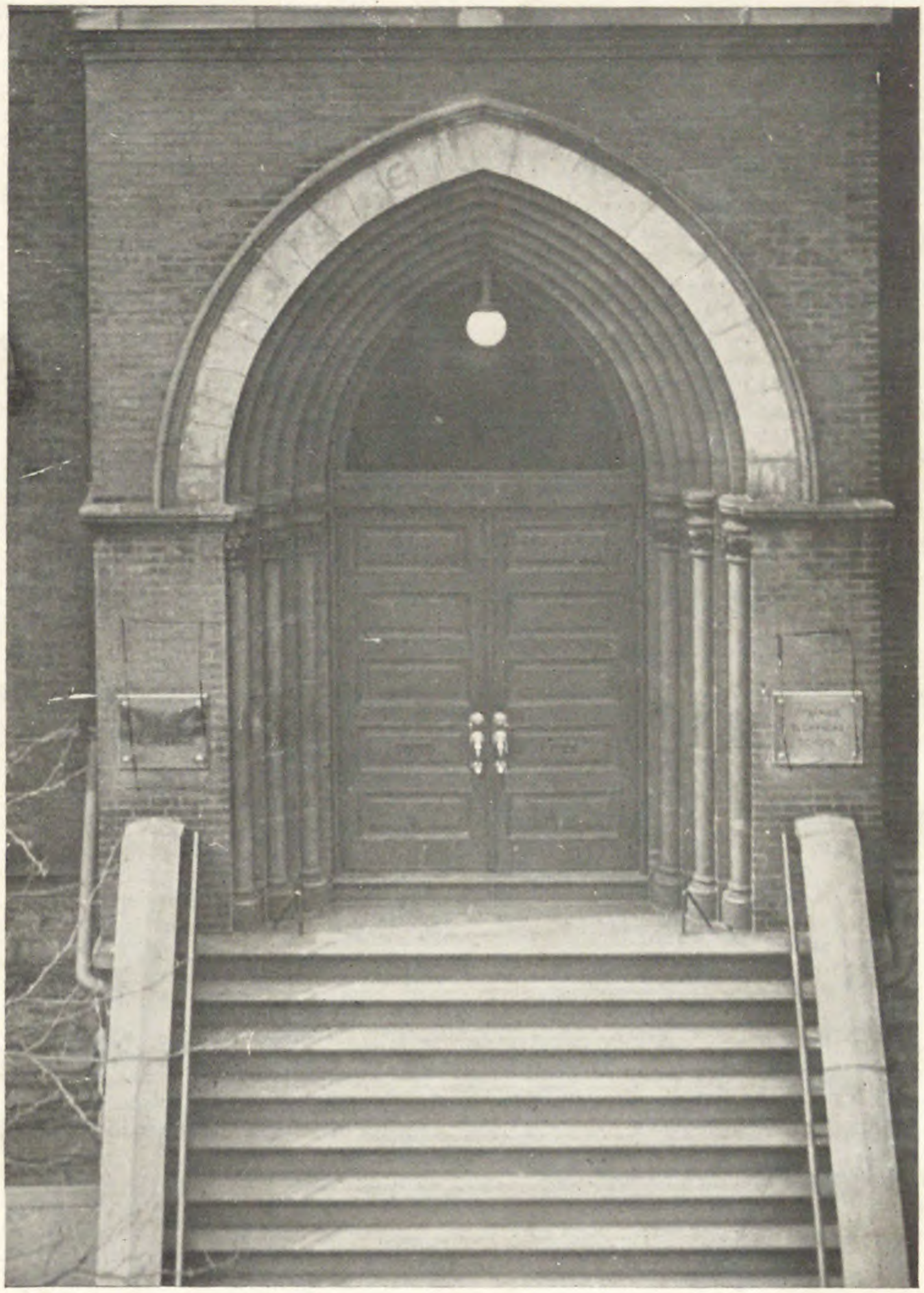
NEWARK ENGINEERING NOTES



Vol. I No. 3 June, 1938

THE PRESIDENT'S DIARY

What Price Publicity? — "Nothing Too Much" — Dr. Weston's Bequest and Library Progress

May 4th

Many times in the last few weeks members of the alumni have asked just what the object of the ENGINEERING NOTES might be, expressing various opinions concerning the general value of publicity, as they are pleased to call it.

Publicity to me seems a little bit like insurance. Both are very broad terms, and while insurance is a very good thing—perhaps some form of insurance always a good thing—a man is very foolish to buy it indiscriminately. In short, publicity is something that if bought and paid for (and most everything in this world is bought and paid for) should be the kind and type of publicity which the buyer really wants or really needs. And so the question comes up with us as to what sort of publicity we really want and we really need.

In an institution which has been for years working to capacity and where more students are not particularly desirable from any angle and where in the main our graduates have been fortunate, we think, in the securing of positions and where the grants from the State and the City have been very modest, it is a little hard to see why and how a wide-spread advertising campaign would be beneficial. This amounts to saying that any sort of publicity and just any sort of publicity is not a thing which is of particular consequence to us.

On the other hand, we do want people to realize the sort of thing that we are doing, the kind of work that we are trying to do, and something of our ideals and our methods of procedure. Unless this is done it is doubtful if the school can fulfill its own specific function in this locality. Like most men and most institutions we desire to be understood and to a certain extent to be appreciated. I think this is true of all of us, from the Board of Trustees and the Faculty, we will say, down to the youngest Freshman.

Perhaps it is too much to expect that we can have this understanding and appreciation. I think it was Emerson, wasn't it, who said, "To be great is to be misunderstood," and yet I think the most fundamental thing which we all desire is some little knowledge and appreciation, particularly on the part of those who are closest to us, of our aspirations and our ideals. Certainly there is no particular or specific material reason why popular publicity should help us in our daily work. But there is, I think, a good and sufficient reason why a full understanding on the part of the community of the work in which we are engaged, is necessary, if for no other reason than that the community, by its support, makes possible our full program of activities.

May 17th

In looking over my last entry I notice that some very important things are left out.

In the studying of publicity over a number of years I have almost come to the conclusion that the desire for publicity in all its phases is one of the most fundamental and probably the most easily understandable frailties to which flesh is heir.

How many of us like to read of our institution, our professors, our alumni, our team, our almost anything else as long as it is ours? Perhaps we might extend this to our automobile, our front lawn, the biggest fish which we caught, or anything else that touches a man's prestige or his ability or even his luck. And yet it seems to me that we should not spend too much time and too much energy in seeking this strictly personal kind of publicity.

After all, an institution such as ours has a work to do. It is broadly considered of a somewhat unselfish nature. We are dealing with the success of other people. We are taking considerable joy and pride in the outstanding achievements of others, and perhaps publicity from this standpoint may be a little more pardonable than from a particularly selfish standpoint. The upshot of it all, perhaps, is that the proper answer is the one that one of our ancient philosophers, Greek I think, expressed in the words, "Nothing too much."

So that the ENGINEERING NOTES may be pardoned if they need pardon because the object is simply to keep in touch with the members of the family and our friends, to have them know of our expansion and our ideals and our objectives, and in the publication of the NOTES there is nothing that we wish to put over in the wrong sense.

