NEWARK ENGINEERING NOTES

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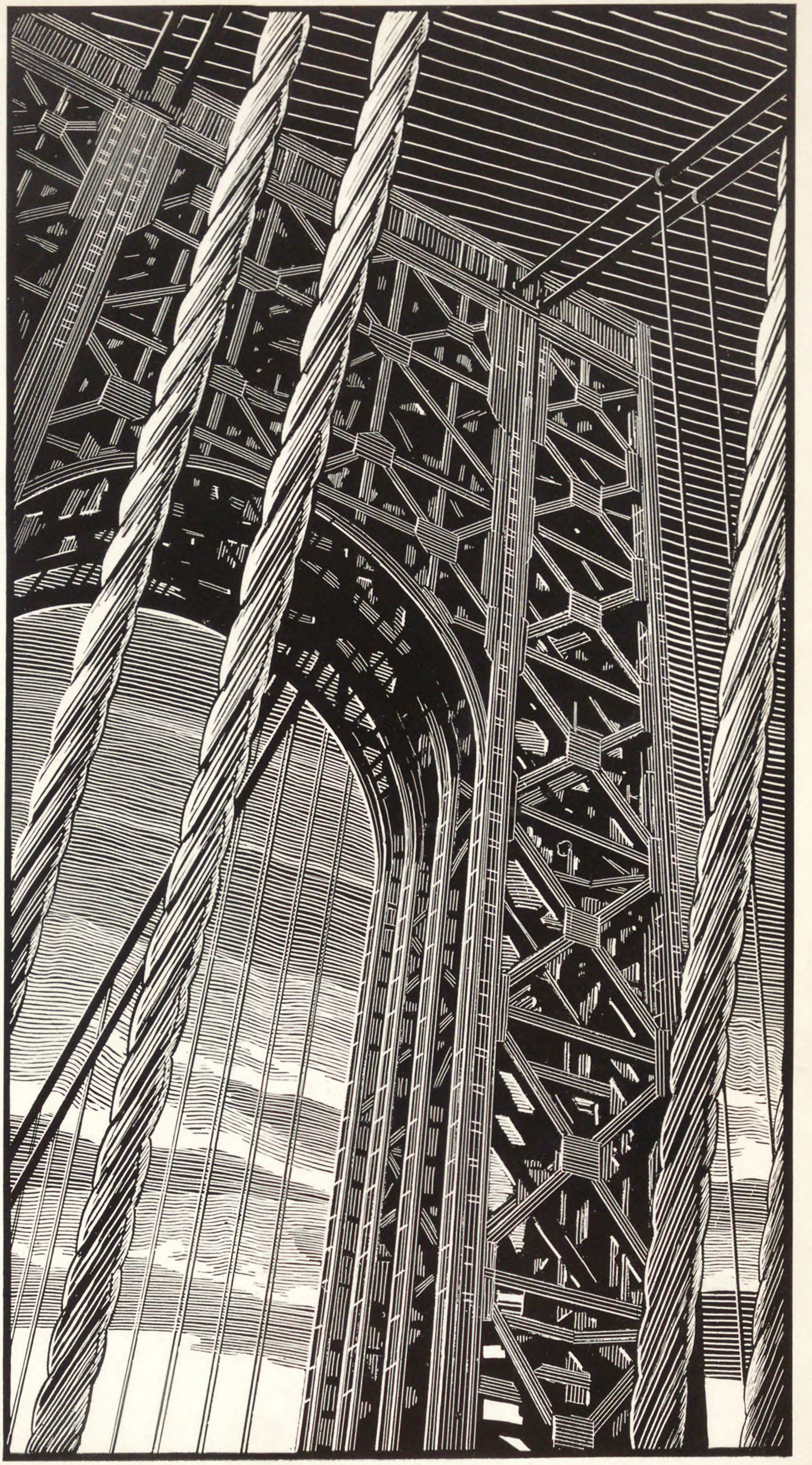
Volume 2 Number 2

NOVEMBER, 1938



What State Makes Possible the Longest Suspension Bridge in the World?

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NEW JERSEY — One of America's Great States

THE PRESIDENT'S DIARY

October 10—Freshman and Sophomore Orientation

One of the most pleasant things that has happened during this school year has been my association with the Freshman and Sophomore classes in connection with the new course in Orientation. The Department of Industrial Relations has sponsored a Freshman and Sophomore course. The Freshman course attempts to interpret the college experience to a new student, and the Sophomore course points out some of the necessary things which a student should know before he enters his coöperative work. Perhaps it would be simpler to say that the Freshman course deals with the situation within the college; that it is intended to give some meaning to the college experience; and to answer rather early in the course any matters which have to do with the internal workings of the institution.

It seems to me that both courses should be productive of a great deal of good. In talking to the Freshmen, I was not only surprised but pleased at the character and maturity of this year's entering class. The questions seemed to be well thought through, entirely reasonable, and ones which I should like to have had answered at this same period in my college experience. The Sophomores, too, seemed to sense the real values of the course and I think both experiments should work out well and prove very satisfactory.

It has been interesting in this connection to compare notes with some of the other members of the faculty who have talked to the groups and with Professor Brooks and Professor Widdop, who have had the work immediately in charge. The consensus of opinion seems to be that it is a step in the right direction. We have in the past years done some work with orientation by means of lectures and by means of outside speakers, but there has been no well thought out attempt to logically arrange a course which should cover every part of the field. The time involved is a two-hour period and one of the surprises about the whole course is how quickly the time goes and what frank and free interchange of ideas is possible with a group of this size.

The work with the Sophomores carries on the Freshman work so that there is a linking of the professional outside values with those of the college experience, with some attempt at indication of various techniques and attitudes which must characterize the work and the background of a professional engineer. The first year explains the academic work in the college, its relation and its values, and the Sophomore work explains an engineer's professional life, its background and its values.

October 18—Conservation of Time

In looking over a little more carefully the outline of our Freshman orientation course, it seems significant that a considerable amount of time is spent in indicating some methods of how to study. It is a little hard at first for Freshmen to realize that what we want here is not in itself a considerable amount of time spent in outside preparation, but we do want what time is spent to be spent efficiently. Time, like any other commodity, is so valuable that it must be conserved and used with the greatest care.

As I have more and more experience in educational work I am of the opinion that the Freshman year in college is none too soon to try to impress this lesson and to try to build up something in the way of habit with respect to the preparation of academic material. I wish that some of these proper habits might have been started a little earlier in the school experience. After all, it is, I think, almost entirely a matter of habit and perhaps of emphasis, too.

I remember very clearly that not many years ago I was giving some advice to a young man as to the easiest way to get through college. I expressed the opinion that the way to get through an engineering college with as little work as possible was to do the work during the first part of the term instead of the last, establish a habit and with it a reputation, and that both the habit and the reputation would continue to function without a great deal of conscious effort. While I have given the same advice to other students, the strange thing about this case was that the advice was taken and it was taken seriously and the results were far beyond my expectations. The young man did the job so well that I am not sure but what he found too much time on his hands in his Senior year. By the end of the Sophomore year he was so well established in the mind and hearts of the faculty that it would have been rather difficult for him to flunk a course.

I am not sure that the reaction was always good on every line but it did bring home pretty clearly to me that it was quite necessary to be careful about giving advice lest it should be taken literally. It was quite interesting to see the young man start off in his Freshman year and attain a reputation for work and consistent work and to get the proper habits of work. It was interesting to see how much more effective this was than to attempt to slide along into the course until a few weeks before examinations trying then to learn it all in a short time. At least this young man found himself ahead of the game with just a little reserve to spare at all stages of the procedure. If something of this general spirit could be transmitted to the Freshmen, it would save all of us, both faculty and students, a tremendous amount of time.

