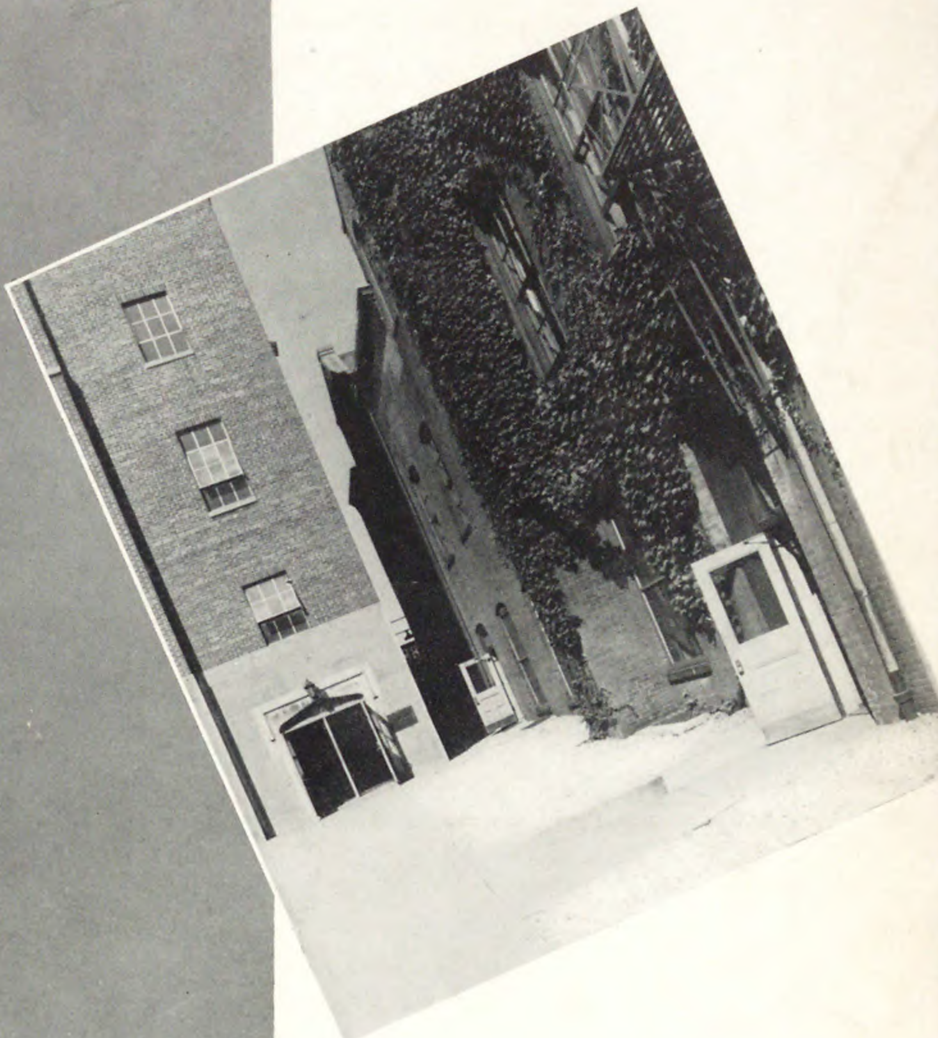

# NEWARK ENGINEERING NOTES

Vol. III, No. 4 May, 1940

Newark College of Engineering will offer the following courses during the coming college year 1940-1941:

(a) Graduate courses designed to be used for credit towards advanced degrees in the several fields of engineering.

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## NEWARK ENGINEERING NOTES

*A Technical Magazine*

*for*

*Chemical, Civil, Electrical, and Mechanical Engineers*

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# NEWARK ENGINEERING NOTES

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# THE PRESIDENT'S DIARY

*May 15th*

In the past few months, and particularly in the past few weeks, a considerable number of the student body and some of the faculty have come to me in real perplexity and asked what I thought about the war and particularly their place and our place in it. This became so general that I spoke to some of the students the other day and to the faculty, about the situation as I saw it, and upon the request of one of these men I am putting it in my Diary.

