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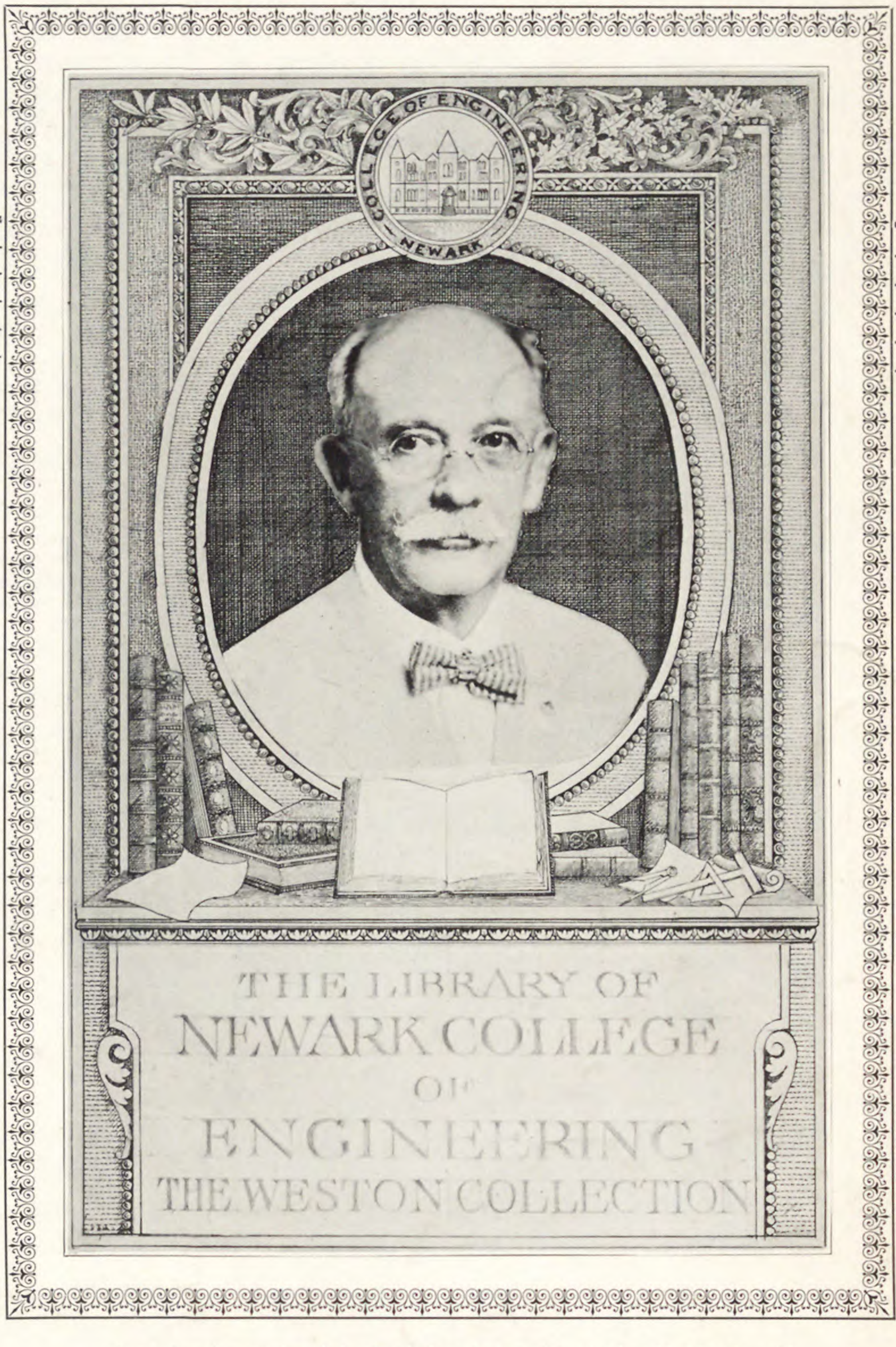

Reproduction of sketch for bookplate designed by Arthur N. MacDonald for collection of 12,000 volumes and 65,000 magazines and periodicals, which together with much scientific equipment and historical apparatus was bequeathed to the College by the late Dr. Weston.

THE PRESIDENT'S DIARY

November 11—Judicial Attitude

It was rather difficult in Convocation today to speak about any war either past, present, or future, and it seemed best to make a rather honest confession that I could not do it, and talk about something else. It does seem in the present crisis as if any individual expression of opinion was rather beside the question. The values at the base of our present trouble are so fundamental, so far-reaching and so emotional that I feel called upon to simply indicate that they require sober serious thought and that it would be perhaps better if we gave it this before we too freely express a superficial opinion based on part of the evidence.

When our sense of right and justice and fair play are all violated it is sometimes hard to prevent an emotional outburst, yet to do so probably does not help matters at all, and it is perhaps well for students to realize the necessity for a judicial attitude rather than the answering of an emotional outburst with another emotional outburst, not thought out and perhaps superficial.

November 21—Peace

In answer to my implied question under date of November 11, I find pinned in my diary a clipping, written by Mrs. M. Casewell Heine as an editorial for the *New Jersey Club Woman*, which puts the matter so directly, so sanely, and so conclusively that I am going to depart from my usual custom with this diary and quote it in full:

> *"When a Country-wench cannot get her Butter to come, she says, the Witch is in her Churn. We have been churning for Peace a great while, and 'twill not come; sure the Witch is in it."*
>
> Thus spoke John Selden three hundred or more years ago. Are our times also bewitched that Peace does not come? Through fear and greed and national ambitions? With these things we are familiar. But beyond these human qualities there is a factor hard to understand, something by which men are forced to act outside of their own wills—automatically—mysteriously. Is it witchcraft?
>
> There are times in history when an idea pulls upon masses of men as the moon pulls the sea. Caught, hurled in the turmoil, borne on by the depth and strength of unmeasured forces, the individual may be crushed, broken, destroyed, as the wave itself moves on, biting into the main land of old traditions, spending itself at last in the salt marshes of inertia.
>
> The control of such historic movements is not yet possible to human intelligence. Those of the past may be analyzed and explained; but to control flood tides in the mass action of mankind within the present day is an undertaking even now too elaborate for the human mind. Methods of coöperation to these ends are as yet imperfectly developed and inadequate—little Peter's finger upon the leak in the dyke. Peace is not a simple thing, simply achieved, by simple means. It is as involved as is the civilization of which it may be a quality. And we are constantly reminded, we daily boast, of the complexity, the intricacy, the interdependent needs, within the civilization in which we live.
>
> Too often are we tempted to see peace in one dimension—like a mural; too often as something we can mould with our own two hands—like a statue.
>
> "Thou shalt not make unto thee any graven image, or any likeness of any thing that is in heaven above, or that is in the earth beneath, or that is in the water under the earth: Thou shalt not bow down thyself to them nor serve them."
>
> It is easy to bend the knee to the image of peace. But the profound philosophy behind the commandment lies in the fact that when we over-simplify an idea which contains spiritual power; when we compress it within the meaning of a single word; encompass it by the lines of a pictured symbol — make an idol of it — we blot out the realities which it involves. This is a trick of the mind when spiritual significance is so great that it is beyond comprehension.
>
> "The heathen in his blindness bows down to wood and stone" and is forgiven. More sophisticated peoples, casting away their idols of wood and stone, with easy lip-service, worship WORDS — justice, democracy, brotherhood—while at the same time society is denying their reality as the cock crows thrice. Peace is such a word, such a reality. It has became a conviction, almost a dogma. We have the will—to—peace. What more do we need?
>
> Knowledge. We need knowledge of the world in all its infinite variety, where springs of action differ among different peoples; knowledge of conflicting human needs and finesse in their adjustment; knowledge of the facts behind peace and the bases upon which it rests, the conditions under which it may be brought about. We need technique in directing the energy of ideas. We need wisdom and patience in the strategy of peace, in the application of appropriate means to appropriate ends at appropriate times. We need a knowledge of history and of the significance of today's event. So much we need to know of the implications of peace that life seems short indeed, and the way long to its realization.
>
> *Milk-maid, do not faint with fear of the Witch of Ignorance who stands at your shoulder. In time, with patient effort, the world will be rid of her. Go on with your churning; for that is the way that butter is made.*

December 15th—Industrial Peace

I wish we might project this same idea with respect to peace into our own industrial disputes in this country. Full knowledge, tolerance, and charity, coupled with extreme tenacity and persistence, might work wonders in domestic as well as in foreign relations.