November 10—A Stage Demonstration

Aside from the pleasure of knowing the Freshmen and Sophomores better, one of the most interesting things characterizing this year is the efforts of a group of Juniors under the direction of Mr. Arnott of the English Department who are preparing a little one-act sketch on "How to Study."

It was my privilege the other afternoon to sit in with them and offer some criticism on the manner of presentation of the sketch. It is hoped a little later in the year to present it before the instructing staff and before the Freshmen with the idea that a dramatization is a very effective teaching. Perhaps it is most effective to see how a thing is done and hear how it is done by people in whom you are somewhat interested. The mere action holds the attention.

I think we could probably do more in the field of pre-college guidance by giving a little sketch, "One hour in the life of a Civil Engineer or a Mechanical Engineer or an Electrical Engineer" than we could by lectures or formal speeches. At least it is worth trying. Some day I would like to take a small group of our upperclassmen to one of the metropolitan high schools in Newark and have them act a sketch of this kind showing about the type of work that an engineer is supposed to do. It seems to me that a little sketch showing a man behind a desk, meeting or trying to meet some of the wide variety of problems that come to an executive in any branch of engineering, might be as enlightening and as interesting to a group of high school students contemplating engineering as either a lecture or a movie showing some of the great engineering works. It certainly would bring out, that engineering and successful engineering is an intimate mixture of many things both technical and human.

If this twenty-minute sketch on "How to Study" seems to the instructing staff worth while and if it seems at all to interest the Freshmen, perhaps we can do something like this in the future. It does seem that our high school graduates should have some faint idea of the type of problems that engineering involves. It is, of course, necessary that this fall within their own experience, which means that they must be interested enough to give close attention to things that they can understand. I hope the Alumni will not think we have in mind a Department of Dramatics and are developing a course in Modern Drama, but I honestly think this line of approach might have some value.

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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.

DESIGNING THE RIM UNDER GEAR TEETH

By WALDEMAR F. LARSEN, B.S., M.E.

Stress Analyst, Wright Aeronautical Corporation

From time to time some designers have asked, "How thick should I make the rim on this gear?" Others have consulted handbooks to find an empirical formula of the type, a constant divided by diametral pitch. Still others have their own empirical methods; such as, making the rim thickness the same as the addendum of the tooth or one-half the circular pitch. It is obvious that there is no standard method of determining the thickness of the rim, and a little study will show that no one formula could be set up to satisfy every gear condition due to the variation in gear design. Some gear rims are supported on spokes; some are supported by solid webs, while others have lightening holes in the web.

The simple spoked wheel gear offers a starting point for determining the rim thickness. The rim can be considered as a long beam, with fixed ends and bent by a couple in the middle. The couple is produced by the tangential load on the tooth when contact is first made with the mating gear. With these assumptions, equations can be written to make the rim as strong as the tooth. The rim must also resist the tensile load caused by the tangential load acting on the tooth.

The stress in the rim, then, is caused by bending and tension.

The Design of Rim Thickness Under Gear Teeth

Equal strength in gear tooth and gear rim.

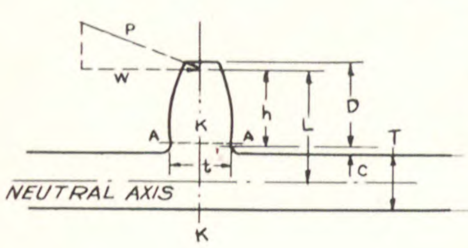


Fig. 1—Free Body Diagram

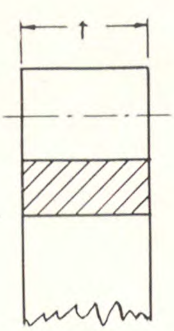


Fig. 2—Spoked Gear

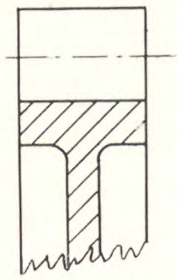


Fig. 3—Webbed Gear

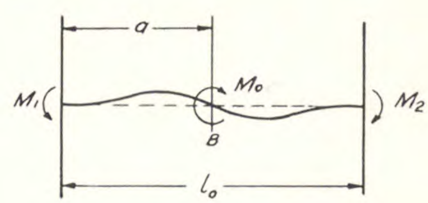


Fig. 4—Stress Diagram

The Lewis formula gives the tangential load as

W=Spfy

where S=stress

p=circular pitch

f=face of gear

y=Lewis Factor

The stress at K considering the rim as a long beam, fixed at the ends and bent by a couple in the middle is

$$S_1 = \frac{M}{Z}$$

But the bending moment $M = \frac{Mo}{2} = \frac{WL}{2}$

and $Z = \frac{fT^2}{6}$

Derivation of M

Max. M at $a = \frac{l_0}{2}$ See Fig. 4.

$$= Mo\left(4\frac{a}{l_0} - 9\frac{a^2}{l_0^2} + 6\frac{a^3}{l_0^3}\right)$$ "Prod. Engine," March, 1937, Pg. 120.

$$M = Mo\left(2 - \frac{9}{4} + \frac{6}{8}\right)$$

$$= Mo\left(\frac{16}{8} - \frac{18}{8} + \frac{6}{8}\right)$$

$$= \frac{Mo}{2}$$

$$S_1 = \frac{M}{Z} = \frac{WL}{2} \cdot \frac{6}{fT^2} = \frac{3WL}{fT^2}$$

Tensile Stress at K

$$S_2 = \frac{W}{fT}$$

The total tensile stress at K

$$S_3 = \frac{3WL}{fT^2} + \frac{W}{fT}$$

$$= \frac{W}{fT}\left(\frac{3L}{T} + 1\right)$$

Making the tensile stress in the gear tooth equal the tensile stress in the rim.

$$S = S_3$$

$$\frac{W}{pfy} = \frac{W}{ft}\left(\frac{3L}{T} + 1\right)$$

$$\frac{1}{py} = \frac{1}{T}\left(\frac{3L}{T} + 1\right) = \frac{3L}{T^2} + \frac{1}{T}$$

Let L = whole depth — clearance + ½ rim thickness.

Note: Subtracting the clearance compensates for the distance from the top of the tooth to the point of application of the load. See Fig. 1.

Whole depth $= \frac{2.32}{P}$ where P = diametral pitch.