The other night, in thinking over the whole situation after I had gone to bed, there came to my mind a chapter in a book called "Camping and Woodcraft" by one Horace Kephart. This particular chapter deals with the general subject of "Getting Lost," and it occurred to me that the advice contained in that chapter was not only applicable to getting lost in the woods, but very applicable to the position which we all found ourselves in at the time of this writing. I will not attempt to quote Kephart exactly, but the idea which I have carried concerning the technique of finding yourself is a very simple one and a very effective one and runs something like this:

If, in the course of an excursion in the woods, you find yourself completely bewildered, without any sense of direction, when you have lost the trail and have not even a theory as to how to proceed, there comes upon you first a sense of panic, a desire to do something at all costs, a desire to run to get somewhere. Many a man beats through the bush, shouting and gesticulating, without any idea at all or any vestige of theory about where he is heading or how he intends to come out. The record shows that many of these men emerge from the woods after several days half-crazed. So Kephart advises this:

Find something to sit down on and give yourself about twenty minutes to get things straightened out. Perhaps the sun is obscured, and perhaps it is raining a little and your compass is not in your possession, or perhaps you are even so bewildered that you know the compass is wrong. At least sit quietly until you have some theory. Do not expend your energy. If, after twenty minutes or half an hour you are still in complete bewilderment, give yourself another twenty minutes. Don't do anything until you have a plan or at least some theory as to how to proceed.

If it is along toward dark, prepare to spend the night where you are. Find something that will serve for a bed and heat some stones and, if possible, get a little water and fix up a shelter. The mere doing of something will be helpful and you may need it sorely. Then, when night does come, if you have a gun, fire your shots and the chances are that there may be someone to help you. Tomorrow will be a new day. You will awake somewhat refreshed and, at least and in the worst case, your chances of getting out have been multiplied many times by a calm and careful consideration of the situation.

I think the parallel between a man lost in the woods and my own feeling is so close that I now feel myself in a position of still sitting, giving myself another twenty minutes; and I am almost ready to prepare for the night and whatever contingency this may bring, whether it is snow or rain or even a forest fire. And so I have told the faculty and the students that I think these are very good directions to follow if we are lost, and I find myself in just that predicament at the present time; somewhat bewildered, somewhat afraid, but trying to gather about me all the things which are usable in finding my way out again.

*June 10th*

After everything was pretty well ready for the night, my theory turned up to help me, as theories sometimes do. I can only pass it along because, conceivably, it may be of help to you as it was to me, and this theory is probably a composite of everything I have heard of, everything I have learned or experienced, that I can remember. It is simply this:

That in a country where there are so many different kinds of people; so many different kinds of blood, so many different racial heritages and traditions, so many groups with good things and bad things mixed in varying proportions, that it is absolutely impossible for all of us to see things with the same eyes and exactly alike. Blood is thicker than water; racial traditions hold like grim death; prejudices and intolerances are passed on from father to son, and here in America we boasted and I hope we will always continue to boast of a great mass of people composed of different elements, welded together on the basis of one fundamental principle—that of democracy.

To some of us who were born and lived in America all our lives, this democracy is not very vital perhaps, but it is becoming more vital as it becomes threatened. Of those who have come from other lands, many can appreciate and many of them remember the reason that they came here, and many of them I think, an overwhelming majority, would prefer to stay here rather than go back. At least we are all divided into not one set of groups but innumerable sets of groups. We have our grouping racially; we have our grouping perhaps from a religious standpoint; we have a certain social grouping; some of us have ideals of one kind, some of another; some have subscribed to one code, some to another; some are of one political faith, some of another. All these groupings must, necessarily, be in opposition at least in some regard, and further down than that we all have our own little personal codes, antipathies, antagonisms, and it is right that we should have these because that constitutes democracy—the opportunity to follow out our own destiny.

Now, our problem in America, it would seem, is to integrate and correlate these different groups, these different codes, these different individuals on the basis of some common ground, some common platform on which we can stand—a platform which in its fundamental conception must be a platform which is for the best interests of all of us taken collectively. Our problem is to me quite clear—to weld all these groups with their codes into one homogeneous large group, and that really ought not to be difficult because, after all, in America we choose our leaders. To be sure, I may not have chosen the leader we now have, but I have the right to exercise the choice, and it seems reasonable to suspect that I ought to do the thing and accept the leadership in which I have the right to voice my opinion.