May 26th

In the past months many inquiries have been made concerning the Weston donation to the library and there has been a great deal of conjecture as to just the use we were to make of all the models and drawings and material which Dr. Weston had gathered together over such a long period. Perhaps just a word concerning this recent addition to our material equipment would be interesting.

In the first place it should be understood that the donation is of direct and immense value to us. This consisted roughly of about thirteen thousand books which mirrored the developments in electricity which particularly touched Dr. Weston's interests, and his interests were exceedingly broad. They extended from research and invention through design and construction, operation and management, sales and distribution, to some of the basic economic and social problems connected with management and labor. It is perfectly true to say that if there had come to the institution a considerable amount of money that the need which Dr. Weston's bequest has filled was a primary need with us.

In addition to the library books, that is, the bound volumes, there were somewhere around ninety thousand pamphlets in the shape of transactions of learned technical societies of the United States and most of the foreign countries. These pamphlets were in some cases almost priceless. If there is any one characteristic that stood out in the Doctor's life it was the characteristic of thoroughness, and most of these files of transactions were complete.

Since the library has come to us over a thousand volumes of these transactions have been bound. The work of the library has been so organized that practically all of the material is on the shelves of the stack room and is being rapidly assimilated into a library proper.

In connection with the whole work of building up the library and its design and arrangement and functioning we had the very good fortune to have associated with us Mrs. Katharine Maynard who was for a considerable time librarian of the famous Vail Library in the Institute of Technology in Boston. Mrs. Maynard comes to us with a splendid background of not only library work but of scientific contacts particularly in the line of electricity. Her work in connection with the Vail Library has been supplemented by writing and research along many lines. At present she is retained as a Consulting Librarian making frequent visits to Newark to, in general, oversee and supervise the reorganization and building up of the library. She has been assisted by our own library staff, considerably augmented, and by a professional cataloger.

(Continued on page 9)

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DO YOU WANT TO BE ON OUR MAILING LIST?

From time to time you will receive a copy of the NEWARK ENGINEERING NOTES. In case you wish to receive this magazine regularly, the only thing you have to do is to write us and say so. Address your letter to the Editor, Newark Engineering Notes, Newark College of Engineering, Newark, N. J.

ECONOMIC GROWTH

A Study of the Concept of Limitless Expansion of Industry

By GEORGE D. WILKINSON, JR.
Assistant Professor in Industrial Engineering, Newark College of Engineering

American industrial and commercial thought is permeated with the idea of limitless growth. Since the days of the first expansion of the nation beyond the barriers of the eastern mountains, no bounds to the magnitude to which American industry can attain have ever been recognized. Few towns exist which do not cherish the dream of some day rivaling New York City in size. To build a factory without adequate provision for plant expansion is considered the height of folly. Businesses with well planned production programs and large staffs of statisticians have been known to go even so far as to dig the foundations for a larger plant, in anticipation of an increase in volume of business which has never materialized.

The Nature of Growth

In order to evaluate this popular concept of economic growth, the nature of growth in general must be understood. Growth is, as Professor Rautenstrauch of Columbia University has pointed out,[1] the first differential of magnitude with respect to time.[2] What is ordinarily considered as growth is in reality the variation of the size of an organism with respect to time. This variation has been studied in the course of the development of several sciences, and has been found to have certain very definite characteristics. The concept of limitless growth which dominates our economic thought finds no parallel in any other field of knowledge, and scarcely any reason exists for considering it to be valid for industry.

The curve shown in figure 1 might be used to illustrate the growth of a plant, the population of a country, or the progress of a pupil learning to multiply. Among the more simple mathematical expressions given for this typical quantity-time curve of growth is the equation[3]

$$y = ke^{-e^{-aT}}$$

where

y=the size of the subject whose growth is being measured.

k=the maximum size of the subject, reached at maturity.

T=time measured from the beginning of the growth period.

a=a constant.

The curve reveals some interesting features of the behavior of an organism as it grows. As shown in the figure, growth can be divided in several periods of peculiar activity. In the first period, the organism is gathering strength for its future growth. The process is one of adaptation to the environment rather than of increase in magnitude. After the organism has firmly established itself in its environment, it enters into the period of expansion, during which most of the actual increase in size occurs. Finally, if it is an integrated organism, it will enter a period in which the increase of size with respect to time will gradually decrease and finally cease altogether. When it has reached this state, the organism is said to have reached its maturity. Of course, a growing mass which has no integrating forces operating within it, such as a coral reef, would not be expected to follow this type of growth curve, since such a mass has no rational limit to its ultimate size, and hence has no maturity. Normal biological and social organisms, however, reach maturity and never grow further. Men, for instance, grow for about twenty years, and then, being fully grown, they become no taller. Occasional examples are found of organisms which for extraordinary reasons seem to have lost some of their integrating force, but these monsters never achieve a well balanced development.

Growth Characteristics of Economic Organisms

Can industry, or the economic structure of the nation as a whole, be considered as an organism having enough of the force of integration to make it follow these general laws of growth? Or does economic growth, like the growth of a coral reef, obey no laws, and is it limited in its growth only by the chance adversities of its peculiar environment? A little reflection indicates that industry is more nearly comparable to a biological organism than it is to a coral reef. It is made up of many small units, as the organism is made up of many individual cells. These units in turn are knit together in organizations, corresponding to the organs in the body of a man, for example. The organizations form an integrated whole for the industry, just as the organs in the body of a man are integrated to form a smoothly functioning organism. To go a step further, the industry does not operate entirely by itself, independent of other industries, any more than a man lives his life by himself without being influenced by the actions of those who surround him. If this analogy between the biological organism and economic organism is so close, is it reasonable to expect that the economic organism will obey the general laws of growth? Logically, it is to be expected that it will.

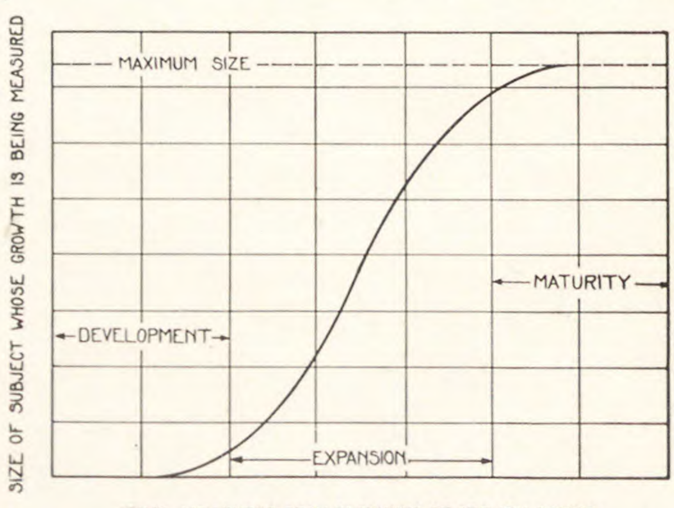


Figure 1—Typical quantity-time curve of a naturally growing organism.