Clearance $= \frac{.32}{P}$

$$L = \frac{2.32}{P} - \frac{.32}{P} + \frac{T}{2}$$

$$L = \frac{2}{P} + \frac{T}{2} = \frac{4 + PT}{2P}$$

Circular pitch $p = \frac{\pi}{P}$

Substituting known values

$$\frac{1}{py} = \frac{3L}{T^2} + \frac{1}{T}$$

$$\frac{P}{\pi y} = \frac{3}{T^2}\ \frac{(4 + PT)}{2P} + \frac{1}{T}$$

$$\frac{P}{\pi y} = \frac{12 + 3PT}{2PT^2} + \frac{1}{T}$$

$$\frac{P}{\pi y} = \frac{12 + 3PT + 2PT}{2PT^2}$$

$$\frac{P}{\pi y} = \frac{12 + 5PT}{2PT^2}$$

$$2P^2T^2 = 12\pi y + 5\pi yPT$$

$$2P^2T^2 - 5\pi yPT - 12\pi y = 0$$

$$T^2 - \frac{5}{2P}\pi yT - \frac{6\pi y}{P^2} = 0$$

Solving by the quadratic equation

$$T = \frac{-b \pm (b^2 - 4ac)^{1/2}}{2a}$$

$$= \frac{5\pi y}{4P} \pm \frac{1}{2}\left[\left(\frac{5\pi y}{2P}\right)^2 + \frac{24\pi y}{P^2}\right]^{1/2}$$

$$T = \frac{5\pi y}{4P} \pm \frac{1}{2}\left[\frac{25\pi^2 y^2}{4P^2} + \frac{96\pi y}{4P^2}\right]^{1/2}$$

$$= \frac{5\pi y}{4P} \pm \frac{1}{4P}\ (25\pi^2y^2 + 96\pi y)^{1/2}$$

$$= \frac{5\pi y + (25\pi^2y^2 + 96\pi y)^{1/2}}{4P}$$

Thus the thickness of the rim of the gear is

$$T = \frac{5\pi y + (25\pi^2y^2 + 96\pi y)^{1/2}}{4P}$$

where y = Lewis Factor

P = diametral pitch (for Fellows Stub Teeth use denominator pitch)

$$\text{Let } K = \frac{5\pi y + (25\pi^2y^2 + 96\pi y)^{1/2}}{4}$$

Then the thickness of the rim of the gear can be written

$$T = \frac{K}{P}$$

By solving K for various values of the Lewis Factor y a curve can be plotted which will simplify the operation of finding the thickness of the rim of the gear.

Let Lewis Factor $y = .100$

Then T becomes

$$T = \frac{5\pi \times .100 + (25\pi^2 \times .1^2 + 96\pi \times .1)^{1/2}}{4P}$$

$$= \frac{.5\pi + (2.465 + 30.15)^{1/2}}{4P}$$

$$= \frac{1.57 + 5.71}{4P}$$

$$= \frac{7.28}{4P}$$

$$= \frac{1.82}{P}$$

Likewise, when the Lewis Factor $y = .150$ the rim thickness T becomes $\frac{2.37}{P}$

Since the Lewis Factor is a function of the number of teeth on a gear, scales can be placed above the Lewis Factor scale which give the number of teeth.

In plotting the following curve, the scale for the number of teeth of a Fellows stub tooth profile was based on values of y for a 5/7 pitch system. If this one is used for other stub teeth, the rim will be stronger than necessary.

It has been found that gears using a centrally located web require less rim thickness than is indicated by the formula and curve just derived.

A dotted line was drawn parallel to the original line which gives results more nearly equal to rim thicknesses found under severe operating conditions for high-grade gears.

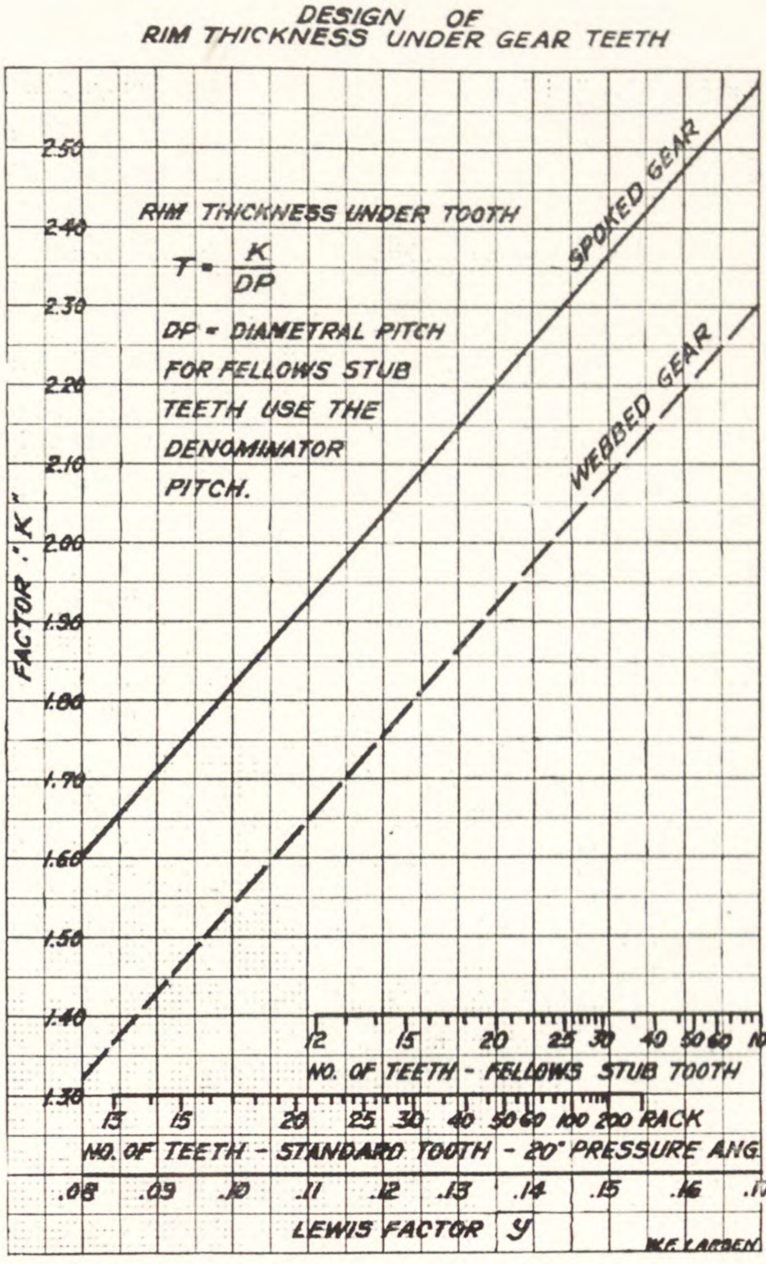


Fig. 5—Design Diagram

Sample Calculation

What rim thickness should be used for a 54 tooth, $\frac{10}{12}$ diametral pitch, 20° stub tooth gear using a spoked wheel type support? (*Continued on page 14*)

EVOLUTION OF THE ELECTRICAL COURSES

Being Particularly the History and Development of Our Own Courses at Newark College of Engineering

By JAMES C. PEET, E.E.
Professor in Electrical Engineering, Newark College of Engineering

On the wall of my lecture hall at an educational institution some hundreds of miles from here is an interesting poster. It is of the type produced for circuses, etc., in the Civil War period, and is yellowed with age. It advertises a course of three lectures to be given at the Athaenaum in the spring of the year 1865 by a certain John Finn on the subject of Electricity. Now! What could John Finn have to tell the people in the year 1865 about electricity that could occupy one lecture, let alone three lectures? The real upswing in electrical development began about 1880 with the invention by Thomas Edison of an economical electrical generator and an incandescent lamp which could compete with the old wing-tip gas burner.

The work of Edward Weston may be mentioned with that of Edison as a potent factor in advance of Electricity. While Weston contributed to the development of the dynamo, his real contribution was in the invention of measuring instruments whose ruggedness and accuracy are world famous.

Electrical Engineering as a separate branch of learning lagged these epochal inventions by several years. The evolution of Electrical Engineering curriculum has largely taken place during the last forty years.

The curriculum at my own University back in 1900 followed about this pattern so far as electrical subjects were concerned: D-C Electricity, D-C Machines, A-C Theory and A-C Machines, Electrical Design, and such application courses as Telephony, Telegraphy, Illumination, and Transmission. The remainder of the course material was patterned after that of the Mechanical Engineering Department in so far as time permitted. Fundamentally it may be said to cover the generation, transmission, and utilization of electrical energy.