To refuse to abide by the rules of our democratic game, to exercise my right of choice in a political leader and not be willing to abide by the vote, seems to me not only to be poor sportsmanship but very poor democracy as well. In a word, it seems to me that what we must do is bury our individual differences in this emergency; to accept such leadership as we have until we wish to change it, and too, insofar as it is humanly possible, modify and bend our codes in politics, in race and in religion, and even in our personal action toward the common objective which is, as I see it, simply the preservation of the way of life which we have chosen. Now, provided a man has chosen this way of life, provided he has contributed to its development, it would seem to me that he has no choice but to uphold it. Perhaps the word "coöperation" is the key-note. A lack of jealousy between individuals and groups for coöperation to my mind means a collection of groups functioning perhaps differently, believing a little differently politically, religiously and socially, and yet functioning to reach a common object. If this can be secured in any great measure in America, we are safe. If it cannot, I think we are lost. To do this without resort to dictatorship, to propaganda, to indoctrinization, is a huge task, but I believe it can be accomplished.

A. R. Cullimore

# THE ENGINEER IN PUBLIC SERVICE

*By* JOSEPH M. BYRNE, JR.

*Commissioner of the Port of New York Authority*

*Member Board of Trustees, Newark College of Engineering*

(Reprinted with permission from *Mechanical Engineering* for October, 1939)

During the last twenty years, a considerable change has occurred in the character of the problems confronting the engineer and in the conditions under which he labors. The tempo of the change has been accelerated during the latter part of this period rather than decreased. The automobile, the airplane, and the radio, through engineering research, have brought about the development of large industries employing many thousands of persons. These industries in turn have given impetus to the construction of highways, expansion of airway systems, broadcasting chains, and telephone systems. The initial upsurge from the demands which were thus created resulted in a tremendous boom in business and industry. When the bubble burst, a correspondingly exaggerated drop in activity resulted and the search for the causes and cures of depressions was on.

It is the author's purpose to consider the present position and outlook of the engineer in relation to current conditions and to suggest ways in which he may aid in improving them, while at the same time bettering himself.

### *Present Conditions Confronting the Engineer*

In general, there are three ways in which the engineer affects the economic life of his city or community. As an adviser to a private client, his views directly impress themselves upon individual projects and developments. In the public service, his work influences to a large extent the trend and characteristics of the growth of a state, city, or community. As a part of the engineering profession as a whole, he is expected to express well-considered opinions and to advise in an increasing degree on public policy in connection with public works and related problems.

When engaged by a private client, the engineer is often required to submit not one design but several alternative designs. He is asked to express his views concerning the merits and defects of each. The client is thus enabled to determine the most economic solution of his problem, with the result that a better investment is secured to the greater benefit of all concerned.

In public service the engineer is often responsible to a large extent for the natural tendency to improve conditions of living and to secure a greater appreciation for the aesthetic aspects of community life, as expressed in housing and planning. He is required at times to play an important part in molding public opinion and, at the same time, is required to have a due regard for the taxpayer's pocketbook.

A better and more complete planning of public works is becoming more and more the responsibility of the engineer. The relationship of an individual project, with regard not only to other projects but also to its functions in the public interest and to its competitive aspect with private enterprise, is an increasingly important factor, meriting the most serious consideration of which the engineer is capable. Due to strong differences of opinion, mental confusion and uncertainty, and ulterior motives, public-works programs require the logical and unbiased thinking of the trained engineer.

Between the extremes of collective security and individualism, between government ownership and private initiative, between self-liquidating projects and purely social undertakings of doubtful value, between government spending with mounting deficits and individual time-proved old-fashioned economy, the engineer finds himself and his profession in the most critical position in history. Many old schemes dressed up in new terminology are being tried out and found wanting. A magic panacea for our economic ills has been vainly sought and we are now returning to the old fundamental laws handed down through the ages. Under such conditions of mental and moral distress, the engineer is faced with the responsibility of making recommendations as well as decisions of the greatest importance.

JOSEPH M. BYRNE, JR.

Despite the assertions of some, that the ability to solve problems in the physical sciences does not imply such ability in social and economic fields, the author believes that the engineer's training to think logically and in orderly sequence, to seek cause and effect, and to maintain an unbiased attitude, is a long step in the direction of solving social and economic problems. Furthermore, since the engineer is blamed for the technological advances and the conditions resulting therefrom, he must contribute his efforts to a more satisfactory adjustment of our economic as well as our industrial life and is excellently equipped to do so.