[1] Walter Rautenstrauch, "Growth Curves," Mechanical Engineering, July, 1933, Vol. 55, no. 7, page 433.

[2] For those mathematically inclined, if the magnitude, m, varies with the time, t, so that $m = f(t)$, then growth is expressed by $\frac{dm}{dt}$.

[3] S. A. Courtis, "The Measurement of Growth," Brumfield and Brumfield, Ann Arbor, Michigan, 1932.

The growth of an economic organism can be normalized somewhat as follows: A discovery is made. This discovery is the seed for the growth. A period of development follows during which capital is attracted to the field and the problems incident to getting the results of the discovery in such a form that they can be of commercial value are solved. Machinery is designed, workers are trained, and the public is educated to the value of the new product. Gradually the kinks are ironed out, and the industry enters the second stage of its growth, when its market is expanded. The public starts to demand the product, and sales increase. During the early stage of this period, most of the sales are to new customers, but as the period advances, old customers begin to come back in increasing numbers for replacements. A limit is eventually reached when all the people of the community have acquired their first unit of the product, and new sales no longer are made. The sales from this point on are only for replacement, and to seek further expansion of sales is futile. The industry has reached its maturity, and will grow no further.

A consideration of biological growth again will show why industries do not always follow this normal growth. If a child is taken from a city and placed in the country, the transfer is often followed by an increase in weight. Or, if a beet plant be left in the ground where it started its life as a seed, it never attains the size at maturity that it would if it were transplanted to a new piece of ground. The growth and maturity of an organism is dependent upon its environment, therefore, and any change in the environment is likely to modify this growth and the maturity. The effect of environment upon an economic organism such as a business or an industry, however, is much greater than it is on ordinary biological organisms, because an economic organism is so much more dependent upon its environment. The automobile industry in Great Britain, for example, can never attain the size of the same industry in the United States for the simple reason that the population which forms the market for that industry in Great Britain is not so great as the population in the United States. The maturity point of an industry, therefore, is closely allied with the size of population, and will, as a matter of fact, increase or decrease with increases or decreases in population. The buggy whip industry, to take another example, was cut off in the very prime of its existence, in the face of an increasing population, because the invention of the automobile so seriously changed its environment that it could no longer flourish. The factors which cause economic organisms to deviate from the normal growth are so many and diverse that any attempt to predict future growth is fraught with many dangers.

The Motor Trucking Industry as an Example of Economic Growth

To see whether industries actually do follow this growth trend, some statistical evidence of industries as they actually operate should be examined. Although any of several industries would serve as an example, the motor trucking industry would seem to be about as well suited to the purposes of study as any other single example because, first, it is of such recent development that fairly reliable figures are available from the very start of the industry in this country; second, it is not a well organized industry. Motor trucking, as a matter of fact, is so diverse in its nature that many people do not recognize it as a distinct industry at all. The industry divides itself very naturally into three distinct classes: the private carriers, who are truckers carrying their own commodities, the contract carriers, who contract to carry the merchandise of another, and the common carriers, who truck the freight of any and all shippers, on the same basis as the railroads. Further, the nature of the goods trucked lends further diversity to the industry, for the problems of shipping ink or milk differ greatly from those of hauling coal or delivering parcels for department stores.

If an industry with such little unity or coherence is found to follow the laws of growth, it would seem to be good evidence of the validity of these laws in the field of economics.

The greatest problem in making any study of this nature is to find a good index of what is to be measured. In this case the problem seems relatively simple, since the number of trucks registered in the United States seems to be the only measurement available that is anywhere near being a good index. It is a quantitative measure, and furnishes no indication of the development of new types of services of trucking or the change in the quality of the services offered, but, on the other hand, it is an absolute figure, and does not have to be corrected for changes in the value of money or the economic conditions of the country. Ton-miles would probably be the best index for the purpose, but such data is, for practical reasons, unavailable. No appreciable number of trucks are probably engaged in trucking which are not registered, and probably very few of those registered are not in use, so that this figure is as valid an index for the growth of the industry as could be desired.

Figure 2 shows in graphical form the variation in the number of motor trucks registered in time. With the same co-ordinates is plotted a theoretical growth curve (quantity-time) derived from the same data. The equation of this curve was found to be:

$$y = 4{,}885{,}000e^{-e^{-(1.491t-1.911)}}$$

where

t=time in years measured from the year 1910.

The equation, as explained at the beginning of this paper, indicates that the maximum number of trucks that will be registered will be 4,885,000, and that this figure will be attained around the year 1950, provided there are no great changes in the economic environment. The actual truck registrations, when compared with this theoretical curve, follows it remarkably closely. The theoretical curve has an inflection point around the year 1924, and a smoothed curve of the actual registration would show an inflection at approximately the same point. After that year the rate of increase of registration

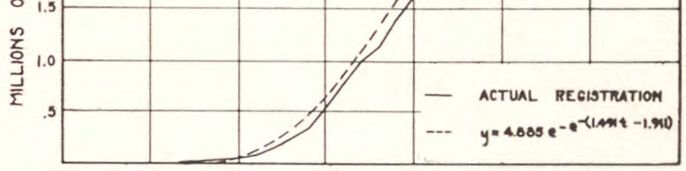


Figure 2—Registration of motor trucks compared with a typical growth curve computed from the same data.

began to decrease in the face of the boom period that ended in 1929. The tremendous economic upset following 1929 has served to cause the actual registrations to deviate more from the theoretical curve than they have at any other previous time in the history of the industry. It remains for time to show, of course, whether this upset has been serious enough to change permanently the structure of the industry to such an extent that the maximum number of trucks registered will differ greatly from the figure indicated by the equation. Population in the country is gradually coming to a standstill, so that further expansion of the industry because of increase in population cannot be confidently expected. On the other hand, should the country continue to suffer from the chronic depressions that have afflicted it since 1929, the maturity of the industry will probably be represented by a lower figure than that indicated by the equation. Again, an unusual expansion of industry and trade, such as might be occasioned by a war or a significant change in the economic or industrial environment, might serve to increase this maximum figure; or a new development in the field of transportation might decrease it in much the same manner as the development of this industry has served to decrease the maximum size to which the railroads might have attained, had trucks not usurped part of their field.

Conclusion

A study of this nature throws a light on the economic picture different from that cast by the concept of ever-increasing growth. Truckers some years ago began to complain that regulation and taxes were hampering the growth of the industry, and cited figures to prove the case. They were working on the supposition that the normal growth of the industry should be represented by a straight line continuing beyond 1934 with the same slope as it had before that point, as frequently seen in current literature and labeled "economic trend." If this study be anywhere near the truth, however, it must be apparent that taxes and regulation are but phases of the growth of the industry, and that a limit to the growth is to be expected if it is to assume its natural place in the economic life of the country, and not become a monstrosity to sap the strength of the nation as a whole.