Newark's First Electrical Course

This was about the situation when the Newark College of Engineering was founded in 1918. Those who had to do with the establishment of the Electrical Engineering Course were not hampered by tradition either as to the course content or method of instruction. The only philosophy that governed was to make the course as direct as possible, adhering absolutely to fundamentals. The real problem was to determine exactly what was fundamental.

The original Electrical Engineering Course given at Newark was of a very conservative type. An elemental course was taught during the freshman year. This was an innovation in teaching which worked well. The textbook study was supplemented with laboratory work in circuits and measurements. *Parallel* with this, a physics course was given from which the electricity and magnetism had been removed. The sophomore year was given over to direct-current machinery with full laboratory tests of the usual types of d-c generators and motors. In the junior year a heavy course in alternating currents was the program. Stress was laid upon the writing of good laboratory reports patterned as nearly as possible after the test reports required by electrical manufacturers.

The senior year consisted of electrical engineering lectures, electrical measurements, and electrical design.

Naturally these electrical courses were buttressed by the usual service courses in mathematics, mechanics, strength of materials, thermodynamics, hydraulics, and mechanical drawing.

The Coöperative System

The President maintained that the College was established to be a cross-section of the life about us, not a thing apart. Development of sound character was to be the supreme objective.

The coöperative plan, established to make contact between the students and industry, has been particularly valuable in this regard. Early association with industry gave the student a close view of what he might be expected to contribute to industry. His early contact with the difficult personal problems of industry proved a very real developer of sound character. The College used the coöperative plan from the start, but scheduled these periods in industry for the junior and senior years only. This arrangement made industry the laboratory in which to try out our students, after we had weeded out about fifty per cent of those entering college. The soundness of this fundamental course and its general plan is evidenced by the number of our graduates remaining in the employ of industry throughout the depression.

The Course Broadens in Scope

No fundamental revision was made in this course until 1929. At that time it was found necessary to discontinue electrical laboratory work for the freshmen. This change was forced by the increased number of students. One year later all electricity, except that which could be given by the Physics Department, was discontinued in the freshman year. It was feared by the Electrical Department that this change might prove to be a decided loss. However, such was not the case. As sophomores, the students were one year older, so more mature. Their broader mathematical background made them better prepared. The misfits had been removed, so that those who remained could do the work more rapidly. The lecture, quiz, and laboratory methods were more closely coördinated. The results achieved were very encouraging.

During this period there was some pressure from outside the College for a division of the work of the upper-class years into two parts—Power and Communication. These were intended to be optional courses; the student to choose the one or the other. Consultation with certain educational advisors in the communication industries led to the belief that such a change was not the best way to secure the results desired. Instead, it was decided to broaden our basic instruction so that it would fit our students for either the power field or the communication industries.

Economics and Management

When the author entered the work of the electrical industry at the beginning of the century, the question the employer asked was, "Can we do this thing electrically?" and the engineer's job was to find the way to do it. Today, the employer does not want to know merely whether or not it can be done; he must know also how much it will cost; is the electrical method the best way to accomplish that which is required? The College early recognized this fact and instituted courses in elementary economics, and since then have broadened this into engineering economics and courses in management.

Along with management of materials and methods comes the management of men. Early in the development a coördinator was engaged who kept in close contact with the student and his industrial boss, actively following the student's relations and progress in his work outside the College. This has been of vital value in maintaining good relations with our coöperating industries. From this beginning has grown our human relations work. The case method is used in all of this work, and the student acquires a real idea of how he must conduct himself with his boss and fellow employees. It has been of material benefit to our students in their jobs.

The advent of the electron tube made necessary another modification of the curriculum. Since it was felt that the course should be broad and general, the work in this field was laid out to include a class and laboratory study of the general types of these tubes together with their operating characteristics. This soon was followed by a course in the application of these tubes to communication and to industrial control. No separate course solely in radio communication was deemed advisable.

The Bilateral Plan

The most important change came with the conception that the older classical division of direct and alternating currents should be discontinued. The bilateral plan of treating d-c and a-c circuits together was adopted. The method was to teach the fundamentals common to both, and then to note the differences. This circuits course was followed by a general machinery course, in which the major d-c and a-c machines were studied with reference to their similarities and their special differences. This plan compresses the laboratory study of each machine into one, or at the most, two laboratory sessions. Time was saved by this means which made possible the electronic work without additional time being devoted to electrical subjects.

The Electrical Course Today

What does all this background make the present-day electrical course? It has become a course originating in the basic concepts, passing on through the three circuits, and emerging in a study of devices and applications.

The first course in electricity is a rapid general view of the field, taught from the point of view of the physicist, and emphasizing the basic electron theory. This is followed by a course in electric circuits in which the interrelations of the three circuits, electric, magnetic, and electrostatic, are studied. These two courses comprise the first year's work and lay a real foundation for the engineering work of the upper-class years.

As juniors, the students are occupied mainly with the heavy general machinery course. It is supplemented by lectures on networks and transients. At the same time, the initial course in electron tubes is given. This year's work requires nine hours of electrical laboratory work.

The curriculum of the senior year consists of electrical measurements, electron tube circuits, electrical machine design, transmission equipment, and transmission circuits.

Along with the electrical subjects which have been mentioned, Hydraulics, Thermodynamics, Machine Design, Strength of Materials, and Mechanical Engineering are included from the Department of Mechanical Engineering. The subjects of Economics, Staff Control, Industrial Management, and Business Law are drawn from the Industrial Engineering Department to broaden the economic viewpoint and to supply some needed information on the general subject of human relations.

The department believes in plenty of instructional help for the students at first —but less and less of it as the course proceeds, so that the work of the senior year is largely one of direction. Thus our graduates are made self-reliant and able to make their own decisions.

What of the Future?

It is hoped to make the course mirror the progress of the Electrical Industry. It must never become fixed. It must always be flexible, adapting itself to new methods, new texts, and new material, assimilating that which is found valuable and discarding whatever is non-essential. As long as our courses are of four years' duration, they must of necessity include only the bare fundamentals of any subject. The real difficulty, with an industry changing as rapidly as the electrical industry, is to determine just what is fundamental.

Editor's Note: Professor James C. Peet was born in Webster, N. Y., in the year 1880. His early education was received in the schools of western New York and he received the degree of Electrical Engineer, with honors, from Syracuse University in 1903. After four years on General Electric test, he taught for several years at Mechanics Institute, Rochester; Harrisburg Technical High School, and Toledo University. He came to the Newark Technical School in 1917 and when the College of Engineering was established he was appointed head of the Electrical Engineering Department.

He is a member of Tau Beta Pi, Sigma Chi, American Institute of Electrical Engineers, and the Society for the Promotion of Engineering Education.

REGISTRAR'S REPORT

Here in November our attention is turned to students who are planning to enter the college in February, 1939. Indications are that a large number of high school graduates intend to apply for admission to the mid-term section.

With the intensive fall registration period of several weeks ago still vivid in our memories, many factors come up for consideration with regard to conditions met with in any registration period.

The procedure of interviewing all prospective freshmen has had considerable effect in two respects. First, as a result some parents are bringing their sons in for the purpose of registering them three years in advance, that is, for classes beginning as far away as 1941. Though we are unable to register any students for that date at this time we are only too pleased to have high school students visit the college so that some recommendations for the student's secondary school training might be made. This will eliminate many of the heartaches for prospective freshmen caused by their deficiencies in entrance subjects.

