amounted to $11,561.79 against total expenditures and losses of $10,749.37, making a net increase in assets of $812.42.

The holdings of the Society in Cooperative Bank Shares were reduced during the year from $12,392.68 on March 6, 1943, to $10,942.02 on March 4, 1944. Ten paid up shares valued at $2000 were sold against an additional investment in running shares of $549.34.

The proceeds of the sale of the ten paid-up shares were re-invested in securities having higher income possibilities.

Several changes were made in the list of securities owned by the Society in order to improve the general character of our investments, and in disposing of certain stocks which had depreciated in value, a loss of $1,298.68 in the book value of our holdings resulted. The Boston Safe Deposit and Trust Company has continued to act as Investment Council for the Society throughout the year and they were consulted in connection with all purchases and sales of securities.

The Puget Sound Power and Light Co., 5½% bond of 1949 was called during the year and was exchanged for a bond of the same company paying 4¼%.

Changes in stocks were made as follows:

Sold

31 Shares of Home Insurance Co., N. Y. Common
10 Shares of New York Central R.R. Common
10 Shares of United States Steel Co. Common

Purchased

25 Shares of Continental Insurance Co., Capital
10 Shares of Standard Oil Co. of N. J., Capital
30 Shares of Union Carbide and Carbon Co., Common

Two shares of Consolidated Natural Gas Co., Capital Stock having a book value of $49.87 were also acquired by the Society representing the pro-rata interest of the Society in that company by virtue of our ownership of twenty shares of Standard Oil Co. of N. J. The book value of our Standard Oil of N. J. stock has been reduced by $49.87 to conform to this consolidated distribution.

The total book value of all securities, plus cash on hand now stands at $97,874 an increase of $812 during the year.

The following table shows the comparative book values of the two principal funds at the close of last five fiscal years and the ratio of market value to book value.

	Mar. 10, 1940	Mar. 10, 1941	Mar. 6, 1942	Mar. 6, 1943	Mar. 6, 1944
Permanent Fund	$58,138	$60,527	$61,080	$62,283	$62,546
John R. Freeman Fund	26,522	27,666	26,528	26,862	27,470
Market Value in per cent of Book Value	92.28%	87.92%	83.44%	88.57%	96.47%

The growth of the Permanent Fund is affected not only by the percentage of return on investments but also by the amount it has been necessary to transfer from the income to this fund, in order to meet current expenses. The value of the Freeman Fund depends largely upon the expenditures made from the fund during the year and as no expenditures were made during the past year the only charge to the fund has been the allocation of the book loss incurred through the sale of depreciated securities, amounting to $365.06, as shown in Table 1.

The following table will show for the past five years the book value of securities and bank deposits and the total value of all holdings, not including the value of the library and physical property.

	Mar. 10, 1940	Mar. 10, 1941	Mar. 6, 1942	Mar. 6, 1943	Mar. 6, 1944
Bonds	$32,524.96	$30,782.49	$31,610.49	$38,670.49	$38,763.93
Cooperative Banks	16,512.94	17,971.92	19,490.68	12,392.68	10,942.02
Stocks	41,747.17	44,957.17	43,967.17	43,967.17	45,186.63
Cash	1,767.45	2,428.01	365.94	2,031.39	2,981.57
	$92,552.52	$96,139.59	$95,434.28	$97,061.73	$97.874.15

In addition to the Treasurer's cash balance of $2981.57, the Secretary has a "change fund" of $30.00 which should be included to show total assets.

Respectfully submitted,

CHESTER J. GINDER, *Treasurer*

TABLE 1—DISTRIBUTION OF FUNDS—RECEIPTS AND EXPENDITURES

	Book Value March 6, 1943	Interest and Dividends Cash	Interest and Dividends Credit	Net Profit or Loss at Sale or Maturity +	Net Profit or Loss at Sale or Maturity −	Transfer of Funds Purchased +	Transfer of Funds Sold −	Book Value March 6, 1944
Bonds	$38,670.49	$1,155.50	$ 60.00	$17.50		$1,058.44	$1,025.00	$38,763.93
Cooperative Banks	12,392.68	133.75	189.34			360.00	2,000.00	10,942.02
Stocks	43,967.17	1,907.52			$1,298.68	4,245.53	3,026.07	45,186.63
Cash available for Investment	531.39					950.18		1,481.57
Total (except Current Fund)	$95,561.73	$3,196.77	$249.34	$17.50	$1,298.68	$6,614.15	$6,051.07	$96,374.15