If these laws of growth be valid in the field of economics, is it not pertinent to suggest that the solution for part, at least, of our economic ills is to be found, not in seeking greater markets and building larger plants, but rather in adjusting many of our industries to a condition of stability? Has not a significant part of our industry reached the stage where it can no longer expect to grow, but must content itself with the market it enjoys? Instead of trying to force an unnatural growth in industry, might we not better turn our attention to the task of finding what may be expected to be the mature size of our industries and attempting to adjust our economic machine in the light of whatever rational results might be obtained from such a study?

Editor's Note:

Professor George D. Wilkinson, Jr., was graduated from the Newark College of Engineering with a Bachelor's degree in Mechanical Engineering in 1933. While at college he received the Charles T. Main award for his paper, "Progress in the Prevention of Smoke and Atmospheric Pollution," and coöperated at the Western Electric Co. at Kearny, as a cost clerk. He received the degree of M.S. in Industrial Engineering from Columbia University in 1937. His record is as follows:

1933-34 Assistant in Mechanical Engineering Dept. at N. C. E.

1934-35 Industrial Engineer, United Parcel Service of N. Y. C.

1935-38 Instructor in Industrial Engineering at N. C. E.

1938 Assistant Professor in Industrial Engineering at N. C. E.

Professor Wilkinson is a member of the A.S.M.E., the S.A.M. and the S.P.E.E.

SOLUTION OF SIMULTANEOUS LINEAR EQUATIONS BY SUCCESSIVE APPROXIMATIONS

By William S. La Londe, Jr., S.B.
Associate Professor in Civil Engineering, Newark College of Engineering

Even though much has been written and expanded upon the value of using iteration and reiteration for the solution of simultaneous linear equations (or in plain language a method of successive approximations) it is not in general use. The structural engineer finds this method exceedingly helpful in the solution of slope deflection equations because the trial values very rapidly approach the true values. This is true in general of linear equations in which the numerical coefficient of one unknown is large in comparison to the numerical coefficients of the other unknowns. The general arrangement of the work as given in the accompanying example was first suggested to the author by Professor L. C. Maugh of the University of Michigan.

The example used here is a structural problem, but if some of the readers are more interested in the solution than in the formation of the equations they may without loss to themselves jump directly to the solution.

Assume uniform cross-sections throughout with force and frame both in the same plane.

Three equations of equilibrium are:

(1) $Mad + Mab = 0$ Joint a ($\Sigma M = 0$)

(2) $Mba + Mbc = 0$ Joint b ($\Sigma M = 0$)

(3) $10 + \frac{Mad + Mda}{10} + \frac{Mbc + Mcb}{20} = 0$

Free body consisting of the two verticals ($\Sigma H = 0$)

Using slope deflection equations to evaluate these moments:

$Mad = 2E(2k)\ (2\theta a - 6R)$
$Mab = 2E(2k)\ (2\theta a + \theta b)$
$Mba = 2E(2k)\ (2\theta b + \theta a)$
$Mbc = 2E(k)\ (2\theta b - 3R)$
$Mda = 2E(2k)\ (\theta a - 6R)$
$Mcb = 2E(k)\ (\theta b - 3R)$

Substituting these new values for the moments in equations 1, 2, and 3 (and with k assumed = 1) the equations become

Eq. 1 $+ 16E\theta a + 4E\theta b - 24ER = 0$
Eq. 2 $+ 4E\theta a + 12E\theta b - 6ER = 0$
Eq. 3 $+ 24E\theta a + 6E\theta b - 108ER = -200$

Note that if the slope deflection equations are not simplified up to this point, reading upward or to the left from the terms on the diagonal line ($16E\theta_a$ to 108ER) the coefficients will be found to be numerically equal in the same order—a worthwhile check.

Before going forward with the next step, it might be well to explain why Eq. 1 was made the θa equation and not Eq. 3, when actually the coefficient of the θa term in the third equation is larger than the coefficient of the θa term in the first equation. To state this another way, why was Eq. 3 taken as the R equation? Simply this, that in the third equation the R coefficient is 4.5 times the θa coefficient, whereas in the first equation the R coefficient is only 1.5 times the θa coefficient, thus showing that the equation having the dominant θa coefficient was the first equation and that the equation having the dominant R coefficient was the third equation. This point of view in deciding upon which is Eq. 1, etc., is here given to help the reader in evaluating other types of linear equations.

Now rewrite these equations as follows:

Eq. $1+16\theta a = -4\theta b + 24R$
Eq. $2+12\theta b = -4\theta a + 6R$
Eq. $3+108R = +200/E + 24\theta a + 6\theta b$

Simplify:

$1' + \theta a = -.250\theta b + 1.500R$
$2' + \theta b = -.333\theta a + 0.500R$
$3' + R = +1.852/E + .222\theta a + .056\theta b$

Solution:

For convenience use the order 3′, 1′, and 2′.

Step 1. Assume θa and $\theta b = 0$ in 3′. Then $R = +1.852/E$ and enter in table below. (In case the 3′ equation had had no constant term, any value could have been assumed for R on the first step).

Step 2. Assume $\theta b = 0$ in 1′. Use $R = 1.852/E$. Then $\theta a = 1.500 \times 1.852/E = +2.778/E$. (Enter below.)
(Enter below.)

Step 3. In equation 2′, use $R = +1.852/E$ and $\theta a = +2.778/E$. Then $\theta b = -0.333 \times 2.778/E + 0.500 \times 1.852/E = -0.926/E + 0.926/E = 0$.

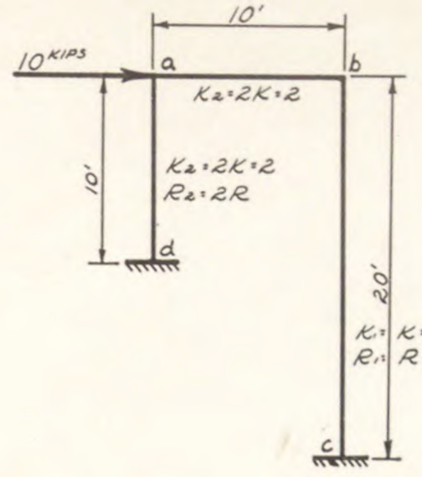
Step 4. In equation 3′, use $\theta a = +2.778/E$ and $\theta b = 0$. Then $R = +1.852/E + .222 \times 2.778/E + .056 \times 0 = +1.852/E + .617/E = +2.469/E$.

Step 5 and on. Continue (as in Step 4), using the "latest" trial values of the θ and R terms until there is little or no change.

Table of Trial Values

Trial No.	R	θa	θb
1	+1.852/E	+2.778/E	0
2	+2.469/E	+3.704/E	0
3	+2.675/E	+4.012/E	0
4	+2.744/E	+4.116/E	0
5	+2.767/E	+4.150/E	0
6	+2.774/E	+4.161/E	0
7	+2.777/E	+4.166/E	0
8	+2.777/E	+4.166/E	0

The results will not here be substituted back into the original expressions to find the moments at the ends of the members. As can be seen, there was really no need to go beyond the 4th or 5th trial round other than to note that there was no mistake in the arithmetic. An important fact is that an error in arithmetic automatically eliminates itself, possibly requiring an extra round or two. The more equations and unknowns the more valuable and rapid



Frame to illustrate example

is this method of solution as compared to the algebraic solution of simultaneous equations, which is quite tedious when applied to more than six equations with as many unknowns. If an exact solution is required to the second, third or *n*th figure, the trial rounds should be extended until there is no change in the last figure desired.