Also, these prospective freshmen interviews, whether by sheer accident or by design, are proving to be of some worth. Here we are at almost the end of the first quarter of the school year, yet this office has no reports of withdrawals from the freshman class as yet. Last year, it is recalled, two men dropped out during the first week of school, evidently from exhaustion caused by the weight of the textbooks, and later there were others who discontinued their courses quite early in the semester.

A complete report has been made on the registration for September, 1938, and the figures as compared to last year are tabulated herewith:

	Former Students	Graduate Students	Freshmen	Total
1938-39	608	14	206	828
1937-38	585		190	775

The 206 freshmen actually registered were selections from a total of 431 applicants as compared to 285 of last year. The number of rejections were probably increased by one hundred per cent because the men were either physically unfit for a difficult program of studies or their academic preparation was insufficient for engineering courses. It is felt that this may be the reason for the absence of drop-outs for this first quarter.

ALUMNI PERSONALITIES

Frank G. Manning, graduate in Civil Engineering, class of '33, has been Assistant Engineer of the Interstate Sanitation Commission since June, 1937. Previously he was a technical supervisor for the New Jersey State Housing Authority. Mr. Manning is a member of the National Society of Professional Engineers, and is continuing his professional work in Sanitary Engineering at New York University toward a Master's degree in Civil Engineering.

Henry Jasik, '38, recently received a Civil Service appointment of Junior Engineer and is at present with the Bureau of Ordnance of the U. S. Navy Department in Washington. Mr. Jasik graduated in Electrical Engineering; his original paper, "A High Speed Electronic Circuit Breaker," appeared in the May issue of the NOTES.

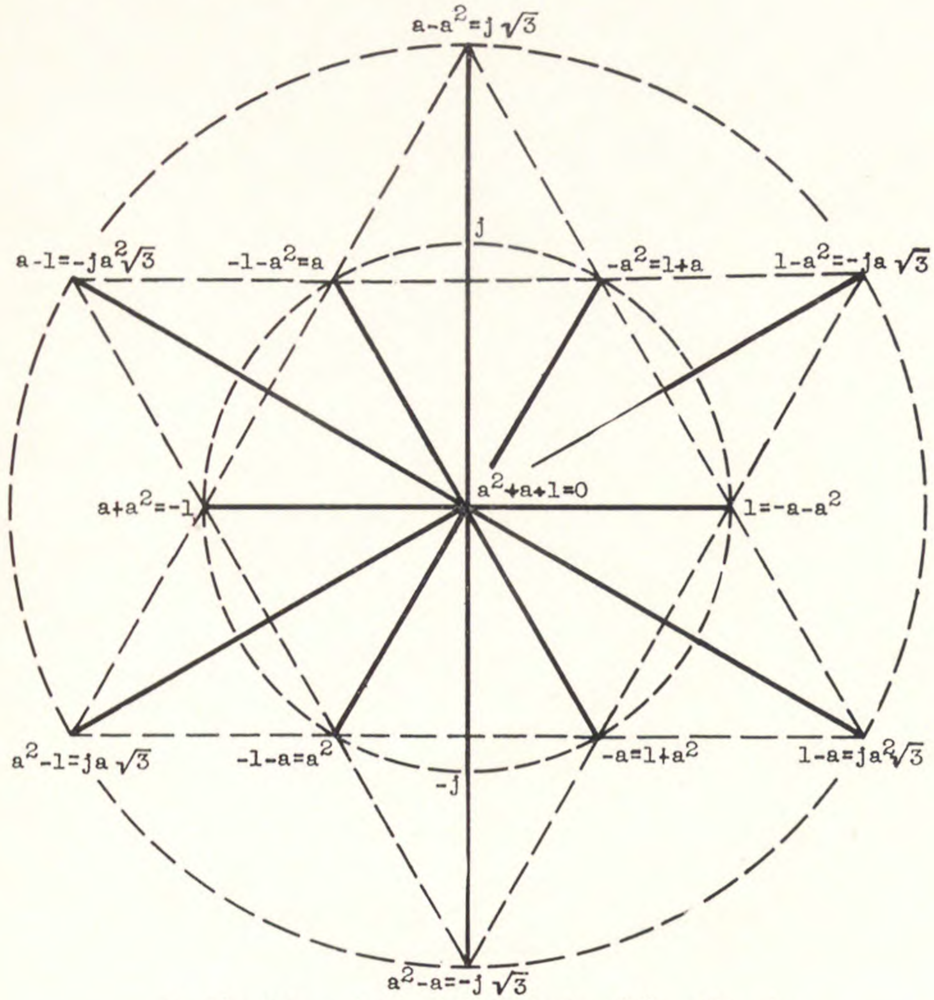
A GRAPHICAL REPRESENTATION OF THE *a*-OPERATOR

By S. FISHMAN, B.S. in *Electrical Engineering*

Assistant Professor in Electrical Engineering, Newark College of Engineering

Fifty million horsepower, twenty-six million customers, more than one hundred million dependents represent the extent of the electric power supply and utilization in the United States. Generating stations, steam and hydro, hundreds of miles of transmission lines, thousands of miles or distribution circuits, countless relays and switches are in orderly combination to provide this electric supply. Dependence of our social and economic well-being on continued unhampered operation and availability and progressive extension of electric power supply is fundamental and generally acknowledged.

With the growth of individual electric power systems and the increasing number of interconnections of these systems, came problems of design and operation which required improved and new techniques for analysis. Among the problems of the first magnitude were those having to do with the settings of relays and the dimensions of circuit breakers to properly protect the systems when short circuits and faults occur. Another problem was to preclude the operation of power systems from interfering with communication systems.



Graphic Representation of the Properties of the a-Operator

Under ideal conditions a power system is symetrical, and the electrical analysis is a relatively simple procedure. When faults occur systems are asymmetrical and analysis becomes relatively complex. Application of a procedure known as the Method of Symmetrical Components permits predictions under fault conditions to be made with satisfactory precision. Within the past decade this technique has been developed to a high degree.

The method of symmetrical components stems from the indication by Fortescue that a three-phase system, such as most power systems are, can, when asymmetrical, be resolved into three other systems. Two of these systems are symmetrical and the third is a residual system. These are known as: the positive-sequence system, the negative-sequence system, and the zero-sequence system. Each of these systems has associated with it voltages, currents, and impedances which in the ordinary circuit do not react with those of any other of the sequence systems.

The positive sequence voltages and the negative-sequence voltages of three-phase circuits are each represented by concurrent vectors of equal magnitudes displaced by 120 degrees. Zero-sequence voltages are represented by three vectors of equal lengths and in phase. The distinction between the positive-sequence and the negative-sequence systems is that the voltages and currents in the latter come to their maximum values in the reverse order from those in the former. Decomposition of an asymmetrical three-phase power system under fault conditions into these symmetrical arrangements facilitates the circuit analysis.

In the process of decomposing a faulted three-phase power system into symmetrical component systems, a rotating operator designated by the letter *a* is used. Operating on a vector with *a* causes the vector to rotate through an angle of 120 degrees in a counter-clockwise direction; operating with a^2 and a^3 result in 240 degree and 360 degree rotations respectively, in a counter-clockwise direction.

Obviously,

$a = \cos 120° + j \sin 120° = \varepsilon^{j\,120°}$

$a^2 = \cos 240° + j \sin 240° = \varepsilon^{j\,240°}$

$a^3 = \cos 360° + j \sin 360° = \varepsilon^{j\,360°} = 1$

Various combinations of sums and differences of a, a^2 and 1 occur in the analyses. The values of these combinations of complex quantities may be determined from the above relationships by addition, subtraction, and simplification. This requires a separate computation for the determination of the simplified value of each function.