Through intimate contact with a great many thousand boys, it has occurred to me that every one of these fellows starts his professional labors with the idea of some time becoming a capitalist of sorts and that he has therefore the germ of both points of view, and in our courses and discussions here it is my hope that we have clarified his knowledge and somewhat directed his point of attack. It is the most important thing, perhaps, that any college can do.

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CONTENTS

THE PRESIDENT'S DIARY - - - - - - - 4

DUPLICATING THE CUBE BY RULE AND COMPASS - - 6
By James H. Fithian

ADDITIONS TO ELECTRICAL LABORATORY EQUIPMENT 7

ADDITIONS TO MECHANICAL LABORATORY EQUIPMENT 7

ALUMNI PROFESSIONALITIES - - - - - - 7

DEVELOPING LABORATORY EXPERIMENTS IN PHYSICS 8
By William Hazell

SHOP SURVEYING - - - - - - - - 9
By William S. La Londe

THE DESIGN OF REINFORCED CONCRETE BEAMS USING THE METHOD OF "CONTROLLED CONCRETE" - 10
By Odd Albert

WHAT OUR READERS SAY - - - - - - 13

IS THE DEAN IN? - - - - - - - 13

EVOLUTION OF THE ELECTRICAL COURSES - - - 13

FROM THE MAIL BAG - - - - - - - 13

THE STUDENT ENGINEERING SOCIETIES - - - 14

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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.

DUPLICATING THE CUBE BY RULE AND COMPASS

Remarkably Close Approximate Solution Analyzed

By JAMES H. FITHIAN, A.B., M.A.
Professor in Mathematics, Newark College of Engineering

The fascinating problems of "trisecting an angle" and "duplicating the cube" have puzzled thousands of minds thruout the ages. People still persist in occupying their spare time with these problems even though mathematical theory has proved that their solution is impossible.* The story of Mr. Arnold Stahel is one of the most interesting that has come to our attention.

Mr. Stahel, a native of Switzerland, is a machinist and toolmaker now residing in Newark. He has long been fond of geometrical problems, such as possible constructions with ruler and compass, and about five years ago he became interested in the problem of duplicating the cube, i. e. of constructing by ruler and compass the side of a cube whose volume shall be exactly twice the volume of a given cube. After working at it off and on for four years he finally believed he had solved the problem. He drew figure after figure and the measurements seemed to check; no matter what length he took for the edge of the original cube, the result, as closely as he could calculate, was always a cube of double volume. Had he really accomplished what was claimed to be impossible? He kept drawing more figures, and when he would run out of notepaper there was an old roll of wallpaper that he had discovered in the attic. He would sit up until one and two o'clock in the morning, and the next day he was at it again, often going without breakfast. (His wife was away from home, he tells us, or she would never have permitted such "foolishness".) The whole thing was beginning to tell on his nerves, until fiinally he decided to consult someone who could tell whether he had indeed solved this reputedly impossible problem. It was for this purpose that he happened to call on our mathematics department and show us the following solution.

Let AO equal an edge and let APYO represent one face of the original cube.

Draw the diagonal PO, and extending the line AO, take AC=PO. Construct the rectangle ACEB with side AB=AO, and draw BC, the diagonal of this rectangle. Now from O draw a line perpendicular to BC and meeting BC in D. Also extend the line PO to meet BC in K.

Through D draw a line parallel to AC and through K draw one parallel to CE. Let L be the intersection of these two lines. Then with OL as radius and O as center describe an arc, cutting AC at M. AM is the length of an edge of the required cube.

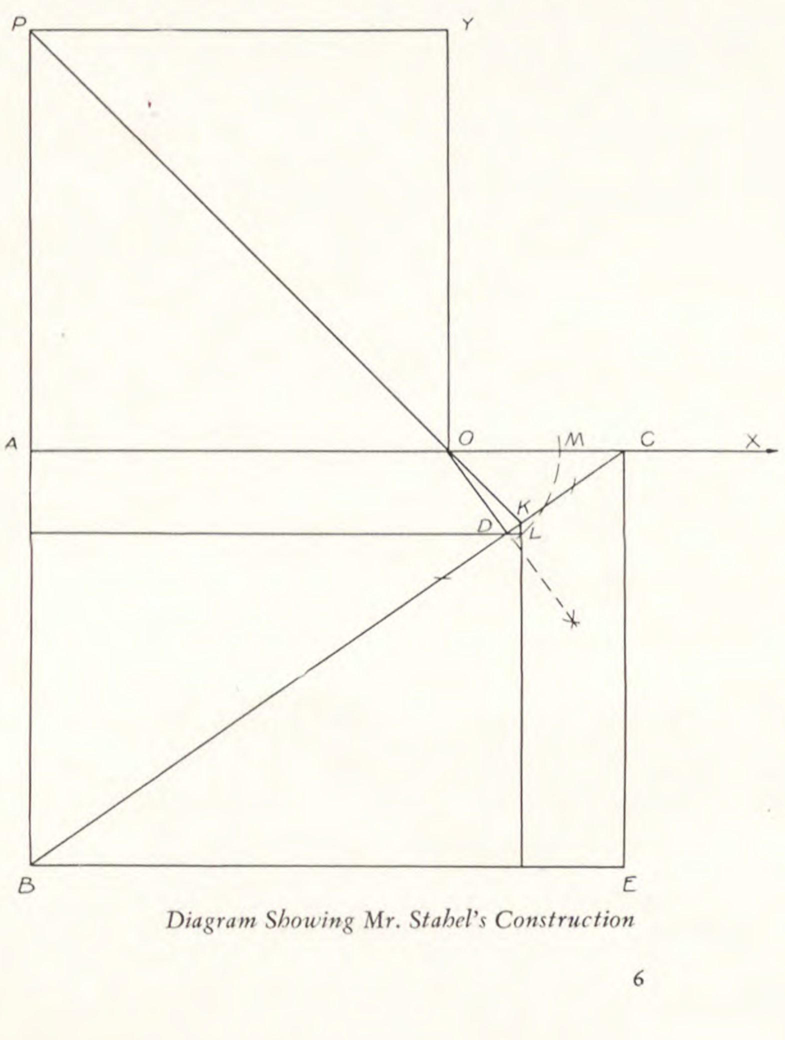


Diagram Showing Mr. Stahel's Construction

Anyone who has studied analytical geometry should have no difficulty in following our analysis of Mr. Stahel's solution, which while employing only the ruler and compass methods allowed in the classical problem, is yet an approximation, although an extremely close one, to the exact duplication known by mathematical reasoning to be impossible. Indeed the remarkable fact is that the edge of the cube found by Mr. Stahel differs from that of a cube of exactly double volume by only about one part in a hundred thousand!

Referring to the figure let OX and OY be the coördinate axes and choose the scale so that the distance AO=1 unit.

The equation of the line OK is $y = -x$.

Since AC is taken equal to the diagonal OP, its length is $\sqrt{2}$ units. The coördinates of C are $(\sqrt{2}-1, O)$, and to find the equation of the line BC we substitute in the type form $y-y_1=m(x-x_1)$.