### *Qualities of the Engineer*

As a citizen who has had the opportunity of higher education, the engineer is in a position to give critical thought and support to measures initiated for the public good. As a result of his education and experience, he is trained in the technique of honest thinking. He analyzes current problems by reducing them to their simplest terms and discriminates between reliable and faulty data. He is trained to distinguish between the possible, the probable, and the actual. A basic contribution of the engineer to society is his respect for the truth and his training in reasoning correctly and cautiously from given premises. The engineer in speaking to the public tends to argue for the "best plan," to tell the "whole truth," as he sees it, partly because of his education, partly from habit, and partly because of his reputation for being logical, consistent, and impartial.

If the energy and ability of the engineer have created wealth and physical comforts, they have also endangered social stability. If the engineer realizes and assumes responsibility for the technological advances, as he has, he must also recognize the dangers and consequences resulting from his work. For every offensive advance in war and industry, a protective defense is soon evolved. For every defect or ill created, a compensating benefit eventually arrives or a superseding improvement eliminates the original complaint. The physician heals, the educator teaches, the lawyer adjusts human relations; but the engineer for his part will be called more and more to direct the mass effort of his race. He is society's indicated master planner, its research worker seeking truth, and the conservator of its natural resources for coming generations.

*Present Status of the Engineer*

With the advent of the WPA, many agencies and communities took advantage of qualified engineers on the relief rolls. Originally planned to undertake projects of low material costs and of short duration, the WPA developed rapidly into an agency undertaking large projects requiring many months to complete. Many projects were worthy but many more were poorly conceived and not of permanent value. After six years, bargains in engineers from the standpoint of education and experience may be found throughout the country to the great detriment of the engineering profession and the disadvantage of recent engineering graduates who, seeking minor positions, find them filled with men of much longer experience.

Those engineers in positions of responsibility and influence are the ones upon whom rests the task of improving the status of the engineer. It is not enough that they do their own jobs better than ever before. It is imperative that they protect the engineering profession from the demoralizing influences that are reducing it to a position of years ago. Let them stand forth as leaders. The less fortunately situated members of the profession will more than repay such efforts with deeds to the credit of the profession. Those who do lead will themselves acquire stature in life's picture.

On several occasions, leaders in industry and finance have said that engineers prepare estimates and reports upon which lawyers capitalize to establish reputations. The engineer has been forced more and more into industrial management and has been compelled to assume new responsibilities; but many times someone else has assumed the leadership derived from and dependent upon the results produced by the engineer. It is, therefore, essential that the engineer should assert his leadership. He should maintain a reasonable amount of control over the situation and not have others do it for him.

*Need for Engineering Studies*

From the foregoing, it will be seen that there is need for serious study by the engineer of remedies for the present conditions. The public is not interested in research itself but rather in the results of research. The engineer should therefore study to broaden his outlook to include not only engineering but also social utility and public welfare.

If the engineer believes, as does almost everyone, that the cost of government should be lowered and with it his taxes, he should study and analyze the problems confronting his government or community in order to contribute constructive criticism of governmental efforts. He should not continue to let others less able and often selfishly motivated make the decisions detrimental to him and at times not in the public interest. It is a human failing, particularly of engineers, to have a quite logical and economic solution of municipal problems but to permit, without tangible protest, less desirable solutions to be perpetrated upon the public. Engineers are essentially creators and builders and are therefore a powerful influence for good in the public interest.

A realization of this need for study and constructive effort is evidently appreciated by the American Society of Civil Engineers. That Society, through its Committee on Professional Objectives, presented at its annual meeting last January a Symposium on "Improvement of Social, Economic, and Professional Status of the Civil Engineering Profession." Some of the objectives of this committee are: (1) to concern itself actively with subjects incident to engineering practice, in order to develop and maintain high standards of practice and ethics, promote understanding among engineers and between the profession and the public; (2) to provide an agency through which both salaried and employer engineers may express themselves more freely and effectively on professional matters; (3) to give general consideration to national and state legislation affecting the engineer; (4) to give *particular* consideration to the economic and social status of the engineer and to national and social trends affecting him; and (5) to encourage and to demand a wider employment of engineers both in engineering and in technical works.