The accompanying diagram* was constructed to indicate the properties of the *a*-operator graphically. From the diagram these values of the functions of the *a*-operator are easily obtained and the reason for the particular value readily discerned.

THE GYURIS STORAGE BATTERY

By V. T. STEWART, Ph.B., S.B. in Chemical Engineering

Professor in Chemistry, Newark College of Engineering

The electric battery field has been dominated from the beginning of its history by such a small number of types that the advent of an entirely new design is a matter of general interest. Among storage batteries, the lead and the Edison accumulators, as they were originally called, are the only ones to ever attain commercial importance, while among primary batteries the number is still only a few, namely the Le Clanche, LaLande and Daniell, together with the Weston and Clark cells, the latter two being of an instrumental type.

This new battery, developed by Janos Gyuris, is unique in that the active elements are fused. Aqueous solutions are not used. Yet the external appearance of the cell is fully as neat as that of the conventional dry cell. The energy capacity on the basis of either weight or volume is several times that of the commercially available batteries.

Mr. Gyuris was led into this development from a study of the operation of thermocouples. This cell is really the hot junction of a liquid thermocouple. There seems to be a popular opinion that there is no transfer of matter in the operation of the conventional thermocouple, which, of course, is not the case. Such justification as there is for that opinion is due to the minute currents which are ordinarily involved.

Description of the Cell

An electric cell is a device for developing continuous current electrical energy. It is a unit from the electrical point of view and has a positive and a negative terminal. The electromotive force is a characteristic of the components and their structural arrangement, as well as of the temperature. The quantity of the ingredients present affects the length of time that the cell will operate and the rate of discharge.

A battery is a combination of two or more cells, in series or in parallel, or both, arranged to yield current and electromotive force in the desired proportions. The conventional automobile battery has three cells in series.

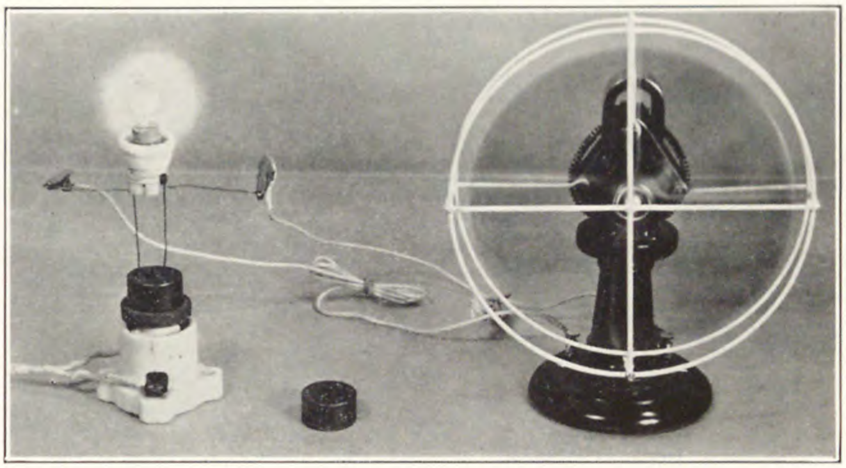
A primary cell or battery is discarded when it has become exhausted and has only one life. The ordinary dry cell is of this type.

A storage cell or battery, upon exhaustion, may be restored to its original condition, by the passage of continuous current from an external source in the direction opposite to that of discharge. In its early days, it was known as an accumulator. From a practical point of view, a storage battery is based upon a reversible chemical reaction, whose constituents can be maintained in a state of electrical insulation from each other, both on charge and on discharge. Another prime consideration is that the reaction shall proceed only when a suitable external circuit is connected.

The Gyuris cell is based upon a chemical reaction of the oxidation-reduction type, part of the ingredients being fused. One side of the cell is made of metallic sodium which becomes oxidized as the cell operates. The other side is a mixture of 80% manganese dioxide and 20% sodium nitrate, both of which are reduced as the cell operates. When the cell is recharged, these reactions are reversed and the constituents are restored to their original condition.

The mixture of manganese dioxide and sodium nitrate is formed into a tablet. If the temperature is 400°C, the pressure used in forming the tablet is from 3,000 to 15,000 pounds per square inch. If the tablet is formed at ordinary temperature, a higher range of pressure is desirable. The use of pressure in the formation of this tablet is an essential feature of the construction. The tablet is not under pressure when in place in the cell. It has been found desirable to place inserts of copper gauze, rolled into small cylinders, in the tablet in order to secure better electrical contact.

The metallic sodium is pressed into the shape of the containers and is placed



An electrical system operated by the Small Gyuris Cell. There is no electrical connection between the cell and the porcelain fixture. The cell was initially heated by a cigar lighter. The fan and bulb together took one ampere at two volts and operated for two hours and ten minutes. The small short cylinder in the center foreground is a second cell. It is one inch in diameter by 5/8 inch high.

A GRAPHICAL REPRESENTATION
(Continued from previous page)

Of interest is the fact that the magnitudes of the functions are either unity or $\sqrt{3}$, as is indicated by the two concentric locus circles. Of further interest is the fact that the functions of the *a*-operator provide a series of operators by which phase shifts in 30-degree steps may be obtained.

Editor's Note: Professor Fishman, a native of Newark, was graduated with the class of 1927 from the Newark College of Engineering. Upon graduation he was appointed instructor in electrical engineering, the first alumnus to teach at the college. In 1933 he was appointed Assistant Professor of Industrial Engineering and did development work in the Staff Control course until 1935 when he was appointed Assistant Professor in Electrical Engineering. Besides developing courses in electronics, machinery, and circuit analysis, the author has served as consultant on several engineering projects outside the college. He is a member of the American Institute of Electrical Engineers, Society for the Promotion of Engineering Education, and a Licensed Professional Engineer in the State of New Jersey.

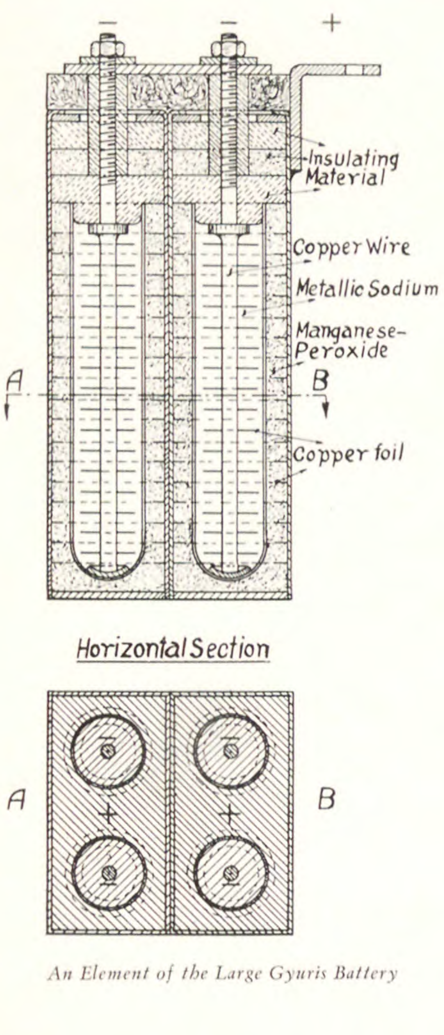
*From the author's communication to the A.I.E.E. "Electrical Engineering," July, 1938.

above the manganese dioxide-sodium nitrate tablet. As the cell operates, the molten sodium migrates downward into the manganese dioxide-sodium nitrate tablet and contact may be lost with the electrical connections at the top. To maintain this contact, short rods or studs are placed in the sodium tablet. These studs are conveniently made of compressed iron filings or graphite. In order to control the reaction of the cell, a grid of copper gauze is placed between the two tablets.