Here (x_1, y_1) is the point C and m is the slope, which is $1/\sqrt{2}$; hence the equation of BC is $y-o=\frac{1}{\sqrt{2}}(x-\sqrt{2}+1)$, or $x-\sqrt{2}\,y=\sqrt{2}-1$.

Since OD is drawn perpendicular to BC, its slope is the negative reciprocal of the slope of BC, and hence the equation of OD is $y=-\sqrt{2}\,x$.

To find the x-coördinate of D we have, solving the equations of OD and BC simultaneously, $x - \sqrt{2}\,(-\sqrt{2}\,x) = \sqrt{2}-1$, or $x=\frac{\sqrt{2}-1}{3}$

From $y = -\sqrt{2}\,x$, the y-coördinate of D is $-\sqrt{2}\left(\frac{\sqrt{2}-1}{3}\right) = \frac{\sqrt{2}-2}{3}$

To find K, solve $y=-x$ with $x-\sqrt{2}\,y$

$=\sqrt{2}-1$, giving $x = \dfrac{\sqrt{2}-1}{\sqrt{2}+1}$, which equals $3-2\sqrt{2}$ when we rationalize the denominator.

Hence the point L, having the same x-coördinate as K and the same y-coördinate as D, is $\left(3-2\sqrt{2}, \dfrac{\sqrt{2}-2}{3}\right)$

The distance from O to L is

$$\sqrt{\left(3-2\sqrt{2}\right)^2 + \left(\frac{\sqrt{2}-2}{3}\right)^2}$$

$$= \frac{1}{3}\sqrt{159-112\sqrt{2}},$$

and since OM was taken equal to OL, the above value added to 1 gives the distance AM. Thus the length of the edge of Mr. Stahel's cube is $1+\frac{1}{3}\sqrt{159-112\sqrt{2}}$ instead of the desired value, $\sqrt[3]{2}$.

To compare these two quantities, we first find $\sqrt{2}$ to nine decimal places, which is 1.414213562. Multiplying by 112, we have $112\sqrt{2}=158.391918944$. (Ordinary log tables are not sufficient for the required accuracy, so we resort to the methods of longhand arithmetic.) Subtracting the above value from 159 gives .608081056. Then we extract the square root of this number and obtain .779795522, which divided by 3 gives .259931841. Adding 1 we have 1.259931841 for Mr. Stahel's value. Now the value of $\sqrt[3]{2}$ as given by cube root tables is 1.259921. Comparing this with 1.259932 (the above rounded off to six decimals) we have a difference of 11 in 1259921, or roughly one part in a hundred thousand. It can be shown by the methods of calculus that the percentage error in the calculated cube of a number is three times the percentage error in the number itself. Hence the volume is in error by about three parts in a hundred thousand.

Editor's Note: Professor James H. Fithian received his bachelor's degree from Lafayette College in 1920, and also holds master's degrees from Brown and Princeton Universities. He taught mathematics at Lafayette, Brown, and Yale, and came to the Newark College of Engineering in 1929. Since 1936 he has been Head of the Mathematics Department.

ADDITIONS TO ELECTRICAL LABORATORY EQUIPMENT

as reported by

PROFESSOR P. C. SHEDD

The installation of a new plug-and-jack system for making rapid connections to electric machines and other equipment in the electrical engineering laboratories of the Newark College of Engineering is now nearly complete. The laboratories have been completely rewired, to supply the increase in load capacity and additional stations required. All stations now consist of enclosed boxes, with the new jacks mounted on the front in bakelite. Two sizes of jacks are used of about 50 amperes and 200 amperes maximum capacity respectively, with small auxiliary jacks for voltmeter connections. New leads with proper plug terminals to fit into the new system have been acquired, so that no tools or thumb screws will be needed to make any connection.

There has resulted a considerable improvement in the appearance of the laboratory, and an appreciable increase in the rapidity with which the students can make connections. An important decrease in the number of incorrect connections made, and improvement in the attitude of the students toward the work have also been noted.

The laboratories have recently acquired a new double-unit generator set. It consists of a General Electric Type A.H.I. 5-kva a-c generator, for one-, three-, and six-phase operation, rated at 110/220 volts, 1200 rpm, directly coupled to a General Electric Type CD73 5-kw compound d-c generator, rated at 240/250 volts, 1200 rpm.

The machines are set up in such a way that either can be used as a motor to drive the other, or the a-c machine can be coupled to separate a-c or d-c motors, and the d-c machine to either synchronous or asynchronous a-c motors. This permits sufficient flexibility for a large number of experiments, and increases the facilities of the laboratories for handling larger numbers of students simultaneously.

ADDITIONS TO MECHANICAL LABORATORY EQUIPMENT

as reported by

PROFESSOR H. E. WALTER

Most Mechanical Engineering Laboratories throughout the country either have felt or are feeling the need of equipment capable of measuring the power output of the modern high-speed Internal Combustion Engines. It is, therefore, with considerable pleasure that we announce our transfer into the "have felt" group for we are now busy with the installation of test equipment which is thoroughly modern in every way.

The equipment is an Electrical Dynamometer built by the General Electric Company. The apparatus is capable of absorbing 125 horsepower at speeds up to 6,000 revolutions per minute acting as a generator. In this type of operation the energy output of the generator is dissipated by means of a grid-resistance bank. The unit can thus absorb the output of prime movers such as gas engines, motors, etc.

In addition the unit can be operated as a direct current electric motor and as such can drive pumps, fans, air compressors, etc. Operated as a motor the equipment will deliver as much as 75 horsepower in a speed range between 2,000 and 6,000 revolutions per minute, and a lower speed correspondingly less. Now for both types of operation the torque developed can be directly measured and through this the shaft horsepower is readily calculated.

The control panel permits a wide range of load and speed adjustment and at the same time is designed to provide maximum protection for operator, dynamometer, and equipment under test. The last is a significant consideration since the apparatus was purchased primarily for student use.

We are fortunate, indeed, to possess such a thoroughly modern piece of equipment, as the apparatus will readily handle practically any type of present automotive engine and in addition has the capacity to keep pace with reasonable future developments in this type of prime mover.

ALUMNI PROFESSIONALITIES

Miss Edythe R. Raabe, Class of '30, has been with the American Telephone and Telegraph Company in New York in the Long Lines Department since her graduation. Her work as a member of the Personnel Group has been concerned primarily with assisting the Supervisor of Instruction in the preparation of employee training text material and the various studies associated with personnel work. She has worked on special articles of employee interest for the monthly company publication, *Long Lines*, and contributed the section on "The Chemical Engineer in *Careers for Women* by Catherine Filene, published in 1934 by the Riverside Press, Cambridge, Massachusetts.

Rudolph Chelborg, Class of '34, has been with the Linde Air Products Company, a unit of Union Carbide & Chemical Corporation, for the past two years, as a member of the technical staff in the Engineering Developments Laboratories. His work, in general, includes the design and development of automatic machinery for oxy-acetylene cutting and welding processes. He is Stress Analyst for the Laboratories and editor of technical reports covering the development and application of oxy-acetylene apparatus and processes to steel and allied industries.

Marshall J. Breen is a Patent Attorney for the Singer Manufacturing Company in Elizabethport, N. J. Mr. Breen entered the employ of the Singer Manufacturing Company in 1931 as a co-operative student in their tool-room apprentice training course. Shortly after his graduation in Mechanical Engineering in 1933 he entered the Patent Department and attended Patent Law courses in Brooklyn Law School. He passed the examination given by U. S. Patent Office in May, 1937.

*See Dickson "First Course in the Theory of Equations."