With the stated objectives of the American Society of Civil Engineers, the author believes the members of The American Society of Mechanical Engineers should be in hearty accord. In the final analysis, the ultimate goal of the engineering societies is the better development and greater advancement of its individual members. In striving to attain that goal, society and government will surely benefit.

*How Can the Engineer Help?*

But, you ask, what can the individual do about it? How can he help his city or community? How can he help himself? In answer, the following suggestions are proposed:

*Get Acquainted!* You have neighbors who are just like yourself and who have opinions to express. Learn their viewpoints; you will be surprised at how different they are. You will find that they, as in your own case, would much rather stay home and contain themselves in their own separate spheres of life and let the "other fellow" do the civic work. But, you should not complain if you yourself will not do anything to help.

Learn who are your representatives in local as well as in state offices. What is their background and experience? You may be amazed at their lack of previous experience in civic affairs.

What about your Board of Education? Who are they and what do they do? In many communities you will be surprised and pleased to find excellent members. This will inspire confidence and induce your support. In other communities you may be disappointed and see a need for change.

*Educate Yourself!* Inform yourself as to the problems under consideration by your local boards and representatives. Perhaps minor matters receive too much consideration and major items are neglected. The first step in considering any problem, as you know from your engineering work, it to obtain complete data before expressing an opinion.

What has your city or community done about planning, or housing, or safety, or law enforcement? Who are the individuals who concern themselves with these matters?

Civic associations and taxpayers' leagues are generally to be found in communities and cities of any size. Where they are not politically dominated and are able to maintain a non-partisan attitude, they serve a useful purpose. While the author does not advocate joining a civic association or reform group, to do so is often broadening as well as informative.

*What Can You Do?* Assuming that you are now informed in a general way upon civic questions and the interested parties, the next step is to analyze your impressions. Questions of public interest, particularly appropriations and public works, are generally subject to the greatest discussion. Place yourself in the position of the local officials and list the arguments for and against. Attend a meeting of the local board and ask questions. Try out your comments on a neighbor. His reaction may not be as logical nor coincide with your views.

Sound out a local official for his reaction. To do so will show two things to him: First, that you are interested, and second, that you are thinking. You will also find that you can probably get from other sources further information which it may be well to secure. If you feel that you can make a suggestion or recommendation, do so by all means. The right kinds of public officials welcome suggestions and, even when busy, make every effort to answer all suggestions, inquiries, and recommendations. By so doing, the public official gets another viewpoint and may either modify his own idea or be confirmed in his convictions when answering you. The successful public official develops tact, patience, and tolerance and, in your dealings with him and others, you may acquire your share of such characteristics.

To many, the work of planning boards and similar commissions is the most interesting activity of public bodies. It is deserving of this interest because of the importance of the questions generally handled. It may be possible for some of you to serve on such boards. Too often the smaller planning boards are composed of real-estate brokers and builders with never a flavoring of engineers. This is in large part due to the greater interest of the former and to the lack of interest of the engineers.

Particularly to the younger engineers, the suggestion is made to get out and get acquainted. It is realized that to do so for most men, and particularly engineers, is most unwelcome, because it is much more restful to the nerves and disposition to stay at home or go to the movies, and not take an active part in civic affairs. Aside from its educational value and as the duty of a free citizen in a troubled age, such activity lends support to the efforts of local leaders and definitely influences the trend for better government. Effective public understanding cannot be realized by a mere handful of broadly educated men; there must be not only those who serve the general welfare directly in their stated capacities but untold others who, as citizens possessed of higher education, will give critical thought and support to measures initiated for the public good.

*Benefits to Be Derived*

The help rendered by the engineer to his city or community by civic activity is also of benefit to himself. Quite apart from the training such experience gives, it is of value, especially to the young engineer, in that it increases his acquaintance and broadens his outlook.

To the younger men of ability, progress seems very slow, with all the good jobs evidently being filled. It is interesting to reflect that those in good jobs are growing older at the same rate as those in minor jobs; in fact in this day and age, they are actually growing older faster. The younger engineers particularly should pay attention to their own preparation for these bigger jobs. They should keep their minds free from bias and broad in outlook because it is inevitable that some of them will have to perform the functions which are now performed by the older men.