	Book Value March 6, 1943	Allocation of the above at 3.62% Income and Profit	Allocation of the above at 1.36% Loss	Misc. Receipts	Misc. Expenditures	Book Value March 6, 1944
Permanent Fund	$62,283.85	$2,257.46	$846.44	$261.00	$1,409.61	$62,546.26
John R. Freeman Fund	26,862.04	973.61	365.06		......	27,470.59
Edmund K. Turner Fund	984.24	35.67	13.37		34.65	971.89
Desmond FitzGerald Fund	1,942.31	70.40	26.40		111.50	1,874.81
Alexis H. French Fund	1,035.74	37.54	14.07		27.75	1,031.46
Clemens Herschel Fund	1,237.73	44.86	16.82		30.00	1,235.77
Edward W. Howe Fund	1,215.82	44.07	16.52		......	1,243.37
	$95,561.73	$3,463.61	$1,298.68	$261.00	$1,613.51*	$96,374.15
Current Fund	1,500.00			9,246.79*	9,246.79	1,500.00
Totals	$97,061.73	$3,463.61	$1,298.68	$9,507.79	$10.860.30	$97,874.15

Secretary's change fund of $30.00 should be added to show total assets.
*Includes transfer of $1,409.61 from income of the Permanent Fund to the Current Fund.

Table 2—Record of Investments

	Date of Maturity or Classification	Fixed or Current Interest Rate	During the Year March 6, 1943 to March 6, 1944: Interest Received	Additional Amount Invested	Sold or Matured: Amount Received	Sold or Matured: Profit + (or loss—)	March 6, 1944: Par Value	Book Value	Market Value
Bonds									
American Telephone & Telegraph Co.	Sept. 1, 1956	3 %	$ 18.00	....	....	....	$ 600.00	$ 603.00	$ 702.00
Baltimore & Ohio R.R.	Aug. 1, 1944	4 %	80.00	....	....	....	2,000.00	2,013.74	1,930.00
Canadian Pacific R.R.	July 2, 1949	4 %	152.50	....	....	....	5,000.00	5,342.50	4,700.00
Eastern Mass. Street Ry. Co.	Jan. 1, 1948	4½%	45.00	....	....	....	1,000.00	1,022.50	1,040.00
Penn. Central Light & Power Co.	Nov. 1, 1977	4½%	45.00	....	....	....	1,000.00	1,052.89	1,062.50
The Pennsylvania Railroad Company	June 1, 1965	4½%	45.00	....	....	....	1,000.00	1,017.74	1,103.75
The Pennsylvania Railroad Company	Apr. 1, 1970	4½%	45.00	....	....	....	1,000.00	971.58	1,001.25
Puget Sound Power & Light Co.	June 1, 1949	5½%			$1,042.50	$17.50+	....	....	....
	Dec. 1, 1972	4¼%	42.50	$15.94 1,042.50			1,000.00	1,058.44	1,085.00
Standard Oil Co. of N. J.	July 1, 1953	2¾%	27.50	....	....	....	1,000.00	1,021.25	1,031.25
Texas Electric Service Company	July 1, 1960	5 %	100.00	....	....	....	2,000.00	2,000.00	2,115.00
The Toledo Edison Co.	July 1, 1968	3½%	70.00	....	....	....	2,000.00	2,092.50	2,172.50
Union Pacific R.R. Co.	June 1, 1980	3½%	70.00	....	....	....	2,000.00	2,125.00	2,195.00
Western Maryland R.R. Co.	Oct. 1, 1952	4 %	40.00	....	....	....	1,000.00	982.78	952.50
United States Savings Bonds, Series D	Jan. 1, 1950	....	60.00	....	....	....	3,000.00	2,460.00	2,460.00
United States Savings Bonds, Series G	June 1, 1953	2½%	200.00	....	....	....	8,000.00	8,000.00	8,000.00
United States Bonds, Series G	July 1, 1954	2½%	175.00	....	....	....	7,000.00	7,000.00	7,000.00
Totals			$1,215.50	$1,058.44		$17.50+	$38,600.00	$38,763.93	$38,550.75