DEVELOPING LABORATORY EXPERIMENTS IN PHYSICS

By William Hazell, Jr., B.S.
Instructor in Physics, Newark College of Engineering

Some laboratory courses hold that the purpose of an experiment is the proof of a particular law or principle, or say that demonstration of a certain phenomena is the only requisite and that the means by which this proof is established is of little importance. To this end, much complicated apparatus has been designed, sold, and installed in college and high school laboratories. Ornateness and gadgets that impress and bewilder seem to be an asset in making laboratory equipment.

The inevitable result of such a process is that the student cannot see the "forest for the trees." He undoubtedly must acknowledge that the proof is just, but often the method is obscured by the apparatus. True, he will have obtained measurements, from which certain computations will be made and so establish his proof that g = 32.2 feet per second each second, but the device or the assembled components by which he obtained those measurements may be a box of mysteries.

For an example, there is a classical experiment for demonstrating the pole position in a bar magnet and the distribution of the field about the magnet. Data is obtained by measuring the deflection of a galvanometer, which is connected to a coil that is moved across the magnet. Deflection is plotted against coil position and a nice curve is the result. The mean abscissae measured in either direction from the zero deflection point gives the pole position. The student has no difficulty in performing the experiment and getting the results, but the device by which he got his measurements is of no meaning to him. He little understands the principle of induced voltage at that part of the course, and the galvanometer is still more of a mystery.

For years the theory of the compound pendulum has been demonstrated in the laboratory by Kater's Pendulum. This pendulum is a long bar with two swinging points and a movable mass at the center. It is timed by a sounder connected to a mercury cup through which a needle fastened to the pendulum swings. When the movable mass has been so adjusted that the pendulum has the same period at both points of swing the period is recorded and from this, and the standard equation of the pendulum, the student is enlightened by the fact that g = 980.62, which he probably already knows. Does he recognize that he has been altering the moment of inertia of the bar, or the reason for having the two periods the same? It is extremely doubtful.

In contrast to this, suppose the student were given a rectangular board (cut from 1" by 6" lumber) about 90 cm. long, and a meter stick. On the board there has been designated a point for the center of oscillation, about which the board is to swing as a pendulum. By the definition of a "simple" pendulum this must be a compound pendulum. In lecture and class the proof of the equation for the period of a compound pendulum has shown that

$$T = 2\sqrt{\frac{I}{mgh}}$$

With the compound pendulum at hand the moment of inertia can be readily computed on the basis of its area, since it is assumed to be of uniform thickness and homogeneous. From this then the period is computed to three significant figures.

A nail is driven through the board at the point of oscillation and the period is timed to three significant figures. The two periods, computed and actual, will check within one per cent.

With this completed, a second pendulum similar to the first but with some rectangular sections removed, is put through the same process.

The experiment is obvious in its intent. The equipment is so simple that no confusion may arise. The objective, the means, and the result are clearly established in the student's mind. This experiment has been used for several years in the Physics Laboratory and has proved to be most successful.

A successful experiment may well be defined as one whose ultimate result is unknown to the student; the procedure is new and novel, and one that fills the students' time; the elements of the experiment must have some familiarity; the objective must not be clouded by the procedure. It must be remembered that in speaking of "experiments," reference is being made to those "laboratory exercises" which are essential to an undergraduate Physics Course.

Most students that have taken Physics remember the struggle surrounding that famous basic equation:

f = ma

Many examples can be given to establish this and give satisfactory proofs, but there are few experiments given that use simple elements to show that the law is true.

An experiment has been developed in the Department of Physics to show that f = ma. It is believed that the experiment is within the specifications of a successful experiment.

The equipment consists of a flat board, a car, a weight, two magnets, a meter stick, and a steel ball.

The time interval allowable for the length of run permissible was so short that simple timing devices were unsuited. In this experiment the time of fall of a ball through a given distance is used to time the run of the car. A key releases car and ball from their holding magnets by opening a common circuit, and the finish of the run of the car and the fall of the ball are coördinated by eye and ear. Trial and error and a series of runs bring sufficiently precise results.

The car is first accelerated by a weight connected to the car by a string over a pulley. Trials are made to determine the distance run by the car while the ball drops 150 centimeters.

A second test is made with the accelerating force a component of the weight of the car obtained by elevating one end of the board until the same acceleration has been obtained as was had previously. The component of the weight is then shown to be equal to the accelerating force in the first test.

The retarding effect of friction, both static and kinetic, is determined by using small weights to pull the car, and by also determining the "limiting angles" to which the board may be elevated.

Work is in progress on a simple accelerometer that may be used to measure acceleration directly. This will be used as a check on the experimental results.

Here again is an experiment in which the elements of the equipment and procedure are understandable and bear a significance to the student.

The use of these experiments has led to the belief that if the student is enabled to build the proof of a law from simple, understandable elements, then the proof will be clearly established and the worth of the experiment will be admitted by the student.

These two examples are perhaps not as impressive as "experiments" as some in which the student follows directions carefully and is pleased because he handles

(Continued next page)

SHOP SURVEYING

By WILLIAM S. LA LONDE, JR., S.B., M.S.
Associate Professor of Civil Engineering, Newark College of Engineering

The traditional course in surveying for civil engineering students is a training along the lines of the land surveyor with instruction in plane, topographical, and route surveys, with only an occasional emphasis on the staking out of work from plans such as one would find on construction projects. The non-civil student, if he takes surveying, as a rule follows along the same pattern as the civil student, the only difference being that the various specialties are curtailed, the amount depending upon the total time allotted to the course. The part usually left in the short course is the topographical work, which is the least useful to the non-civil engineering student. For the same reason that the civil student doesn't enjoy work in the chemical, electrical, and mechanical laboratories, the non-civils feel out of place "in the field."

To overcome this prejudice, to stimulate interest, and to give the non-civils practise in the type of survey work that will be of the most benefit to them later on, the Newark College of Engineering has set up a course in Shop Surveying. This brings the survey work into the electrical, mechanical, and chemical laboratories, and makes it possible to give the instruction in the day or evening, as the case may be, without dependence upon good weather.

Very little formal instruction is given. Probably an hour of lecture on both the engineer's level and the engineer's transit is sufficient. One or two preliminary exercises are required in the use of the level and transit, and in learning how to tape and measure distances correctly. Emphasis is placed upon how to use the instruments correctly in order to eliminate errors in non-adjustment rather than upon how to adjust them. The students are encouraged to use chalk lines freely so as to help them to visualize their working lines. They learn to work with coördinates. Fully as many positions are established with the transits by "jigging" into line between two points or by getting parallel to something as are directly set or occupied. Blunders are eliminated as far as possible by rough checks for reasonableness of the work, and extra measurements and checks are brought into the work to insure the proper degree of accuracy.

At first the students are told to set up the transit at a given point, and each step and procedure is as directed by the instructor in the same manner as a chief of party in actual practise would direct the men under him to perform certain operations. Because of the comparative "nearness" of the various parties, one instructor usually "manages" three parties of three to four men each. At the proper time, certain fundamental principles and practises are pointed out and explained to the students, but the students are encouraged to observe closely the procedure used by the instructor and to reason out the why of it for themselves. After a few exercises, the amount of "management" by the instructor is lessened and his "orders" are given to the man acting as chief of party for the day.

To give a little idea of the nature of the problems in the course one or two typical ones will be described. It is assumed that a second machine like one of the machines in the laboratory has been ordered for delivery and it is necessary to prepare a foundation upon which to place the new machine. The first step is to make an anchor bolt plan. Here the student "frames" the existing machine with a rectangle of offset lines made parallel with, and any convenient distance from, the center-line of shaft or steam cylinders and with lines at right angles to the first ones. Now the right angle distances from the center of the anchor bolts to these offset lines are measured, and from these data a plan of the anchor bolts is made, showing their relationship or distance from the center-line of shaft, etc. Next, the position of the new machine is decided upon and the students lay the work out on the floor with chalk and line, placing the center-lines of shaft and cylinders or ends of shafts to the position planned, and locate the anchor bolts and form lines for concrete. Vertical control is also established by using the transit or level.