The insulation of the tablets from the steel shell and the connection of the lower tablet to the terminal to the top are simple matters.

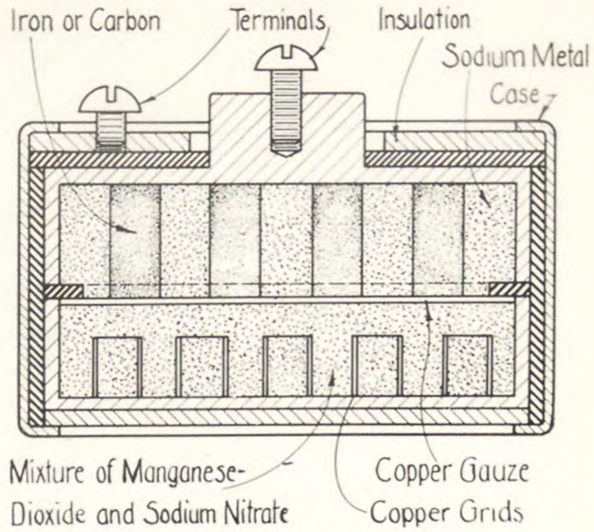
A cell, which contained 4.8 grams of manganese dioxide, 1.2 grams of sodium nitrate and 1.5 grams of metallic sodium gave 2.17 watt-hours at an average E. M. F. of 2.5 volts when heated to the temperature range of 300 to 450°C. In operation, the cell will maintain a suitable temperature, once it has been heated up. At 1.85 volts, the chemical efficiency is 67%.

A great variety of constituents have been investigated for both sides of the cell, and the inventor has selected the foregoing combination as one which is



An Element of the Large Gyuris Battery

both inexpensive and satisfactory in performance. There is no tendency of the cell to function on open circuit, which is to say that the shelf-life is indefinite. There are no gases or water involved. The liquids are so viscous that they are easily retained. Aside from the obvious necessity to recharge the cell, a short circuit does no harm. The recharging rate is high, that is, the charging can be done in a very short time. No solutions are used and no gases of any kind are evolved. The appearance is neat, simply a steel cylinder, with the two screws for terminal connections on one end.



The Small Gyuris Cell

This is a cross-section of the cell shown in the accompanying cut. It is one inch in diameter by 5/8 inch high.

The Large Cell

For heavy service a large cell has been developed. The chemical reaction, the ingredients and the details of electrical connections are identical with the small cell already described. This large cell will be contained in a square-drawn steel tube, about 2½ inches square, and long enough to give the desired capacity.

The manganese dioxide-sodium nitrate mixture is pressed into square tablets which just fit into the tube. Between each tablet is placed a thin copper plate which serves the same purpose as the small grids in the small cell. There are four round holes in the tablets and plates which form tubes for the metallic sodium when they are assembled. The metallic sodium is placed in these holes with strong copper wires provided with lateral fins through the center. The ends of these wires are led out to the terminals.

These large cells may be assembled in any suitable manner for volts and amperes. A 12 kilowatt-hour battery in one design would have the following data:

Open voltage 100 volts
Operating voltage 80-90 volts
Capacity 150 ampere-hours
Normal load 30 amperes
Overload for short time 200 amperes
Weight, complete 285 pounds.
Overall dimensions 3 ft.x1.5 ft.x1.5 ft.

The comparison of this battery with the conventional lead storage battery of the same electrical capacity shows that the Gyuris cell has about one third of the volume of the lead cell and about one fifth the weight. The manufacturing operations are of a very simple nature, being largely press work. The metal materials are all available in commercial shapes and sheets. An estimate of costs indicates that the Gyuris cell can be sold for one half the price of the lead cell. In larger sizes the circumstances favor the Gyuris cell even more.

In order that the large cell may operate efficiently it is necessary to maintain the temperature at approximately 450°C or 850°F. When the battery is cold the heat necessary is supplied through resistors placed between the cells of the battery, from an external circuit. The operation of the battery evolves some heat and a small fraction of the discharge current through the resistors is sufficient to maintain a suitable temperature. The outside of the battery is covered with 4 inches of glass wool for the purpose of insulating against heat losses. Since the capacity of the battery is proportional to the volume and the heat losses are proportional to the surface, it is obvious that the larger sizes will be still more efficient.

It is to be particularly noted that this battery does not convert heat into work.

Applications

The field of applications is very interesting and includes: submarine, mine locomotives, industrial trucks, stationary power plants, railroad cars, and electric motor trucks, buses and taxis. In the matter of submarines, the submerged mileage could be increased from the present 60 to 250 miles or more, with an accompanying reduction of the first cost of $800.00 to about $100.00. The installation of air conditioning has placed a serious load on the electrical equipment of railroad cars and the considerable saving of space, weight and initial cost presents a feature of importance.

The significance of this battery can best be illustrated through its application to an electric street truck. If the lead storage battery of such a truck were replaced by a Gyuris battery of the same volume and weight, the truck could cover the same distance ten times over before the battery would be discharged and in need of recharging. This distance, about 400 miles, is nearly twice that covered by a gasoline truck without refueling. Consequently some of this saving in weight and volume, or again in power and performance could be utilized to increase the speed of the truck from a present maximum of 20 miles per hour to a maximum of 40 miles per hour. This involves roughly, doubling of the weight of the motor and doubling the discharge rate of the battery on the assumption that the rate of 40 miles per hour would be maintained continuously. In practice, a rate of 30 miles per hour is adequate. This all sums up to the estimate that a truck, converted to use the Gyuris battery, could maintain a speed of 30 miles per hour for 200-250 miles or at 20 miles per hour for 400 miles.

United States Patent No. 2,081,296 was issued on June 1, 1937, and No. 2,101,701 on December 21, 1937, respectively, and other patents are pending on the matter which has been presented here.

Editor's Note: Professor V. T. Stewart is a graduate of Syracuse University and of the Massachusetts Institute of Technology. He spent three years with the Edison organization, working on various phases of the Edison primary battery and the Edison storage battery. Later, he was associated with Mr. Carleton Ellis on chemical development work. He came to the Newark College of Engineering in 1921, where he has been ever since.

INTRODUCTION TO ENGINEERING PHYSICS. By Franklin N. Entwisle, Professor in Physics, and William Hazell, Jr., Instructor in Physics, Newark College of Engineering. Published by Newark College of Engineering, First Edition 1938. Plastic binding, 8½x11 in., 138 pp., illus., $1.75.

Reviewed by EASTMAN SMITH

"It is essential that a prospective engineer should become acquainted with common engineering problems, engineering methods of computation, and acceptable standards of presentation of the solution of these problems. For this reason practice should begin early and this practice should begin with material that is fundamental to all branches of engineering."

With this aim, a thoroughly usable text for technical students has been designed by the authors, to match a time-tried "get-acquainted" course for freshmen. A former course in *Physical Computation*, invented to swing the high school graduate sharply over into the exacting career of the engineer, in which high standards of excellence shall prevail, has been rebuilt by Professors Entwisle and Hazell, with this text, as a course in Physics. Since it is in Physics that most of the fundamentals of engineering are first met, the problems are drawn largely from that field.

The outstanding merit in this study, and one which has brought forth praise from outside engineers and students alike, is that from the very first day of technical college work, the students start *in full production*, on the solution and presentation of practical problems.