TABLE 2—RECORD OF INVESTMENTS—*Continued*

	Date of Maturity or Classification	Fixed or Current Dividend Rate	During the Year March 6, 1943 to March 6, 1944: Dividends Received	Additional Amount Invested	*Sold or Matured*: Amount Received	Profit + (or loss—)	March 6, 1944: Number of Shares	Book Value	Market Value
CO-OPERATIVE BANKS									
Codman Co-operative Bank	*Paid Up Shares	3%, 2¼%	$48.75	....	$2,000.00	....	10	....	....
Codman Co-operative Bank	Matured Shares	3%	60.00	....	....	....	10	$2,000.00	$2,000.00
Suffolk Co-operative Federal Savings & Loan Assoc.	Matured Shares	2½%	25.00	....	....	....	5	1,000.00	1,000.00
Suffolk Co-operative Federal Savings & Loan Assoc.	Series 134	....	189.34	....	....	....	30	7,942.02	7,942.02
TOTALS			$323.09		$2,000.00	....		$10,942.02	$10,942.02

*Dividend cut from 3% to 2¼% in June 1943.

TABLE 2—RECORD OF INVESTMENTS—*Continued*

	Date of Maturity or Classification	Fixed or Current Dividend Rate	During the Year March 6, 1943 to March 6, 1944: Dividends Received	Additional Amount Invested	Sold or Matured: Amount Received	Sold or Matured: Profit + (or loss—)	March 6, 1944: Number of Shares	Book Value	Market Value
STOCKS									
American Tel. & Tel. Co.	Common	$9.00	$414.00	....	....	....	46	$5.346.04	$7,308.25
Bankers Trust Co., N. Y.	Common	1.40	42.00	....	....	....	30	1,590.00	1,530.00
Central Hanover Bank & Trust Co. of N. Y.	Common	4.00	120.00	....	....	....	30	3,210.00	3,060.00
Commonwealth & Southern Corp.	Cum. Pfd.	4.75	38.00	....	....	....	8	....	684.00
Commonwealth & Southern Corp.	Common	....	....	....	....	....	25	1,019.89	18.75
Commonwealth & Southern Corp.	Opt. Warrants	....	....	....	....	....	12	....	....
Consolidated Natural Gas Company	Capital	....	....	49.87	....	....	2	49.87	43.75
Consolidated Edison (Gas) Co. of N. Y.	Common	1.60	32.00	....	....	....	20	1,906.50	437.50
Continental Insurance Co.	Capital	1.00	25.00	1,206.44	....	....	25	1,206.44	1,090.62
General Electric Co. of N. Y.	Common	1.40	70.00	....	....	....	50	2,341.47	1,787.50
Hartford Fire Insurance Co.	Common	2.50	25.00	....	....	....	10	761.25	1.010.00
The Home Insurance Co. of N. Y.	Common	....	....	....	950.30	294.70—	31	....	....
Minnesota Power & Light Co., Minn.	Pref.	7.00	70.00	....	....	....	10	980.00	997.50
National Dairy Products Corp.	Common	1.00	50.00	....	....	....	50	1,154.74	1,018.75
National Fire Insurance Co. of Hartford	Common	2.00	40.00	....	....	....	20	1,240.00	1,150.00
New England Power Assoc.	Pref.	4.00	80.00	....	....	....	20	1,815.00	1,200.00
New York Central R.R.	Common	....	5.00	....	171.79	698.66—	10	....	....
North American Trust Shares	Jul. 15, 1944	12.2¢	183.00	....	....	....	1500	5,342.00	4.087.50