In the solution of problems of continuous beams using "three moment equations" there might be some advantage in using iteration as the coefficient of one unknown term is large in comparison to the coefficients of the other unknown terms in the same equation, as for example:

Eq. $1+2M_1+M_2 = -180$
Eq. $2+3M_1+10M_2+2M_3 = -540$
Eq. $3\quad + 2M_2+10M_3+3M_4 = -600$
Eq. $4\quad + M_3+2M_4 = -200$

However, in the solution of equations of problems applying Kirchhoff's Law in electricity there would appear to be considerable labor in applying this method of iteration as the coefficients of the unknowns in each equation differ little from one another, and therefore, the trials converge slowly to a solution. Typical equations illustrating this are as follows:

Eq. $1 + 10.5I_1 + 9\ I_2 + 6\ I_3 = +12$
Eq. $2 + 3\ I_1 + 3.4I_2 - 1.5I_3 = +10$
Eq. $3 + 6\ I_1 + 6.3I_2 + 7.8I_3 = +6$

While a student at Northwestern University the author worked as a computer on some special research work being conducted by Prof. John F. Hayford. In this work, least squares were used and the "normal equations" were solved using the Doolittle method of solution. These equations might very successfully have been solved by the use of iteration. For an illustration of this type of equations and of certain other features similar to those mentioned earlier in this paper, attention is called to page 12 and elsewhere in Special Publication No. 28 of the U. S. Coast and Geodetic Survey.

Overemphasis should not be placed on any one method of solving a problem unless experience shows it to be the best method. When the equations lend themselves to the means of solution indicated here, this method is a time saver and will be found to be a worth while tool.

References:

"Simultaneous Equations in Mechanics Solved by Iteration" by W. L. Schwalbe. Transactions A.S.C.E. Vol. 102, Page 939.

"Analysis by Moment Distribution Aided by Iteration" by A. Floris. Eng. News-Record Vol. 116, Page 922.

"Analysis of Vierendeel Trusses." Discussion by L. C. Maugh. Transactions A.S.C.E. Vol. 102, Page 919.

"Application of the Theory of Least Squares to the Adjustment of Triangulation" by Oscar Adams. Special Publication No. 28 on Geodesy by the U. S. Coast and Geodetic Survey.

Editor's Note: Professor La Londe was a native of Chicago and received his training in civil engineering at Northwestern University and the Massachusetts Institute of Technology, where he graduated in 1923. Railroad, municipal, coast and geodetic, and bridge and industrial construction work held his attention until he came to the Newark College of Engineering in 1929. He is a licensed Civil Engineer and Land Surveyor in New Jersey, a Member of the American Society of Civil Engineers, and holds an appointment of Civil Engineer with the rank of Lieutenant in the U. S. Naval Reserve.

WHAT OUR PROFESSORS AND INSTRUCTORS ARE DOING

Professor Frank D. Carvin, of the Mechanical Engineering Department, will receive the Ph.D. degree in June from the Physics Department of New York University. His research was on an "Investigation of the Absorption Spectra of Hydrogen Sulphide Gas in the Photographic Infra-red Region."

Professor W. S. La Londe, of the Civil Engineering Department, will continue his graduate studies this summer at the University of Michigan.

Mr. P. O. Hoffmann, Instructor in the Department of Mechanics, intends to take some graduate courses this summer in the Department of Mathematics at Columbia University.

Professor Edward G. Baker, of the Mathematical Department, expects to complete the course requirements for the degree of Doctor of Education in the Advanced School of Education in Teachers' College, Columbia University, this summer.

Mr. D. C. Frost, Instructor in Civil Engineering, is to receive the degree of Master of Education at Rutgers University, New Brunswick, N. J., this June, and plans to continue his doctorate work during the summer.

EVALUATION OF AN ELLIPTIC INTEGRAL

Reduction to Standard Form and Numerical Discussion of Dr. Joffe's Integral

By EDWARD G. BAKER

Assistant Professor in Mathematics, Newark College of Engineering

Every student of the calculus has experienced the chagrin arising from inability to integrate such an expression as

$$\int\sqrt{1 - .5\sin^2\varphi}\quad d\varphi$$

in terms of familiar functions. In most such cases, an engineer resorts to numerical integration, with the aid of Simpson's rule or some similar device. But it may happen that even this very general method fails.

Problem of the Flexible Trough Filled with Water

For example, consider the integral

$$x = -\int_{y_2}^{y} \frac{(y^2 + c)\ dy}{\sqrt{4K^2 - (y^2 + c)^2}} \qquad (1)$$

In the April issue, Dr. Joffe showed that this equation gives the curve assumed by the rectangular canvas bottom of a tank filled with water. (See Fig. 1.) The quantity y is the depth at any point $P(x, y)$ along the canvas.

Values of the Constants K and c

From another equation

$$1 + p^2 = \frac{4K^2}{(y^2 + c)^2} \qquad (2)$$

in Dr. Joffe's paper, it may be seen that the constant of integration c has the value

$$c = 2K - y_2^2$$

(since the slope p vanishes at $y = y_2$).

It therefore appears that the integral in equation (1) is improper; the integrand becomes infinite at the lower limit. The convergence of the integral is, however, easily established. (See Osgood's *Advanced Calculus*, p. 475 et seq., for the method.)

There remains in the integrand the constant

$$K = \frac{T}{w} \qquad (3)$$

where T is the tension in the canvas, and w is the density of the water. It is clear that K would not be known *a priori*. In order to make use of equation (1), one must first find T or K, by using the condition that

$$x = x_1 \quad \text{when} \quad y = y_1.$$

A Numerical Example

Suppose Dr. Joffe's tank of width six feet is filled with water to a depth $y_2 = 4$ feet. Let the sag be one foot (i.e., $x_1 = y_1 = 3$ feet). By assuming various values for K, and comparing the two members of equation (1) for $x = x_1$, one may find K by trial.

The integral is difficult to compute, however, in the form given. Numerical integration is not possible because the integral is improper.