To facilitate the work between the several buildings and floors of the same building, a system of coördinates was adopted so that the entire college plant would lie in one quadrant.

This horizontal control is carried from one floor to the next and from one building to another, forming a series of interesting problems in this transfer of coördinates itself. The levels are carried by the usual procedure or by means of a tape stretched vertically. Here the student has need for negative rod readings and soon finds that he is able to handle them as easily as an inverted image in his telescope. If it is desired to connect a machine in one building with the water and steam supply mains in another building, or even in the same or another room, the coördinates of the flanges on the mains and on the machines are determined as well as those of any pipes, ducts, or utilities to be avoided. Three dimension oblique sketches are drawn, and when the proposed connecting lines are shown to clear existing facilities, the students then lay out on the walls and floors with chalk the outlines of the holes to be cut through the walls and floors.

This matter of laying out the work with chalk and visualizing the layout cannot be emphasized too much. The author has seen many young college graduates who, when asked to lay out simple construction work, haven't had the faintest idea of where to start, and if and when they do get the work laid out they have no confidence in what they have done even though it may be correct. It would seem that to measure or map existing work was not enough, but that it should be followed with some laying out of work as well. For this reason the civil engineering students receive a certain amount of Shop Surveying along with their other surveying field work. It is not our purpose to make surveyors of our students, but rather to give them a little knowledge of the surveyor's equipment and methods, so that they will later be able to execute the necessary full-scale layout work for the satisfactory solution of problems as they may arise in the shop or in the laboratory.

Editor's Note: Professor La Londe was a native of Chicago and received his undergraduate training in Civil Engineering at Northwestern University and the Massachusetts Institute of Technology and his graduate training leading to a Master of Science in Civil Engineering at the University of Michigan. 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.

(Continued from previous page)

complicated "scientific equipment." Nevertheless, these experiments keep the student interested in the experiment and not the equipment.

The ideal experiment must work in the converse of the old story of the three stone masons. The first stone mason was laying stone; the second, building a wall; and the third, building a cathedral. In the language of the ideal experiment, to build a cathedral a wall must be built. To build the wall a stone must be laid, and too often that is a sadly forgotten but vital point.

THE DESIGN OF REINFORCED CONCRETE BEAMS USING THE METHOD OF "CONTROLLED CONCRETE"

By ODD ALBERT, C.E., M.S.
Assistant Professor in Structural Engineering, Newark College of Engineering

The new Building Code of 1936 has a provision in it that in the design of reinforced concrete beams, the allowable concrete stress to use may be established by tests—designated as the "Controlled Concrete" method.

The Code states that the allowable unit stress (f_c) in extreme fiber in compression shall be

a/ for positive moment $f_c = 0.40 f'_c$ ....(1)
b/ for negative moment $f_c = 0.45 f'_c$ ....(2)

and that the value of (n) shall be determined by the formula

$$n = 30{,}000 / f'_c \qquad (3)$$

where f'_c represents the value found from tests carried out in accordance with the "Standard Method of Making Compression Tests of Concrete." (A.S.T.M. Serial Designation: C 39:33).

By using the "Controlled Concrete" method the designer will find himself dealing with stresses not to be found in ordinary tables, as can be seen by example 1, in which the concrete stress to use in compression is found to be 880 p.s.i., and the value of (n) is 13.64.

The new Code specifies as a rule an allowable steel tension stress of 20,000 p.s.i.

It is assumed that the reader has a working knowledge of the theories involved in reinforced concrete design. Reference is also made to the articles by this writer in *Civil Engineering* for April, 1931, *Engineering News-Record* for June 16, 1932, NEWARK ENGINEERING NOTES for May, 1938, and *Concrete* for June, and July, 1938, dealing with short-cut methods in reinforced concrete design.

The Position of the Neutral Axis

We have

$$k = \frac{nf_c}{nf_c + f_s} \qquad (4)$$

For the condition that $f_c = 0.40\ f_c$, we find that

$$nf_c = 12{,}000 \qquad (5)$$

so

$$k = \frac{12{,}000}{12{,}000 + 20{,}000} = 0.375 \qquad (6)$$

For the condition that $f_c = 0.45\ f'_c$, we find that

$$nf_c = 13{,}500 \qquad (7)$$

so

$$k = \frac{13{,}500}{13{,}500 + 20{,}000} = 0.403 \qquad (8)$$

Thus it will be noted that for fixed ratios of f_c/f'_c the value of (k) is constant for various concrete stresses, and that we need to consider only two values of (k), k = 0.375 and k = 0.403.

Tension Steel Only

Tension steel only is required, when the effective depth is equal to or less than

$$d = \sqrt{\frac{M}{K\,b}} \qquad (9)$$

when the tension steel (A_s) is obtained from the following formula:

$$A_s = \frac{M}{f_s\, j\, d} \qquad (10)$$

where the constants (K) and (j) can be found in table 1, and M is the moment in inch-pounds.

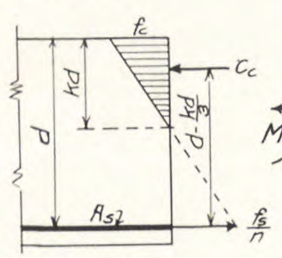


Fig. 1a

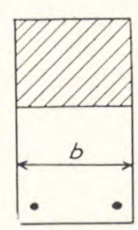


Fig. 1b

Tension and Compression Steel

If a certain maximum depth is specified, and formula (9) gives a value of (d) larger than this maximum depth, then compression steel is required, unless the beam can be made wider.

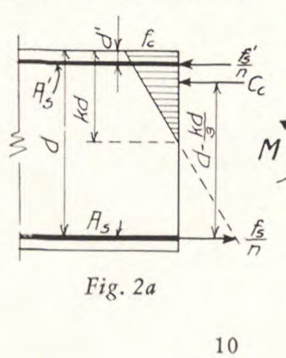


Fig. 2a

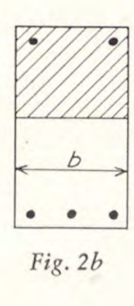


Fig. 2b

A study of figure 2a will give for the tension steel area a moment equation around the compression steel area.

$$A_s f_s (d - d') - \frac{f_c\, b\, kd}{2}\left(\frac{kd}{3} - d'\right) = M \qquad (11)$$

or

$$A_s = \frac{M + \frac{f_c\, b\, kd}{2}\left(\frac{kd}{3} - d'\right)}{f_s (d - d')} \qquad (12)$$

and a moment equation around the tension steel will give the compression steel area.

$$A_s' f_s' (d - d') + \frac{f_c\, b\, kd}{2}\left(d - \frac{kd}{3}\right) = M \qquad (13)$$

or

$$A_s' = \frac{M - \frac{f_c\, b\, kd}{2}\left(d - \frac{kd}{3}\right)}{f_s'(d - d')} \qquad (14)$$

Further similar triangles give

$$nf_c / f_s' = kd / (kd - d') \qquad (15)$$

so the compression stress in the compression reinforcement becomes

$$f_s' = \frac{nf_c (kd - d')}{kd} \qquad (16)$$

So far these formulas are general, and as there are no approximations made, they are mathematically correct. They also give the steel areas directly and quickly. They are easy to use, and it is only for the designer to introduce his values for M, f_s, f_c, k, b, d, and d'. Note that M is the moment in inch-pounds.

The "Easy Formulas"

By the use of the "Easy Formulas" as given in the NEWARK ENGINEERING NOTES for May, 1938, we had the tension steel area

$$A_s = A_x - A_s' z \qquad (17)$$

and the compression steel area

$$A_s' = K_3 (A_x - p\, bd) \qquad (18)$$

with

$$A_x = \frac{M'}{K_2\, d} \qquad (19)$$

where in all instances M' is the moment in foot-pounds, and the constants K_2, K_3, p,

Table 1. The constants for the "Easy Formulas" to be used in reinforced concrete beam and column design, when the "Controlled Concrete" method is adapted. $f_s = 20{,}000$ p.s.i.