TABLE 2—RECORD OF INVESTMENTS—*Continued*

	Date of Maturity or Classification	Fixed or Current Dividend Rate	During the Year March 6, 1943 to March 6, 1944: Dividends Received	Additional Amount Invested	*Sold or Matured* Amount Received	*Sold or Matured* Profit + (or loss—)	March 6, 1944: Number of Shares	Book Value	Market Value
STOCKS									
Pacific Gas & Elec. Co.	Cum. 1st Pfd.	$1.50	$ 90.00	....	....	....	60	$1,922.02	$2,182.50
Pacific Gas & Elec. Co.	Cum. 1st Pfd.	1.37	27.52	....	....	....	20		
Pacific Gas & Elec. Co.	Common	2.00	128.00	....	....	....	64	1,808.79	2,096.00
Southern California Edison Co. Ltd.	Cum. Orig. Pfd.	1.50	60.00	....	....	....	40	1,161.22	1,560.00
Southern California Edison	Common	1.50	30.00	....	....	....	20	539.75	470.00
Standard Oil Co. of N. J.	Capital	2.00	20.00	....	22.54	....	10	*457.00	538.75
Standard Oil Co. of N. J.	Capital	2.00	10.00	581.43	27.33	....	10	*554.10	538.75
Tampa Electric Co.	Common	1.60	48.00	....	....	....	30	1,151.25	727.50
Timken Roller Bearing Co.	Common	2.00	30.00	....	....	....	15	1,018.97	699.37
Trimout Dredging Co.	Pref.	....	....	....	....	....	2	....	....
Union Carbide & Carbon	Capital	....	....	2,407.79	....	....	30	2,407.79	2,340.00
U. S. Smelting Refining & Mining Co.	Pref.	3.50	70.00	....	....	....	20	1,365.04	1,075.00
United States Steel Corp.	Common	4.00	20.00	....	555.43	305.32—	10	....	....
United States Trust Co. of Boston	Conv. Pref.	.80	180.00	....	....	....	225	4,837.50	3,656.25
TOTALS			$1,907.52	$4,245.53	$1,727.39	$1,298.68—		$45.186.63	$41,963.24

Add value of Consolidated Natural Gas shares, $49.87 to show original book value.

REPORT OF THE SECRETARY

Boston, Mass., March 6, 1944

To the Boston Socety of Civil Engineers:

The following is a statement of cash received by the Secretary, and of the expenditures approved by the President, in accordance with the Budget adopted by the Board of Government.

FOR THE YEAR ENDING MARCH 22, 1944
CURRENT FUND ACCOUNT

	Account Number	Expenditures	Receipts
Office			
Secretary, salary and expense	(1)	$ 240.00	
Stationery, printing and postage	(2)	279.17	
Incidentals and Petty Cash	(3)	144.14	
Insurance and Treasurer's Bond	(4)	50.50	
Safety Deposit Box	(5)	12.00	
Quarters, rent, light, telephone	(7)	1,827.27	$600.00
Office—clerical	(8)	1,418.60	
Auditors for 1943 accounts and Investment Services	(9)	230.00	
Reserve for Taxes and Expense	(10)	263.49	
Meetings			
Rent of halls	(11)	240.00	
Stationery, printing	(12)	34.65	
Social Activities	(13)	893.70	843.64
Steropticon and Reporting	(14, 15)	9.00	
Annual Meeting (March, 1943)	(16)	91.50	
Sections			
Sanitary Section	(21)	13.00	
Designers Section	(22)	12.00	
Highway Section	(23)	4.00	
Northeastern Univ. Section	(24)	4.75	
Hydraulics Section	(25)	7.75	
Journal			
Editor, salary and expense	(31)	308.00	
Printing and Postage	(32)	2,313.83	
Reprints	(33)	10.53	
Advertising	(34)		1,106.00
Sale of JOURNALS and reprints	(35, 36)	3.50	564.58
Library			
Books and expense	(41)	47.79	
Periodicals	(43)	115.13	
Binding	(44)	30.55	
Fines on Overdue books and Misc.	(54, 45)	3.45	9.39
Bank Charges	(53)	1.60	
Dues to Eng'g. Societies of N.E.	(59)	596.41	
Dues to B.S.C.S. Members	(70)		4,676.00

	Account Number	Expenditures	Receipts
Badges for Members	(51)	28.08	28.08
Binding JOURNALS for Members	(52)	12.40	9.49
Transfer Income Permanent Fund to Current Fund			1,409.61
Total Current Fund to be accounted for		$9,246.79	$9,246.79
Entrance Fees to Permanent Fund			$261.00

18 new members; 2 juniors; 27 students; 2 juniors transferred to member; 16 students transferred to juniors.

The above receipts have been paid to the Treasurer, whose receipt the Secretary holds. The Secretary holds cash amounting to $30 included as payment under Item 3 (Petty Cash) to be used as a fixed fund or cash on hand for making change at buffet suppers.

Respectfully submitted,

EVERETT N. HUTCHINS, *Secretary*

REPORT OF THE AUDITING COMMITTEE

Boston, March 22, 1944

We have reviewed the records and accounts of the Secretary and Treasurer of the Boston Society of Civil Engineers and the report of William J. Hyde, Certified Public Accountant, who has examined said records and accounts and we have examined the securities enumerated by the Treasurer.