Reduction to Standard Form

To make numerical calculations easier in cases of this kind, tables of elliptic functions have been prepared. The integral under consideration may be expressed in terms of two integrals, which were studied and tabulated by the great French mathematician, Legendre:

$$F(\varphi, k) = \int_0^{\varphi} \frac{d\varphi}{\sqrt{1 - k^2\sin^2\varphi}} \qquad (4)$$

$$\text{And } E(\varphi, k) = \int_0^{\varphi} \sqrt{1 - k^2\sin^2\varphi}\ d\varphi$$

Methods for reducing any elliptic integral to standard form are well known, though sometimes the transformations are laborious to carry through. In equation (1), the integral is real if

$$y_2^2 - 4K < y^2 \leq y_2^2$$

For this interval, the substitution

$$y = y_2 \cos\varphi \qquad (5)$$

$$\text{With } k^2 = \frac{y_2^2}{4K}$$

is appropriate. Noting that

$$k^2\sin^2\varphi = 1 - (1 - k^2\sin^2\varphi)$$

one readily obtains the desired result

$$x = \sqrt{K}\,[2E(\varphi, k) - F(\varphi, k)] \qquad (6)$$

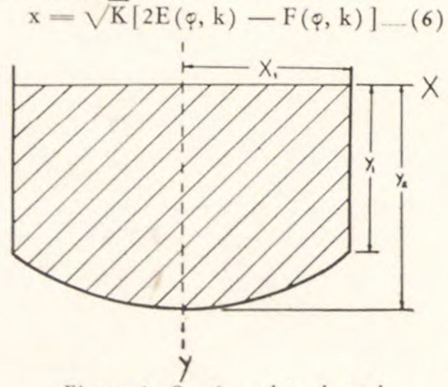


Figure 1. Section of tank with flexible bottom

Application of the Smithsonian Tables of Elliptic Functions

When $x = 3$, $\varphi = 41°\ 24.6'$. In selecting a trial value for K, a somewhat delicate affair, it should be noted that for a tank of similar proportions, but with a sag of one-fourth of a foot, Dr. Joffe found by an approximate method that T was 4500 lbs. per foot. For a sag of one foot, a tension of the order of 1000 lbs. per foot would appear reasonable. This suggests $K = 16$ as a first approximation.

Filling in the first row of Table I, one obtains for the right hand member of equation (6) the value 2.7. For convenience in using the tables, it is desirable that the modular angle be chosen as some multiple of 5°; in this instance, try $\theta = 25°$ for the next higher value of K. This leads to 3.2 for the right hand column. By interpolation, $\theta = 27°$ should be about right; and, in fact, it checks to about one per cent. The use of the tables for such a value of θ presents some interesting problems in interpolation, linear interpolation being invalid in many cases.

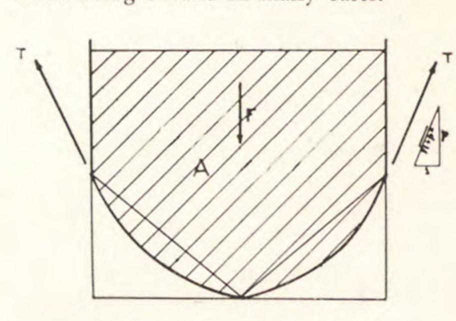


Figure 2. Equilibrium of a strip of canvas

Another Method for Determining the Constant K

The value obtained, $K = 19.3$, may be checked in the following manner. The equations of equilibrium of a one-foot strip of canvas (See Fig. 2) lead to

TABLE I

Values of the right hand member of equation (6) for various values of K

K	$k = \frac{2}{\sqrt{K}}$	$\theta = \text{arc sin } k$	E	F	$\sqrt{K}(2E - F)$
16	0.500	30°	.7085	.738	2.7
22.2	0.423	25°	.713	.733	3.2
19.3	0.4540	27°	.7112	.7349	3.029

$$2T \frac{p}{\sqrt{1+p^2}} = F$$
$$= Aw$$

where A, the area of the cross section of water, may be approximated. By the aid of equation (2), one easily obtains

$$K = \frac{A^2}{4(y_2^2 - y_1^2)} + \frac{y_2^2 - y_1^2}{4} \qquad (7)$$

Using A=24 (the area of the circumscribing rectangle), one finds that $K < 22$. Using the polygon inscribed in A, of area 21 square feet, it may be seen that $K > 18$.

The tension in the canvas is about

19.3 x 62.5 = 1200 lbs. per foot

in this instance, corresponding to a modular angle of 27°. It is now easy to compute other points on the curve directly from equation (6). Table II, calculated in this manner, was used in drawing Figure 1.

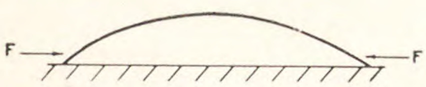


Figure 3. Curve assumed by a rectangular elastic lamina

TABLE II

Points on the curve of Fig. 1, with K taken as 19.3

φ =	10°	15°	20°	25°	30°	35°
x =	0.77	1.14	1.50	1.87	2.23	2.58
y =	3.94	3.86	3.76	3.63	3.46	3.28

The Case Where $y_2^2 > 4K$

Although formally correct, the integrals in equation (6) become imaginary when $k^2 > 1$. If this occurs, the substitution

$$\sin \Phi = \frac{1}{k} \sin \Psi \qquad (8)$$

leads to $F(\Phi, k) = \frac{1}{k} F(\Psi, \frac{1}{k})$

And $E(\Phi, k) =$

$$kE(\Psi, \frac{1}{k}) - (\frac{k^2-1}{k}) F(\Psi, \frac{1}{k})$$

Whence x = (9)

$$y_2[E(\Psi, \frac{1}{k}) - (1 - \frac{1}{2k^2}) F(\Psi, \frac{1}{k})]$$

Other Physical Problems Leading to This Elliptic Integral

It is interesting to note that an elastic lamina bent by forces applied as shown in Figure 3 assumes a curve identical with that of equation (1). A simple model may be constructed out of a sheet of stiff paper on a table top; or by making a crude bow from lath and string.

The following problem is proposed for those who prefer to work out a table for themselves, instead of studying a table computed by someone else. Suppose a liquid under a pressure equivalent to y_1= 20 feet is being forced through a filter cloth, with y_2=20.50 feet, under conditions such that equation (1) is valid (the threads of the cloth in one direction must be horizontal straight lines). Let x_1 be 0.307 feet. What is the tension, and how does the curve look? (See Fig. 4.) Would the shape of the curve be different if a fluid of different density were used?

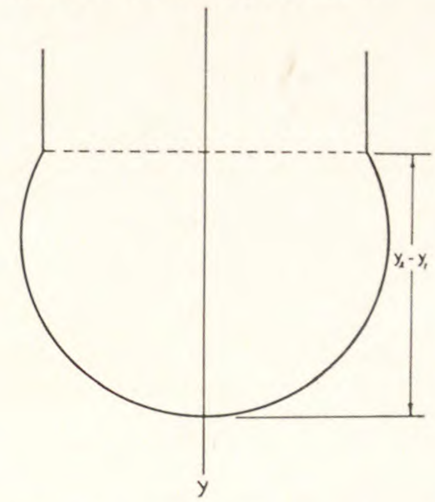


Figure 4. Curve assumed by a rectangular filter cloth

Editor's Note:

Professor Baker graduated from Columbia University in New York in 1930. During his senior year, he held the Faculty Scholarship in the School of Engineering. In 1931 Columbia granted him the degree of Master of Arts in Mathematics. Coming to Newark in 1930 as part time instructor, he served as full instructor in Mathematics from 1931 to 1937, and since then as Assistant Professor.