	$nf_c = 12{,}000$ or $f_c = 0.40f'_c$		$nf_c = 13{,}500$ or $f_c = 0.45f'_c$	
d'/d	K_3	z	K_3	z
0.24	5.3301	—0.0284	4.1724	—0.0333
0.22	4.5233	—0.0269	3.6211	—0.0303
0.20	3.9063	—0.0241	3.1862	—0.0258
0.18	3.4201	—0.0196	2.8265	—0.0197
0.16	3.0281	—0.0138	2.5321	—0.0121
0.14	2.7059	—0.0064	2.2852	—0.0029
0.12	2.4371	0.0023	2.0754	0.0078
0.10	2.2096	0.0126	1.8953	0.0201
0.08	2.0150	0.0243	1.7393	0.0340
0.06	1.8469	0.0374	1.6024	0.0493
0.00	1.4583	0.0858	1.2825	0.1047
K	$0.16406\, f_c$		$0.17445\, f_c$	
K_1	$\sqrt{73/f_c}$		$\sqrt{69/f_c}$	
K_2	1458.33		1442.79	
p	$0.000009375\, f_c$		$0.000010075\, f_c$	
j	0.875		0.866	

Important Note: For values of (z) put in actual signs. If table gives minus, it thus will be an addition, and if table gives plus, it will be subtraction.

and z can be found in the accompanying table 1.

The Constants to Use for the New Code

The constants are more easily figured for "controlled concrete," because there are only two values of (k), either $k = 0.375$ for $nf_c = 12{,}000$ (or $f_c = 0.40\, f'_c$) and $k = 0.403$ for $nf_c = 13{,}500$ (or $f_c = 0.45\, f'_c$). Table 1 will give necessary values.

Example 1. A reinforced concrete beam, 12 x 22 inches, is subject to a positive bending moment of 760,000 inch-pounds. Find the reinforcement, if $f_c' = 2{,}200$ p.s.i., $f_s = 20{,}000$ p.s.i., $d' = 2$ inches, and $d = 20$ inches.

In accordance with (1) we get

$f_c = 0.40 \times 2{,}200 = 880$ p.s.i.

and the position of the neutral axis is fixed by (6), or $k = 0.375$, so

$kd = 0.375 \times 20 = 7.5$ inches

Therefore the compression steel stress is figured by (16). We get

$$f_s' = \frac{12{,}000(7.5-2)}{7.5} = 8{,}800 \text{ p.s.i.,}$$

so the tension steel area will be, by the use of (12)

$$A_s = \frac{760{,}000 + \frac{880 \times 12 \times 7.5}{2}\left(\frac{7.5}{3} - 2\right)}{20{,}000(20-2)}$$

$= 2.165$ s.i.

and the compression steel area becomes by the use of (14)

$$A_s' = \frac{760{,}000 - \frac{880 \times 12 \times 7.5}{2}\left(20 - \frac{7.5}{3}\right)}{8{,}800(20-2)}$$

$= 0.423$ s.i.

Using the "Easy Formulas" as given in Newark Engineering Notes for May, 1938, and tabulated values from table 1, we pick out for $d'/d = 0.10$, $nf_c = 12{,}000$, $K_2 = 1458.3$, $K_3 = 2.210$, and $z = 0.0126$ and figure

$p = 0.000009375 \times 880 = 0.00825$

Hence

$$A_x = \frac{769{,}000}{12 \times 1458.3 \times 20} = 2.172 \text{ s.i.}$$

$A_s' = 2.210(2.172 - 0.00825 \times 12 \times 20) = 0.424$ s.i.

so

$A_s = 2.172 - 0.424 \times 0.0126 = 2.167$ s.i.

Thus two different methods, not yet published in any textbooks, have been shown to give the same results. If no compression steel is required, A_s' becomes negative.

The Steel Ratios p and p'

By introducing the relations

$A_s = p\, b\, d$ .... (20)

$A_s' = p'\, b\, d$ .... (21)

into the expressions (12) and (14) we obtain the general formulas for the steel ratios. Hence

$$p = \frac{\frac{M}{b d^2} + \frac{f_c k}{2}\left(\frac{k}{3} - \frac{d'}{d}\right)}{f_s\left(1 - \frac{d'}{d}\right)} \quad (22)$$

$$p' = \frac{\frac{M}{b d^2} - \frac{f_c k}{2}\left(1 - \frac{k}{3}\right)}{f_s'\left(1 - \frac{d'}{d}\right)} \quad (23)$$

These formulas are also mathematically correct, as there are no approximations made, and (M) is the moment in inch-pounds.

The Plotting of the Chart

By introducing known values of f_s, k, and d'/d, and changing the moment to foot-pounds ($M = 12M'$), these formulas can be simplified considerably. For the plotting of this chart, assume $f_s = 20{,}000$ p.s.i., $nf_c = 12{,}000$ [as per (1) and (5)], and $d'/d = 0.10$. Then formula (16) gives the compression steel stress: Hence

$$f_s' = \frac{12{,}000(0.375 - 0.10)}{0.375}$$

$= 8{,}800$ p.s.i. .... (24)

so expressions (22) and (23) become

$$1{,}500\, p = \frac{M'}{b d^2} + 0.000391\, f_c \quad (25)$$

$$660\, p' = \frac{M'}{b d^2} - 0.0137\, f_c \quad (26)$$

For other values of f_s, or nf_c, or d'/d, similar expressions are easily obtained. The expressions (25) and (26) represent straight lines for fixed values of f_c. Thus, for instance, for $f_c = 800$, we get

$$1{,}500\, p = \frac{M'}{b d^2} + 0.3125 \quad (27)$$

$$660\, p' = \frac{M'}{b d^2} - 10.9375 \quad (28)$$

By use of a double chart, with the middle axis representing M'/bd^2, the minus x-axis representing the p ratio, and the plus x-axis representing the p' ratio, these lines are easily plotted.

The Compression Steel Ratio p'

Using formula (28) we get for $p' = 0$, that $M'/bd^2 = 10.94$, and for $M'/bd^2 = 20.0$, that $p' = 0.0137$. These two points connected will locate the line represented by $f_c = 800$.