We have accepted and present herewith with our approval the signed report of the Accountant.

HERMAN G. DRESSER
EMIL A. GRAMSTORFF
Auditing Committee of the Directors of the Boston Society of Civil Engineers.

Boston, Mass., March 17, 1944

MR. HERMAN G. DRESSER,
Chairman of the Auditing Committee,
Boston Society of Civil Engineers

DEAR SIR:

In accordance with instructions, I have completed the annual audit of the Society for the fiscal year ended March 6, 1944, and report as follows:

Securities held by the Society as at March 6, 1944, were examined and found in order. All coupons for interest due were collected. Dividends earned were correctly accounted for.

All changes in the permanent fund were recorded in the accounts. Receipts from Cooperative Bank shares sold and all receipts of income, as recorded in the Secretary's records, together with entrance fees, interest and dividends were found correctly entered in the Treasurer's accounts and were traced to the bank.

Cooperative Bank earnings were verified and found correct.

All disbursements were in settlement of vouchers duly approved by the President and Secretary and were substantiated by examination of checks paid by the bank.

Following past custom, the Secretary's "Change Fund," $30.00, is not included in the summary of assets reported by the Treasurer.

A verified copy of your Treasurer's Report is attached hereto and summarizes the detailed accounts shown in his ledger.

I have audited the records for the fiscal year ended March 6, 1944. They are correct and in excellent condition.

Respectfully submitted,

WILLIAM J. HYDE, *Certified Public Accountant*

REPORT OF THE EDITOR

Boston, Mass., February 8, 1944

To the Board of Government
Boston Society of Civil Engineers:

The JOURNAL for the calendar year 1943 (Volume XXX), was issued quarterly, in the months of January, April, July and October, as authorized by the Board of Government on December 20, 1935.

During the year there has been published nine papers presented at meetings of the Society and Sections, and six other technical articles. The Table of Contents and Index for the year are included in the October, 1943, issue.

The four issues of the JOURNAL contained 269 pages of papers and discussions, 6 pages of Index, and 37 pages of advertising, a total of 311 pages. An average of 1087 copies per issue were printed. The net cost was $871.30 as compared with $1,017.32 for the preceding year.

The cost of printing the JOURNAL was as follows:

Expenditures		
Composition and printing	$1,381.32	
Cuts	534.24	
Wrapping, mailing and postage	72.92	
Editing	300.00	
Copyright	8.00	
		$2,296.48
Receipts		
Receipts from sales of JOURNALS and Reprints	$ 613.18	
Receipts from Avertising	812.00	
		1,425.18
Net cost of JOURNAL to be paid from Current Fund		$ 871.30

Respectfully submitted,

EVERETT N. HUTCHINS, *Editor*

REPORT OF THE COMMITTEE ON SOCIAL ACTIVITIES

Boston, March 22, 1944

To the Boston Society of Civil Engineers:

The Committee on Social Activities submits the following report for the year 1943-44.

Eight regular meetings in addition to the Annual were held during the year. Two meetings were held at the Engineers' Club, three at the 20th Century Association, two at Northeastern University and two at the Boston City Club.

One hundred and forty-one members and guests attended the annual dinner at the Boston City Club. This was two less than for the previous annual meeting. Two hundred and sixty-nine were served at the Student Night meeting in September at Northeastern University. The meeting included the Student Chapters of the American Society of Civil Engineers at Harvard, Tufts, M.I.T., Brown, Rhode Island State, New Hampshire University, Worcester Polytechnical Institute and Northeastern University Section of the Boston Society of Civil Engineers. The number of persons attending this meeting was 126 greater than for the previous year.

A summary of attendance at the various meetings follows:

		Dinner	Meetings
3-17-43	Boston City Club	141	141
4-21-43	Engineers Club	84	84
5-19-43	Engineers Club	46	52
9-22-43	Northeastern University	269	300
10-27-43	20th Century Assoc.	99	135
11-17-43	20th Century Assoc.	80	99
12-15-43	20th Century Assoc.	28	28
1-26-44	Northeastern University	89	102
2-16-14	Boston City Club	203	220
		1,039	1,161

The average attendance at meals at all nine meetings was 115 or 30 more than for the previous year. The average total attendance at the meetings was 129 or 39 more than for the previous year. It is interesting to note that there was a 37 per cent increase in attendance at the suppers over the previous year.