CONVENTION IN TEXAS

President Allan R. Cullimore is scheduled to preside at the meetings of the Orientation Section of the Society for the Promotion of Engineering Education. These meetings are to be held at the A. & M. College of Texas, June 27-30, 1938. Mr. Cullimore is National Chairman of this important section of the Society which has to do with methods of guiding young men in the choice of profession, in their adjustment to college life, and in the professional work following graduation.

Professor Robert Widdop, Director of Industrial Relations, is planning to attend the Forty-Sixth Annual Meeting of the Society for the Promotion of Engineering Education at College Station, Texas. He is to deliver a paper on "College Guidance for Engineers" as part of a general program having to do with the orientation of Engineers to the profession.

PROPOSED EVENING COURSE IN TIME AND MOTION STUDY

The Industrial Engineering Department at the Newark College of Engineering contemplates offering a laboratory course next fall in Time and Motion Study. Actual production jobs will be studied and the theory of time and motion study will be presented and discussed. The proposed course would extend over a ten-week period. As contemplated, one three-hour session each week may be held beginning early in October. The facilities available would limit the enrollment to fifteen students.

Professor J. Ansel Brooks will be in charge of the course. Additional information regarding fees and course content may be had by communicating with Professor George D. Wilkinson, Jr., at the college.

THE PRESIDENT'S DIARY

(Continued from page 2)

Another item of very considerable interest concerning the library is a definite change of policy with respect to the functioning of the library. The library has been placed actually in the hands of a library committee of the faculty, headed by Dr. Paul M. Giesy, Professor Wilkinson and Professor Robbins who have already started the reorganization of the library from top to bottom along the most modern lines. The ultimate responsibility for the functioning of this very important part of the institution therefore lies in the hands of this committee, the committee having at their disposal the technical knowledge and background of Mrs. Maynard.

I can hardly close this rather sketchy account of the library situation without indicating that one of the things in which I think we should take most pride in the work of this institution, and a thing which touches all departments and all branches of our work, is that in the five years preceding the addition of the Weston library the use of the library increased among our student body almost fifteen hundred per cent. And, after all, while the number of books in the library is of some interest, and while their character is of considerable interest, the thing of most importance is the *use* of the books, not their mere residence on the shelves, and the emphasis in the last years with us has been on using the books rather than simply possessing them.

I hope that some time in the near future I may have a chance to tell you something about our plans for the Weston Reading Room, how we will use his original drawings and blue prints, and all the material which this great scientist used in connection with his monumental work. But that is a rather long story and perhaps should be saved for two or even three issues to come.

GRADUATE WORK IN GEODETIC SURVEYING

By JAMES M. ROBBINS

Assistant Professor in Civil Engineering, Newark College of Engineering

The facilities of Camp Technology, the summer surveying camp of the Massachusetts Institute of Technology at East Machias, Maine, are now available for qualified upper classmen and graduates of the Civil Engineering Department of the Newark College of Engineering who desire to gain further experience and training in the fields of surveying and sanitary engineering.

Among the subjects offered at Camp Technology is that of Geodetic Surveying. This is an advanced course, open to graduate students and qualified undergraduates, which may be used as credit toward the degree of Master of Science in Civil Engineering.

Geodetic surveying has been defined by the late George L. Hosmer as "that branch of the art of surveying which deals with such great areas that it becomes necessary to make systematic allowance for the effects of the earth's curvature."

The instruments and methods used for geodetic surveys have been developed for two principal purposes. In the first place, accurate determinations of large distances must be made by precise measurement and triangulation to provide the basic data of geodesy, from which the shape and dimensions of the earth may be determined. In the second place, such precision measurements must be carried out to furnish accurate control for maps of large areas.

These two purposes of geodetic surveys are interrelated. Geodetic measurements must be carried out before the figure of the earth can be determined with precision. Conversely, the figure of the earth must be known before geodetic surveys can be accurately computed. Thus the determination of the length of each new triangulation arc provides data which may be used to increase the accuracy of future surveys.

The execution of the work of this nature by such agencies as the United States Coast and Geodetic Survey has led to the development of instruments and surveying methods capable of yielding results of a high order of precision. These instruments and methods are not, however, confined in usefulness to the mapping of large areas or to the delineation of international boundaries. The engineer today encounters many situations which call for the application of geodetic methods and the use of surveying instruments of precision. The construction of many long-span bridges and subaqueous and rock tunnels involves the execution of control surveys of an order of accuracy comparable to the best geodetic work. Geodetic control for city surveys is used in an ever-increasing number of instances. The coördination of surveys of all types, making use of geodetic coördinates and benchmarks, results in the elimination of much duplication and in the avoidance of many errors.

Because of the rapid increase in the use of geodetic methods and instruments in municipal and construction work, it appears fitting for the Newark College of Engineering, situated as it is in a huge metropolitan and industrial area, to arrange for training in this field for its most promising civil engineering students.

The facilities available at Camp Technology for conducting such training are unexcelled. The student will have an opportunity to use the invar tape for base line measurements. A direction theodolite reading directly to one second of angle, and a number of ten-second repeating theodolites are available for triangulation. Experience can be gained in the use of heliotropes and lights for triangulation sights and in the erection of steel and timber towers at stations where towers are necessary to permit the lines of sight to clear obstructing ridges. A vertical collimator permits centering the theodolite when mounted in such towers. A Coast Survey-type precise level is available for the accurate determination of differences in elevation while precision instruments permit the measurement of zenith distances for trigonometric leveling. Accurate determinations of azimuth can be made with a Hildebrand theodolite. A completely equipped observatory provides for observations for latitude, longitude and time with an astronomical transit. Equipment is also provided for magnetic observations for declination of the needle, dip and intensity. The work of the geodesist is closely related to seismology. The camp is equipped with a seismograph and complete laboratory equipment for the determination of earth movements.

It is evident that precision instruments are available for conducting substantially all phases of geodetic surveying. The surrounding terrain is well adapted for such operations. Numerous classrooms permit the making of all necessary computations. The camp experience is healthful and provides many values not included within the scope of the instruction alone. Most important of all, the instruction is conducted by teachers whose qualifications are of the highest order, men whose sound theoretical knowledge has been strengthened and broadened by much field experience on large-scale geodetic operations.

* * *

Editor's Note:

James M. Robbins, Assistant Professor in Civil Engineering, received his S.B. in Civil Engineering at M. I. T. in 1923. He was awarded an S.M. by the same institution two years later. After five years of varied engineering work, which included positions with engineering and contracting firms in New England and work in South America for the Tacna-Arica Arbitration Committee in determining the boundary between Peru and Chile, he came to the Newark College of Engineering in 1929 as Instructor in Civil Engineering and became Assistant Professor two years later. At this institution he has had supervision of the courses in the fields of surveying and sanitary engineering.

Professor Robbins is a member of the Boston Society of Civil Engineers, of the Society for the Promotion of Engineering Education, of the American Museum of Natural History, a Military Engineer Member of the Society of American Military Engineers and a First Lieutenant in the Engineer Reserve Corps.

Professor Cummings reports that this summer the following thirteen students from the Newark College of Engineering will attend the Massachusetts Institute of Technology Summer Surveying Camp Session to be held from July 26th to September 16th inclusive. All of these students are participants in the Honors Option.