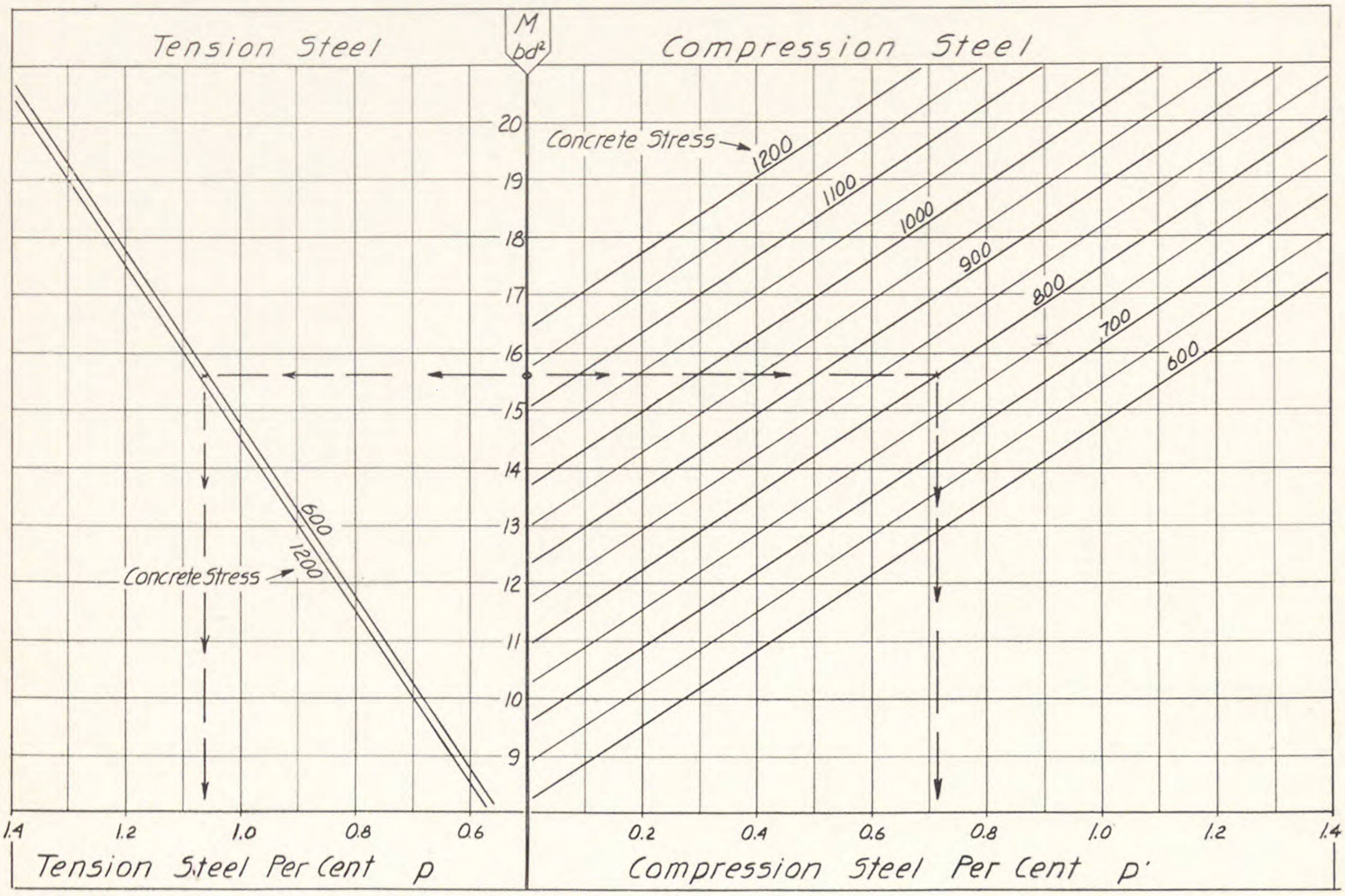
The Tension Steel Per Cent p

Using formula (27), we get for $p = 0$, that $M'/bd^2 = -0.3125$, and for $M'/bd^2 = 20.0$, that $p = 0.0135$. These two points connected will locate the line representing $f_c = 800$ p.s.i.

Similarly the other concrete stresses have been plotted.

Chart 1. Reinforced Concrete Beam with Compression and Tension Steel

f_s=20,000 p.s.i; nf_c=12,000; k=0.375; d'/d=0.10; and f_s'=8,800 p.s.i.



General Information

The chart contains only straight parallel lines, and covers all values of the concrete stresses under the conditions given. It will be noted that k=0.375 and f_s'=8,800 p.s.i. for all stresses of concrete.

The value of (n) is in reverse ratio to the concrete stress f_c, thus for

f_c= 600, n=20
f_c= 700, n=17.14
f_c= 800, n=15
f_c= 900, n=13.33
f_c= 1,000, n=12
f_c= 1,100, n=10.91
f_c= 1,200, n=10

No approximations have been made, so the chart is mathematically correct.

For the tension steel per cent two lines only have been drawn, one for f_c=600, and one for f_c=1,200. That these lines are so close together indicates that a change in the concrete stress has very little effect upon the tension steel per cent.

Values to Be Used

In the chart the following values must be used only:

M'=bending moment in foot-pounds
b=width of beam in inches
d=effective depth in inches
A_s=tension steel area in square inches
A_s'=compression steel area in square inches

Tension Steel .... A_s=p b d
Compression Steel .... A_s'=p' b d

Note that the percentages p or p' should be changed to actual numerical values in above formulas.

Example 2. A beam 12 x 22 takes a moment of 75,000 foot-pounds. If f_s=20,000 p.s.i., f_c= 800 p.s.i., and d'=2 inches, find the reinforcements.

We find d'/d=0.10. This corresponds with the chart, so we figure

$$\frac{M'}{b\,d^2} = \frac{75{,}000}{12 \times 400} = 15.63$$

Entering the chart for this value at the middle axis (see dotted lines)

1/ we go left, and turn down for f_c=800, and read p=1.06, so

A_s=0.0106x12x20=2.54 square inches

2/ we go right, and turn down for f_c= 800, and read p'=0.71, so

A_s'=0.0071x12x20=1.70 square inches

Tension Steel Only

If only tension steel shall be utilized, then the chart can be used to determine either the width for a given depth, or the effective depth for a given width, as has been shown by the following example.

Example 3. A 12-inch-wide beam takes a moment of 75,000 foot-pounds. If f_s=20,000 p.s.i., f_c=800 p.s.i., find the reinforcement for balanced design as well as the effective depth. (Balanced design has tension steel only, thus p'=0.)

For p'=0 and f_c=800, we read M'/bd^2 =10.9. Therefore the effective depth is figured from the relation

$$\frac{75{,}000}{12 \times d^2} = 10.9$$

or d = 23.9 inches

In order to find the tension reinforcement, use the chart for the value of M'/bd^2=10.9, go left, turn down for f_c=800, and read p=0.75. Therefore

A_s=0.0075x12x23.9=2.15 sq. in.

WHAT OUR READERS SAY

IS THE DEAN IN?

This article by our Dean and Associate Professor James A. Bradley in the October issue of the NEWARK ENGINEERING NOTES has aroused many favorable comments. Some of the letters received pertaining to his article follow:

Dean J. A. Bradley
Newark College of Engineering
Newark, N. J.

Dear Sir:

It seems our paths crossed at Indian Head, although I confess I don't remember you. Perhaps you arrived after my transfer in October, 1918, to the Naval Ordnance Plant at South Charleston, West Virginia. Perhaps my memory is poor; I was at Indian Head only three months—on black powder, ammonium picrate, phenol, sodium nitrate, cotton, sulfur, mineral oils—in a lab with Carl May of California. It all seems far away, influenza epidemic and niter bag fire the high spots.

However, I think I remember the man to whom you refer in your article. At least I knew very intimately one who fits your description. Still voluble, still doing unimportant work in the selling field, still "not exactly down and out." But I am not sure I agree as to the reasons for his failure. At that, we may not be thinking of the same man.

I've stayed in the chemical field throughout, operating this business for 16 of the past 20 years. One of my people here is one of your graduates, I believe.

It is nice to know that one of the Indian Head chemists is Dean and Associate Professor in Chemistry at Newark College of Engineering. My congratulations.

Sincerely,
EDGAR S. GENSTEIN, *President*,
Kem Products Company.

Newark, N. J., October 22, 1938.

To the Editor:

We are wondering if we may have permission to reprint "Is the Dean in?" by James A. Bradley, A.B., A.M., from your October, 1938, issue of NEWARK ENGINEERING NOTES, in *Everybody's Life* magazine.

Full credit and proper references will be made to your publication. Thanking you very kindly in the anticipation of your approval, we are

Very truly yours,
J. I. RODALE, *Editor*,
Everybody's Life.

Emaus, Pa., November 17, 1938.

EVOLUTION OF THE ELECTRICAL COURSES

Professor James C. Peet presented some interesting facts and valuable data in his article "Evolution of the Electrical Courses," that was published in the November issue of the NEWARK ENGINEERING NOTES. One letter that refers to this article follows.