These are grouped — as Geometrical, Trigonometrical, Graphs, Motion, Work and Energy, Vectors, Precision, Power, and Building Costs.

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One outstanding chapter is Chap. V, Precision of Measurements, an excellent summary, with arithmetical methods; and in which a simple explanation of certain fundamental principles gives the student something with which he can make easier work out of hard.

The book is recommended for all colleges where students are expected to learn thoroughly to do their own work, and with professional presentation.

THE STUDENT ENGINEERING SOCIETIES

On November 3 the Student Branch of the American Institute of Chemical Engineers heard a talk by Mr. F. J. Van Antwerpen, Associate Editor of *Industrial and Engineering Chemistry*, and a graduate in 1938 from Newark College of Engineering. The subject of Mr. Van Antwerpen's talk was "Chemical Periodicals."

Mr. Van Antwerpen developed his subject from the historical point of view, beginning with a discussion of the laborious methods used in the Middle Ages when books were made by hand (usually in monasteries) and copied page by page. Then, and for a long time after, he pointed out, scientific knowledge was disseminated chiefly by lectures and by the interchange of letters between scholars.

The first scientific journal, according to the speaker, was either the *Journal des savants*, published in France by Denis de Sallo, or the *Philosophical Transactions* of the Royal Society in England. Both appeared in 1665. The latter publication is still being issued.

Mr. Van Antwerpen then talked at length on the modern development of the scientific journal as a means of spreading and preserving technical knowledge. He pointed out that American scientific workers at a very early date produced such a periodical: *Silliman's Journal*, which appeared first in 1818. He then discussed journals of the present day and exhibited a number of current periodicals.

The speaker concluded with a discussion of the value of periodicals to students and professional chemists, pointing out particularly, with examples, the important fact that work of the greatest value published today may not find its way into textbooks for years.

(Reported by Dean James A. Bradley.)

The Student Branch of the American Institute of Electrical Engineers held its first meeting on October 24, 1938. Mr. F. W. Allen of the Eclipse Aviation Corporation flew in from Washington to give fifty members of the Society some of the highlights of recent developments in power supplies for airliners. His talk, which brought us close to the practical problems of the power engineer, was supplemented with sketches and an unusually clear picture of the requirements of the aviation power plants.

Mr. Paul Geyer of the Engineering Department of the Lackawanna Railroad will detail for us some of the unusual problems of electric transportation and supervisory control at our next meeting on November 21, 1938.

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

The Student Branch of the Society for the Advancement of Management held its first meeting for the year 1938-1939 on October 10. Three graduates of the college spoke at the meeting: Joseph A. Babeor, Forstmann Woolen Company, Passaic; John Desmond, B. G. Corporation, New York City; and William F. Weir, Aluminum Company of America, Edgewater. The subject of the talk was "A Young Engineer in Industry."

The subject for the meeting in December will be "Building Loan Associations." The speaker will be a graduate of the College.

In October, the three speakers were graduates who have been in industry less than five years. In January, members of the Student Branch will hear from two graduates who have been in industry more than ten years. The subject will be, "My Job in Industry."

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

The Newark College of Engineering Student Chapter of the American Society of Civil Engineers held its second meeting of the year on November 14th. It has become a custom and looked-forward-to pleasure each year to ask the President of the College, who by-the-way is a Civil Engineer, to come and speak to the Chapter. President Cullimore's timely talk this year was on the subject of "Some Disadvantages of Dictatorships." His remarks were to the point and carried added weight as the result of his first-hand observations from his trip to Europe this Summer. The members of the Chapter entered into a lively discussion with President Cullimore at the end of his formal remarks. After the meeting all adjourned for refreshments.

(Reported by Professor W. S. LaLonde, Jr., Faculty Adviser.)

DESIGNING THE RIM UNDER GEAR TEETH

(Continued from page 7)

Using the Stub Tooth Scale and the spoked gear line on the curve it is found that for a 54 tooth gear the factor K is equal to 2.50. Since the rim thickness $T = \frac{K}{DP}$ it becomes $= \frac{2.50}{12} = .208$ inches.

For the same gear, but using a web support the rim thickness becomes

$$T = \frac{K}{DP} = \frac{2.21}{12} = .184 \text{ inches.}$$

Conclusions

It is recognized that it is practically impossible to set up a formula for the thickness of the rim of a gear which can be applied under all conditions. However, the formula which has been derived above which makes the rim without webs or arms, as strong as the root of the gear tooth will provide a starting point for the designer. The simplicity of the final formula lends itself to a standardization program.

Editor's Note: After graduating from Newark College of Engineering in 1931 with a degree of Bachelor of Science in Mechanical Engineering, Waldemar F. Larsen was employed by the Wright Aeronautical Corporation in Paterson, New Jersey, as a detail draftsman. In 1933 he became a stress analyst in the same company. This work was to check new designs for strength and to assist designers with layout problems. The professional degree of Mechanical Engineer was awarded to Mr. Larsen in June, 1938, by N. C. E. for his thesis, "The Design of Valve Cams for Radial Internal Combustion Engines."

Comments by Paul E. Schweizer, Assistant Professor in Mechanical Engineering, Newark College of Engineering:

Mr. Larsen is to be complimented upon the development of a rational relationship for the determination of the rim thickness under gear teeth. The method of design advocated in the standard texts and references is empirical and as is known is based on the number of teeth, the diametral pitch, and the number of arms. The formula seems logical and apparently gives satisfactory results although it would seem reasonable to believe that a more rational formula could be developed. It is not apparent why Mr. Larsen uses the denominator pitch instead of the diametral pitch when the formula is applied to Fellows Stub Teeth but in so doing the results agree quite closely with those obtained from the standard formula.

The new relationship seems to indicate that it is possible to safely use fewer arms or to extend the size of gears with the same number of arms. For example, it is considered good practice to use six arms when the gear diameter is about twenty inches or more. Mr. Larsen's formula seems to indicate that four arms could be used beyond the twenty inch limit.

No doubt the formula will require the determinations of factors because the rim thickness as computed by the Larsen formula is in most cases greater than that obtained by the standard one. It seems that this is a problem which would make an excellent project for study by means of polarized light.

Mr. George P. Slockbower, Advertising Manager of L. Bamberger & Co., courteously supplied the drawing used for the front cover of this issue.

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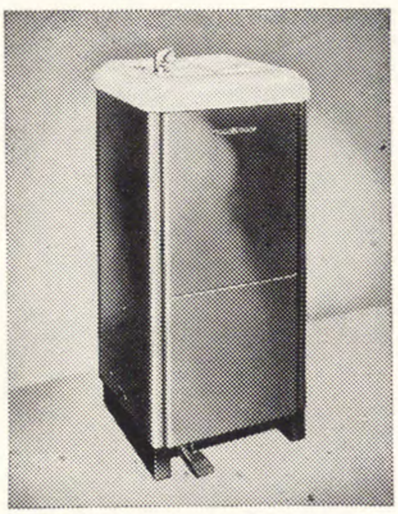

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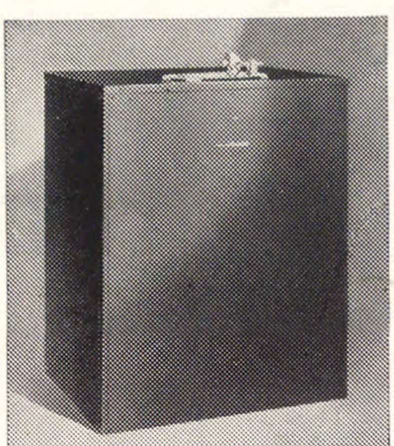

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