To the engineer who is employed, experience in civic affairs gives the engineer a better appreciation of the relationship between his city or community and his employers, particularly if he is employed by one of the larger corporations. His value to his employers is greater, whether they know of his experience or not, because his viewpoint will be reflected eventually in the public relations of his employers, even though not remotely connected with the political subdivision in which he has become interested. The author does not believe it to be in the public interest for employees to be politically active in localities where they are engaged in business. They should, however, take an active part where such conditions do not prevail.

To the engineer who is not definitely established in some line of employment or in some company, such experience is often very helpful in leading to employment at times when it is most needed, due to the friendships which are made. Neither does this necessarily mean political friendships. Men of initiative and ability are sought even more by hardheaded business executives than by political leaders.

Another benefit to the engineer is often the public recognition which such activity affords. The engineer is on the threshold of increasing prominence. In the advertising over the radio and in publications, the engineer is mentioned many times as the authority for facts and new discoveries. It is, therefore, logical for the public to appreciate and to credit the engineer with efforts made toward civic betterment, and, as a result, to support him in his efforts along such lines.

Finally, to quote Dr. Robert E. Doherty, president of Carnegie Institute of Technology, who expresses a thought which seems particularly appropriate at this time:

"There are certain things to which we must cling at all costs. We must keep intellectual freedom; we must keep personal liberty to the greatest possible degree; we must keep incentives to constructive effort. These tongue - worn phrases still symbolize the American dream. They represent ideals for which great sacrifices already have been made in life, treasure, and change of view. And it is unthinkable that, as trustees of these gifts, we should fail in the decision and action that should preserve them.

"Will professional men not only in industry but also in politics, finance, and education, on all of whose shoulders this responsibility rests, act in time? Or will the ossification of view as we reach the age of professional decision prevent our taking the initial step that is necessary before the younger generation, yet in college, can have the opportunity to prepare itself? I have no fear, that, given plenty of time, we should not reach the right decision; I do have fear that under the now greatly increased tempo of life we may wait too long."

Bearing in mind what may not have been too clearly expressed by the author, will you not seriously consider the many and varied ways in which you, as engineers, can help your city and yourself? And if you can lend your aid in a field of endeavor which you feel will benefit your community, it is certain that you as well as your city or community will benefit.

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## PETER HOMACK WINS AWARD

A young man from the Newark College of Engineering has been awarded the Robert Ridgway Student Chapter Prize of the Metropolitan Section of the American Society of Civil Engineers. He was presented with the award by the President of the American Society of Civil Engineers on Wednesday, May 15, at the Engineering Societies Building in New York.

The award is presented annually to one student from each of the eight colleges from the Metropolitan Area having student chapters of the Society. Peter Homack was selected from the Newark College of Engineering.

The selection of the recipient is based upon scholarship in civil engineering, extra-curricular activities in the college, and personal attributes. The prize consists of remission of the entrance fee and dues for one year and a badge of a Junior in the American Society of Civil Engineers.

Peter Homack is a senior in the Department of Civil Engineering. He is the son of Mr. and Mrs. A. Homack of 108 Besler Avenue, Cranford, New Jersey. He was graduated from the Cranford High School in 1936, where he was a member of the National Honor Society. At the Newark College of Engineering, he is a member of the Trunnion Society, honor group patterned after Tau Beta Pi, the national engineering honor organization.

# "WHY SHOULD I STUDY THIS?"

*By* JAMES A. BRADLEY, A.B., A.M.

*Dean and Associate Professor in Chemistry, Newark College of Engineering*

Just after the last war, when I took my first industrial position, I was placed under the direction of a man slightly older, who had been mustered out of the Navy about the same time as myself. We were working in the rather specialized field of dyestuff chemistry. I had been with him for some weeks before I discovered that he was not a chemist at all, but a mechanical engineer.

I asked him how he had happened to stray so far from his profession. He said that he did not know whether to blame it on the fortunes of war or the fortunes of peace, and that, furthermore, he did not feel that he had wandered so very far, anyway, because, once you get a chemical process going, it becoms a matter chiefly of mechanical engineering. He had left the Navy, he went on, at a time when a good many civilians were also leaving the services of industries that had been necessary while the war was on; leaving them because there was no longer a demand either for them or for the industries. It was no time to be very particular about what one would do. The best that could be hoped was that you would not fit too badly into whatever position you could get.