Respectfully submitted,

JOHN H. HARDING, *Chairman*

REPORT OF THE COMMITTEE ON WELFARE

Boston, March 22, 1944

To the Boston Society of Civil Engineers:

During the past year the situation as regards engineering employment in this locality has been reasonable healthy. However, in recent months there has been somewhat less demand for men in civil engineering.

No matters pertaining to the welfare of members of the Society have come to the attention of the Welfare Committee and in consequence, no meetings of the Committee have been held during the year.

Engineering Societies Personnel Service, Inc., located at 4 Park Street, Boston, which is the outgrowth of the Emergency Planning and Research Bureau, Inc., continues to function as the official local agency for the placement of engineering employees, and solicits the patronage of both employees and employers.

Respectfully submitted,
R. W. HORNE, *Chairman*

REPORT OF THE LIBRARY COMMITTEE

Boston, March 22, 1944

To the Boston Society of Civil Engineers:

Two meetings of the library committee were held during the year. Ways and means of making the library more useful to the members were discussed, and two progress reports were submitted to the Board of Government.

Arrangements were made during the year with the Federation of Sewage Works Associations to obtain the Sewage Works Journal in exchange for our Journal. The library would like to obtain back numbers of the Sewage Works Journal from any member who would be willing to donate copies he no longer needs.

We are now binding "Waterworks & Sewerage" and "Public Works", in addition to magazines which have been regularly bound, and the "Sewage Works Journal" will be bound.

The following books were purchased:

Sewage Treatment Works, by C. E. Keefer
Industrial Wastes Treatment Practics, by E. F. Eldridge
Water Supply Engineering, 3rd Edn., by H. E. Babbitt and J. J. Doland
Practical Tunnel Driving, by Richardson & Mayo
Water Purification for Plant Operators, by Norcom & Brown
Water Purification, by Charles G. Cox
Preparation of Engineering Reports, by Agg & Foster
Public Water Supplies, 4th Edn., by Turneaure & Russell
Water Supply & Sewerage, by Ernest W. Steele
Municipal and Rural Sanitation, 3rd Edn., by Harold E. Babbitt and Ernest W. Steele
Stream Flow, by Grover & Harrington
Modern Timber Design, by Hansen
Steady Flow in Open Channels, by Woodward & Posey
Handbook of Applied Hydraulics, Calvin V. Davis
Handbook of Chemistry and Physics, 27th Edn., published by Chemical Rubber Company.
Drainage and Flood Control Engineering, 2nd Edn., by G. W. Pickels
Diesel and Gas Engine Power Plants, by Glen C. Boyer
Industrial Instruments for Measurement and Control, by Thomas J. Rhodes
Structural Frameworks, by Morris & Carpenter

Chemical Engineers Handbook, 2nd Edn., by John H. Perry
Electrical Transmission and Distribution Reference Book, published by Westinghouse
Principles of Highway Construction as Applied to Airports, Flight Strips and Other Landing Areas for Aircraft, by Public Roads Bulletin

The following books were donated:
"Theoretical Soil Mechanics," by Dr. Karl Terzaghi (gift of the author)
"Hydraulics," 5th Edn., by George E. Russell (gift of the author)
"Water Power Engineering," 3rd Edn., by Prof. Harold K. Barrows (gift of the author)
"1943 Guide" of the American Society of Heating and Ventilating Engineers
Cameron Hydraulic Date (gift of Ingersoll-Rand Company)
Compressed Air Date (gift of Ingersoll-Rand Company)

A review of one of the above books appeared in the January issue of the JOURNAL and we hope to be able to publish others in the near future.

The number of books loaned during the year was 132. The fines collected for overdue books amounted to $5.94.

Respectfully submitted,
ALLEN J. BURDOIN, *Chairman*

REPORT OF THE COMMITTEE ON SUB-SOILS OF BOSTON

Boston, March 13, 1944

To the Boston Society of Civil Engineers:

The newly elected Committee on Sub-soils of Boston held its main meeting of the year on November 4, 1943, with all but one committee member present.

The committee was unanimously of the opinion that there should be a continuation of the collection of boring data of the type covered in the "Report of Committee on Boston Sub-soils" in the September 1931 JOURNAL. It was not believed feasible to start further work at this time, however, and no definite program has been set up. The suggestion has been made that in order to inaugurate this work as soon as possible it might be well to restrict the investigations at first to a small portion of the area.