To the Editor:

I must thank you very much for the November number of the NEWARK ENGINEERING NOTES which you, or one of your colleagues, has been good enough to send me. I have looked it over with considerable interest, especially the article by Professor Peet on Engineering Courses.

Yours very truly,
C. H. MITCHELL, *Dean*,
University of Toronto.

Toronto, Ontario, Dec. 10, 1938.

FROM THE MAIL BAG

To the Editor:

Regularly NEWARK ENGINEERING NOTES have come to hand without my even having to ask for it, much less "remit by check." In fact, even without my having to thank you or acknowledge receipt of the paper.

Belatedly, I wish to express my gratitude and acknowledge my obligation.

The publication performs a manifold function for me. It keeps me in touch with the steady, rapid growth of the college facilities. It provides news of prime interest about the men with whom I associated in college. It adds odd items to my professional knowledge via its technical articles. More important than these, though, it allows me further to capitalize on my collegiate training, when I consider its material as a whole, by providing data for forming and altering my philosophy of education and its relation to industrial work. My admiration of the paper could be written in Hollywood-press-agent language.

GEORGE DANALD, '33, *Supervisor*,
Agfa Ansco Corporation.

Binghamton, N. Y., October 29, 1938.

To the Editor:

I have seen and read the October issue of the NEWARK ENGINEERING NOTES. The contents of the numerous articles were of much interest to me. By placing my name on your mailing list you will do me a great kindness.

Let me wish you and your staff the greatest success in this new venture. Thank you.

Yours truly,
ALEXANDER M. ROSS.

Bayonne, N. J., October 26, 1938.

To the Editor:

We shall appreciate your placing our name on your mailing list to receive NEWARK ENGINEERING NOTES. Would it be possible for us to get volume 1 complete? We would appreciate the favor if this could be sent to the library.

Thanking you for the current number which you recently sent us, I am

Very truly yours,
MRS. J. H. CROSLAND, *Librarian*,
Georgia School of Technology.

Atlanta, Georgia, October 25, 1938.

To the Editor:

Our Engineering Library is very desirous of obtaining a file of your publication, NEWARK ENGINEERING NOTES, as they have had numerous requests from their faculty and students for this title.

If you could place the University of Minnesota Library on your complimentary mailing list to receive your NOTES we should be very grateful. We should also appreciate receiving any of the back issues which you may have available for distribution.

Thank you for any courtesy you may extend to us.

Very truly yours,
RAYMOND H. SHOVE,
Head of Order Department,
University of Minnesota.

Minneapolis, Minn., November 1, 1938.

To the Editor:

It has been over eight years since I last had the pleasure of seeing any of the staff of the Newark College of Engineering, and today, I have received the NEWARK ENGINEERING NOTES, which reminds me of the pleasant association that we had during my college studies.

I think that the publication of such a paper is a real asset to the College, and I know that its continuing success will go hand in hand with the progress of the college.

Sincerely yours,
S. PAUL NASTASIO, JR., '30,
Director of Public Works.

City of Long Branch, N. J., October 25, 1938.

To the Editor:

It has been a pleasure to read over your May issue. I feel that congratulations are indicated . . . May you continue to maintain the high standard that you have established.

Yours very truly,
M. M. EELLS, *Vice-President*,
Breeze Corporations, Inc.

Newark, N. J., June 9, 1938.

To the Editor:

Just recently a copy of your NEWARK ENGINEERING NOTES came to my desk. This issue so appealed to me as being a definite contribution to the engineering literature that I am impelled to ask if it is possible to include the Duke University Engineering Library on your mailing list. The issue I have is volume 1, No. 2, and I find in it some interesting reading, especially the article by Mr. Jasik on "High Speed Electronic Circuit Breaker." The article is well written and extremely interesting . . .

Yours very sincerely,
WALTER J. SEELEY, *Chairman*,
Dept. of Electrical Engineering.

Duke University, Durham, N. C., June 6, 1938.

THE STUDENT
ENGINEERING SOCIETIES

Two meetings are scheduled in December for the Newark College of Engineering Student Chapter of the American Society of Civil Engineers. The first, on Monday, December 12, will be the regular monthly meeting of the Chapter at the College. Mr. George W. Booth, Chief Engineer for the National Board of Fire Underwriters, will present a paper on "Engineering as Applied to Fire Protection and Prevention." Then on Wednesday, December 21, a delegation from the Chapter together with delegations from the other seven Student Chapters comprising the Metropolitan Conference of Student Chapters will be the guests of the Metropolitan Section of the A. S. C. E. at its regular December meeting. This joint meeting of students and engineers has taken on the status of an annual affair. After the meeting there will be a collation at which time acquaintances can be renewed and extended.

(Reported by Professor W. S. La Londe, Jr., Faculty Adviser to the Student Chapter.)

The popularity of the recent Western Electric "Open House" has created a demand from the members of the profession to arrange their own inspection groups to see behind the scenes at Kearny. The student chapter therefore plans to visit this telephone plant on Wednesday, December 28, at 1:30 P. M. A detailed routing is being prepared and will probably include the cable plant, switchboard design and wiring, and methods of precision measure with especial attention to the manufacture of electrical bridges. The manufacture of condensers, vacuum tubes and cutting of quartz crystals are some of the features of the trip. Several of the alumni have indicated their intention of making the trip with the chapter. Those others of the alumni who would like to take in this inspection tour are invited to make necessary reservations with the undersigned.

(Reported by Walter Waldau, President of the Student Branch, A. I. E. E.)

A meeting of the Student Branch of the American Institute of Chemical Engineers was held on December 14, 1938. The members listened to a talk by Mr. Howard S. Carpenter of the Public Service Corporation of New Jersey. Mr. Carpenter discussed the *Manufacture of Carburetted Water Gas.* During the Christmas holidays the members of the chapter plan to make a trip to one of the local manufacturing plants to study some phase of large scale chemical operation.

(Reported by Dean James A. Bradley.)

The annual meeting of the Student Branches of the Society for the Advancement of Management met in New York on December 10. The Newark College of Engineering Branch was represented by fifteen members.

The next meeting of this Branch will be held at the College on December 19. Mr. Clifton J. Keating, president of the Woodside Building and Loan Association, will speak on "Building Loan Associations."

(Reported by R. B. Foster, president of the Student Branch, S. A. M.)

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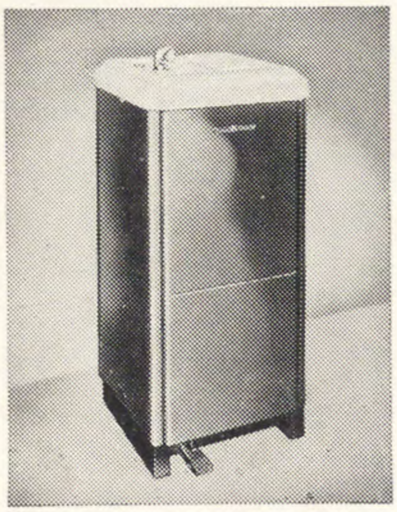
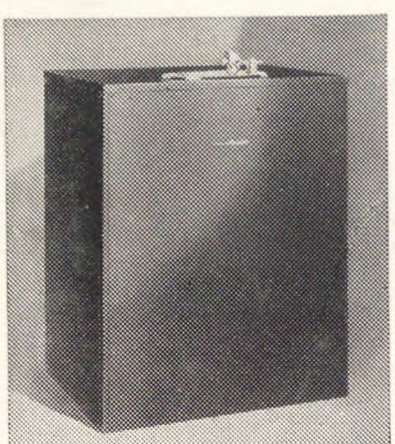


This small pressure cooler will take care of the normal needs of 50 persons doing light work, or 35 doing the hardest kind of labor. There are many other models.



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