My future director, on looking about him, decided that the dyestuff industry seemed to have been started in earnest in America; that it looked like a healthy infant with a good future; and that he would try his luck in it. What arguments he used to persuade the company to employ him, I do not know, but there he was, and there he stayed through a minor depression, while highly-trained chemists were let go. Perhaps the company felt that a mechanical engineer who had grown into the ways of a new chemical industry had a rare value; that he was a trained member of a technical team who could not easily be replaced.

This kind of adaptability is a quality that one needs more and more in these uncertain days. Seldom, either now or in the past, has there been a secure little niche awaiting many of us. Each of us may start with the intention of becoming some particular kind of engineer or doctor or business man. Some of us may hold to our plans and, if we have a touch of the superman in us, may reach our predetermined goal in spite of all obstacles. But most of us bend with the winds of fortune (which may be a wise procedure), adapt ourselves to the world as we find it, go into regions which are more or less attractive and which are allied to our training, and do well for ourselves. Some men, however, as employment officers know, will show no interest in any but one particular kind of work and, letting opportunities in other fields pass by, will be satisfied with nothing except that to which they seem to have dedicated themselves. A heroic attitude such as this, one might think, would carry with it a corresponding ability in the work, but, unfortunately, in most cases it does not. We are dealing here with a kind of mental stubbornness like that of the traditional artist who would rather paint pictures and starve than become a useful apothecary or grain merchant. Of course, the artist might have become an apothecary and painted pictures, too, in his spare time, and waited for the masterpiece to come. And the man who has decided to become a great designer might, conceivably, work for a while at another job and continue his studies while awaiting his great chance.

This was the very path followed, in the earlier days of chemistry, by more than one great chemist. At that time there was no profession of chemistry, as we now know it. Applied chemistry (an unknown term at the time) was an art practiced by such people as tanners and glass makers and miners; an art handed down from master to apprentice. Little or nothing was known by the practitioners about the chemical nature of the operations they tended. But there were some men, the scholars and investigators, who studied the chemical behavior of matter because of their intellectual curiosity. They worked in their own laboratories or in the laboratories of their patrons or they lectured in universities. A few, like Boyle and Cavendish were wealthy. But most of them had to depend, in part at least, on another means of livelihood. Scheele was an apothecary who carried out his famous investigations at odd times in his shop. Priestley, an early worker on gases and the discoverer of oxygen, was a clergyman. Lavoisier was primarily a civil official. But their greatest work was in chemistry.

There is no harm in straying for a time from our particular technical fold. In fact, we might pick up an amount of valuable experience and knowledge on the way. Perhaps we may never come back to it because we find the pastures through which we stray greener and richer. We must remember that the first choice may be a narrow choice and a poor one. A famous schoolmaster once said: "No one is infallible, not even the youngest of us." And a first choice of a profession may be based on a very limited knowledge of the possibilities of that profession and of life in general. What does the recently graduated technical man know of the avenues that may be open to him or of the requirements or the rewards in various fields? He has been studying chiefly, and has been primarily interested in, the technical aspects of industry. The meetings of his student societies have been usually devoted to reading or listening to papers on specialized scientific subjects. In a field where development is very rapid it is no more than wise to listen occasionally to specialists who can bring news of the latest happenings. There is much to be said, of course, for this use of the monthly meeting which may serve as an abstract of some phase of engineering or science. But might it not be wise also to devote this activity, in part at least, to a survey, necessarily limited, of some branch of industry or technology?

At the Newark College of Engineering, the Student Branch of the American Institute of Chemical Engineers has undertaken to do this very thing. Instead of hearing, month after month, talks on distillation or filtration or plastics or ceramics, the members are planning to have an occasional speaker who can tell from his own experience what a certain industry is like. Last year an editor of a chemical journal talked on his work. This year we have listened to an engineer from the National Board of Fire Underwriters who told us about the role of the engineer in insurance work. Later this year an engineer from the Socony-Vacuum Oil Company will talk on the "future utilization of technical men in the petroleum industry." And other meetings, of the same type, will be held, it is hoped, in later years.