It was also agreed that consideration should be given at some future date to the possibility of the collection of water table data, settlement records and perhaps other data.

DONALD W. TAYLOR, *Chairman*

REPORT OF COMMITTEE ON JOHN R. FREEMAN SCHOLARSHIP FUND

Boston, March 22, 1944

To the Boston Society of Civil Engineers:

Since the last report, the Committee has lost two of its members, Mr. Charles T. Main, Chairman, who signed that report, and who died less than two weeks before its presentation; and on July 30, 1943, Mr. Robert Spurr Weston died.

On December 15, 1943, the Board of Government approved the appointment of Mr. William F. Uhl, of Boston, as a member of the Committee.

Under present conditions the Committee has made no award during the current year. There is clearly no possibility of travel grants for students abroad. In 1941 research funds of $800 each were granted to the Harvard Engineering School, the Massachusetts Institute of Technology and Worcester Polytechnic Institute. None of these institutions were able to use these funds. The two former returned them to the Society, the latter is holding its allotment for the future when conditions will enable it to be used.

Under these circumstances the Committee has decided to allow the income to accumulate, anticipating the great opportunities that will exist after the war, for Mr. Freeman's chief purpose, encouraging young engineers.

The standing of the fund is shown in the Treasurer's Report.

Respectfully submitted,

THE FREEMAN FUND COMMITTEE,
CHARLES M. ALLEN
WILLIAM F. UHL
HOWARD M. TURNER, *Chairman*

REPORT OF THE EXECUTIVE COMMITTEE OF THE SANITARY SECTION

Boston, March 1, 1944

To the Sanitary Section, Boston Society of Civil Engineers:

During the past year five meetings have been held as follows:

March 3, 1943.—Annual meeting and election of officers. Mr. F. Wellington Gilcreas spoke on "The Function of Sanitation in the Control of Food Dispensing Establishments." Attendance, 60.

May 19, 1943.—Joint meeting of the Boston Society of Civil Engineers with the Sanitary and Hydraulics Sections. Professor Thomas R. Camp presented a paper on "Velocity Gradients and Internal Work in Fluid Motion." Mr. P. Charles Stein was co-author of this paper. Attendance, 52.

October 6, 1943.—Mr. Harry A. Faber presented a paper on "The Handling and Application of Chlorine in Sewage Treatment." Attendance, 29.

December 15, 1943.—Joint meeting of the Boston Society of Civil Engineers with the Sanitary Section. Mr. Seth G. Hess presented a paper entitled "Interstate Agreements for Pollution Abatement." Attendance, 30.

February 10, 1944.—Mr. George W. Coffin presented a paper entitled "Water Supply and Sewage Disposal at Certain Outlying Airfields in Southern New England." Attendance, 27.

The average attendance was 40.

Five meetings of the Executive Committee have been held during the year.

Respectfully submitted,

For the Executive Committee,
GEORGE C. HOUSER, *Clerk*

REPORT OF THE EXECUTIVE COMMITTEE OF THE DESIGNERS' SECTION

Boston, Mass., February 17, 1944

To the Designers Section, Boston Society of Civil Engineers:

The following is a list of the meetings which were held during the year March 1943 to February 1944 inclusive.

March 10, 1943.—Annual meeting and election of officers. Mr. T. S. Carswell spoke on "The Structural Use of Plastics." Attendance, 80.

April 7, 1943.—Rev. Daniel Linehan spoke on "Applications of Seismology to Engineering." Attendance, 40.

May 12, 1943.—Mr. Burtis Brown spoke on "The Proposed Boston Building Code." Attendance, 40.

October 13, 1943.—Mr. Albert Dietz spoke on "The Design of Timber Structures." Attendance, 58.

November 10, 1943.—This was a joint meeting with the Highway Section. Mr. Leslie G. Sumner spoke on "The New Thames Bridge." Attendance, 35.

December 8, 1943.—Mr. Alexander B. Daytz spoke on "The Analysis of Stresses in Pipes under High Temperature and Pressures." Attendance, 58.

January 26, 1944. This was a joint meeting with the Parent Society. Mr. Townsend spoke on "Modern Ship Construction." Attendance, 100.

February 9, 1944.—Mr. Eric P. Muntz spoke on "Pre-stressed Concrete Structures." Attendance, 80.