W. J. Brown	A. C. Grossi
O. Cocchiarella	L. Kates
M. Egger	S. Koch
M. H. Garfunkle	R. F. Schenk
J. N. Garratt	L. E. Sullivan
C. W. Garrison	G. Walker
D. Zarin	

Each student will take three of the following courses: Geodetic Surveying, Railway and Highway Field Work, Hydrographic Surveying, and Limnology.

COMING ISSUES OF NEWARK ENGINEERING NOTES

For coming issues of the NOTES we report that the following articles are being prepared by: *Professor Peet* on the development of the electrical course since the beginning at Newark College of Engineering. *Professor B. S. Koshkarian* on "The Motion of a Chain within a Plane Smooth Tube." *Professor Cummings* and *Professor Walter* on the progress of their investigations, in the Hydraulics Laboratory. *Professor V. T. Stewart* on a new electric storage battery, designed by Janos Gyuris. *Professor J. Ansel Brooks* on Management in the Small Shop. *Dean James A. Bradley* on "The Problems of the Dean."

WHAT OUR READERS SAY

THE PRESIDENT'S DIARY

Editor's Note:

As was expected, the page entitled "The President's Diary" has been received with appreciation and approval. Numerous are the verbal comments about it heard by the Editor, and here are excerpts from some of the letters received commenting about it:

To the Editor:

Dean MacQuigg has just shown me the first number of NEWARK ENGINEERING NOTES . . . Your "President's Diary" has given me the idea that perhaps we'd better give Dean MacQuigg a chance to express himself in our *News* regularly . . .

Sincerely yours,
JOHN M. WEED,
Junior Dean, The Ohio State University.
Columbus, Ohio,
April 29, 1938.

To the Editor:

. . . Have found it to be very interesting and helpful. Enjoyed especially "The President's Diary," and hope you retain that page in all your other copies.

Sincerely yours,
A. ALBERT CARNEVAL,
N. T. S. '38.
Newark, N. J.,
May 19, 1938.

To the Editor:

. . . This is an excellent magazine published by the Newark College of Engineering. I enjoy it very much, particularly the page containing the President's Diary. I only hope that the following editions will have more than one page under this caption.

Yours truly,
HERBERT W. HEILMAN,
Director Public Works, Township of Maplewood.
Maplewood,
May 23, 1938.

THE "EASY FORMULAS"

Comments by Harold N. Cummings, Professor in Civil Engineering, Newark College of Engineering

Professor Albert's "Easy Formulas" offer the designer of reinforced concrete columns that have both tension and compression stresses an additional advantage over the formulas presented in current standard texts. He uses k (which is standard notation) always to represent a ratio of depth of neutral axis to depth of tension steel, that is, the neutral axis is located by the dimension kd, whereas the textbooks change over from the familiar kd of beams carrying only moment to ka, kt or what not, when they discuss the complication introduced by adding a direct stress to the bending effect. In addition, he is consistent in using p always as a factor of bd, rather than introducing a modified notation, such for example as p_t for the special case of column in bending action.

He has not sufficiently emphasized, it seems to me, the advantage for his "Easy Formulas" in making possible a direct solution of design of columns that carry eccentric loads with the resulting bending effect. This would show up clearly if he had added to his "Example 2" a solution of the problem by the methods recommended in some one of the various standard textbooks.

Several other prominent men in the Engineering Profession have also offered comments, some of which follow:

To the Editor:

. . . I have read your article and find it quite interesting, particularly the idea of adapting ordinary beam formulas to columns . . .

Very truly yours,
S. G. ROEBLAD,
Chief Engineer, Aberthaw Company.
Boston, May 19, 1938.

To the Editor:

. . . The procedure outlined seems to greatly simplify what is sometimes a cumbersome problem.

Very truly yours,
MILES N. CLAIR,
Vice-President, The Thompson & Lichtner Co.
Boston, May 20, 1938.

To the Editor:

. . . The article on Concrete is very interesting and valuable for future reference . . .

Very truly yours,
J. C. BUXTON,
Otis Elevator Company.
New York, May 23, 1938.

To the Editor:

. . . containing your article "The Easy Formulas in Reinforced Concrete Design" . . . I admired your art of presentation, and in this case your article certainly satisfies the "Four C's": it is clear, concise, compact and convenient.

Faithfully yours,
D. B. STEINMAN,
Consulting Engineer.
New York, May 29, 1938.

To the Editor:

. . . You are to be congratulated upon the fine appearance of this magazine and the real expression it will be for your helpful articles . . .

With best personal wishes,
C. T. SCHWARZE,
Professor of Civil Engineering,
New York University.
New York, May 20, 1938.

FROM THE MAIL BAG

To the Editor:

Will you please put me on your mailing list so that I may receive a copy of NEWARK ENGINEERING NOTES? I am a student of Central High School and am anticipating attending your school. Thank you.

Sincerely yours,
NATHAN SABEL.
Newark, N. J., April 28, 1938.

To the Editor:

I would like to be included in your mailing list to receive copies of the NEWARK ENGINEERING NOTES. I have before me the May issue which I have found to be very interesting.

I wonder if it would be possible to secure the first number of this series. I wish to place the publication in the Engineering Library and would like to have a complete series.

Very truly yours,
M. L. ENGER,
Dean and Director, College of
Engineering, University of Illinois.
Urbana, Ill., May 23, 1938.

To the Editor:

. . . May this effort meet with the same success that has deservedly attended all the activities of your growing institution.

I note that Bob Van Houten is acting as business manager. Recalling my acquaintance with him during High School days, I know that you have enlisted splendid support.

Cordially yours,
E. J. CLEARY,
Assistant Editor, *Engineering News-Record.*
New York, N. Y., May 20, 1938.

To the Editor:

I shall be delighted to receive a copy of your NEWARK ENGINEERING NOTES regularly. This reception will be most helpful to our faculty and student body.

I wish that Manhattan College had a publication similar to yours so that we could exchange. A copy to me personally and a copy to our Student Library would be gratefully appreciated.

Wishing you continued success in your efforts, I am,

Sincerely yours,
BROTHER A. LEO, Dean,
School of Engineering,
Manhattan College.
New York, N. Y., May 23, 1938.

To the Editor:

. . . The first two numbers have contained some articles of interest particularly in regard to myself and also to my son who has planned to enter the Newark College of Engineering this fall.

It occurs to me that an article on fire protection and particularly some of the newer devices and systems, recently brought out by ourselves, might be of general interest to the recipients of your paper. If you agree with this, one of our engineers could supply such an article . . .

Very truly yours,
R. B. DICKSON,
Assistant General Sales Manager,
Pyrene Manufacturing Co.
Newark, N. J., May 20, 1938.

ABBEY PRINTING COMPANY, EAST ORANGE, N. J.


Mr
Mrs
and
Chesterfields
for a lifetime of
MORE PLEASURE
..better taste
..refreshing mildness
they Satisfy
Chesterfield
CIGARETTES
LIGGETT & MYERS TOBACCO CO.
CHESTERFIELD