The total attendance for the year was 491. The average attendance per meeting was 61 which is 7 per cent greater than the average attendance for the preceding 10 years.

The average length of meeting was 2 hours.

Respectfully submitted,

EUGENE MIRABELLI, *Clerk*

REPORT OF THE EXECUTIVE COMMITTEE OF THE HIGHWAY SECTION

To the Highway Section, Boston Society of Civil Engineers:

During the past year the following meetings were held:

May 13, 1943.—A special luncheon meeting was held jointly with the Massachusetts Highway Association. Major William J. Bingham spoke on "Dimouts". Attendance, 126.

September 22, 1943.—Mr. A. N. Carter spoke on "Building the Inter-American Highway". This was a joint meeting with the Boston Society of Civil Engineers, the Northeastern Section of the American Society of Civil Engineers, and various student chapters of both societies. Attendance, 300

November 10, 1943.—Mr. Leslie G. Sumner spoke on "The New Thames River Bridge at New London", and commented briefly on the Charter Oak Bridge and Traffic By-Pass at Hartford. This was a joint meeting with the Designers Section. Attendance, 35.

February 23, 1944.—Annual meeting and election of officers. Mr. Hans E. Bernt spoke on "The Construction of the Alaska Highway". Moving pictures were furnished by the B. F. Goodrich Co. and by Mr. John R. Perkins, Attendance, 67.

The total attendance at the meetings was 528.

The average attendance was 132.

Respectfully submitted,

THOMAS C. COLEMAN, *Acting Clerk*

REPORT OF THE EXECUTIVE COMMITTEE OF THE HYDRAULICS SECTION, B. S. C. E.

Boston, Mass., February 2, 1944

To the Hydraulics Section, Boston Society of Civil Engineers:

The following meetings were held during the past year:

May 10, 1943.—Professor Thomas R. Camp presented a paper prepared jointly with Dr. P. Charles Stein, "Velocity Gradients and Internal Work in Fluid Motion". Attendance, 52.

November 17, 1943.—Professor Theodore B. Parker spoke on "T.V.A. River Engineering". Attendance, 90.

February 2, 1943.—Mr. Allen J. Burdoin presented a paper prepared by Lt. Edwin B. Cobb, U.S.N.R., entitled "Flow of Water in Network Piping Systems". Attendance, 24.

The total attendance at the meetings was 166. The average attendance was 55.

Respectfully submitted,

HAROLD A. THOMAS, *Clerk*

REPORT OF THE EXECUTIVE COMMITTEE OF THE NORTHEASTERN UNIVERSITY SECTION

Boston, March 15, 1944

To the Boston Society of Civil Engineers:

The Executive Committee of the Northeastern University Section submits herewith the annual report of the Section's activities for the year 1943, as follows:

March 12, 1943.—Mr. Lansing S. Heberd, Senior Civil Engineer for the Massachusetts Department of Public Works lectured to the group on "Highway Construction". Attendance, 34.

April 30, 1943.—Lt. Comdr. Jewett, C.E.C. (v.s.) U.S.N.R., spoke on the subject "The Navy Civil Engineering Corps". Attendance, 54.

June 4, 1943.—Mr. F. E. Votaw, Chief Field Engineer, Portland Cement Association, addressed the group on "Cement Soil Stabilization". Attendance, 45.

September 29, 1943.—Seventy-five Northeastern students attended the annual Student Night sponsored by the Boston Society of Civil Engineers and the

Northeastern Section of the American Society of Civil Engineers which was held at Northeastern University for the second consecutive year.

October 22, 1943.—Mr. Athole B. Edwards, Member of Massachusetts State Planning Board and past president of the Boston Society of Civil Engineers, spoke on "What's Doing After Graduation". Attendance, 37.

The average attendance for these meetings is 42. It will be noted that this average does not include the attendance of the annual Student Night held on September 29, 1943.

We sincerely hope that our year's work, as herein described meets the standards set up for student sections.

Respectfully submitted,

HENRY J. BISHOP, *Chairman*

ADVERTISEMENTS

The advertising pages of the JOURNAL aim to acquaint readers with Professional and Contracting Services and Sources of Various Supplies and Materials. You would find it of advantage to be represented here.

Vol. XXXI JANUARY, 1944 No. 1

BOSTON SOCIETY OF CIVIL ENGINEERS

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INDEX TO ADVERTISERS

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1944-1945

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