To return to the role of chance in the determination of the life work of an individual, we have had interesting illustrations of this in the stories of some of the men who have talked before our student society in the past two years. Two of them, I remember, prefaced their talks by remarking that they had entered their present positions with the understanding, and the hope, that they would be temporary only. One had studied law. He is now running a distillation plant. Another had begun life as a civil engineer, but, after thirty-one years of insurance work, he is beginning to feel that his present position is permanent. Among our other speakers who did not refer directly to their wanderings, it was possible, nevertheless, to discover some who had travelled a rather winding road.

If, out of a dozen or so representative technical men, such a notable proportion have strayed into bypaths, we may wonder whether this is not a common happening. How many men who plan to enter particular fields actually spend the major part of their productive years in it? I suspect that the answer varies with the profession. There are probable few medical graduates who do not become doctors. But in engineering the way is open to a diversity of occupations. One may expect to find an engineering graduate almost anywhere: in business, banking, politics, salesmanship, promotion, the law, or one of the other unexpected activities that may be found listed in alumni directories of engineering schools. One is tempted to think that they have looked on engineering as a tool rather than a trade, adopting the advice which Teeple has given to the chemists.

Of course, it must not be assumed that in these strange occupations they make no use of their training. Fundamentally, engineering is planning and directing, and engineering education is concerned with learning how to use the tools by which the plans are made possible. The greater the choice of tools at one's disposal, the more varied may be the work which one may plan and direct.

I find sometimes in working with students, and the discovery is more common in dealing with the poorer ones, an attitude which depreciates those things which seem to have no bearing on technology. They may tolerate such courses as English or economics, but not consider them important or take them seriously. They plan, perhaps, to enter research or to engage in manufacturing and hope to leave what they consider the nonprofessional side of their "trade" to others. This attitude, of course, stems from an ignorance of the nature of professional work. When they are out of college for some years they will feel differently. They will realize that they cannot get away from such matters as English and economics and live a life wholly concerned with research or design or manufacture.

It would be interesting in this connection to consider the results of a survey that was reported recently from a western university. A set of questions was sent to the alumni of the last twenty-five years, whether they had graduated, been flunked out, or had merely "left," since the purpose of the study was, in part, to find out something about all students, not those who had been good enough or fortunate enough to graduate. The survey showed, among other things, that what the average alumnus felt he needed most was training for the ordinary things of life: how to write a business letter, how to plan work for others, how to make a speech, how to interpret economic trends, how to keep a budget, and so forth.

To one not intoxicated with too high a respect for technical knowledge, it would seem that one of the most precious talents is the ability to express one's self clearly and fluently and, perhaps, gracefully. And this brings us face to face with the question of English composition. Looked at from a practical angle, one might be tempted to call a course in composition a course in persuasion. Just as we can be attracted by words, we can be repelled by them. We have all had the experience of reading a few pages of a novel and then throwing it aside. Then later we are told by some one: "Oh, you should have read a little further. It goes much better. A wonderful book." And so the author has lost a reader, perhaps an admirer, by a dull first chapter. The same neglect could befall a technical report or an article in a scientific journal which had a high concentration of interest in its middle, but a very flat beginning. While in the hands of a clever writer the very title could be made an effective "For Sale" sign.

It is a pity that we cannot write as simply as we speak. But most of us, when we use the pen or the typewriter, begin to use language that is unnecessarily involved. In fact, we may start a sentence and find it so complicated before it is ended, that in discouragement we cross it out and begin again. This is part of the hard work of writing. Few people, even among those who live by writing, find composition pleasant. I have heard writers say that they have to drag themselves to the work table. But once they get there, the process of creating as good a piece of work as possible may become an actual pleasure. Then, after the first draft, there comes the polishing up, the elimination of unnecessary yardage. And at last there is the finished piece of writing with which the creator is so seldom satisfied.

The finished writer cannot be developed in an undergraduate course in English composition. But the college course can take a raw writer, criticize his work, analyze its defects, give him the basic ideas of clearness, structure, unity, and other elements of composition, and finally warn him that he must write as well as he can, not only when trying to please the English Department, but at all times. After that there is nothing left for him to do but practice. If he wants to be very good, he can use Kipling's method and write a gem of a few thousand words on a few sheets of paper, leaving a waste basket filled with discarded material under the desk.

But, one may object, technical matter cannot be made into good literature. This was the objection I once made to a teacher of composition when he suggested that I choose a subject from one of my other courses. "But," he said, "you could write on the steam engine and make it good literature." I have learned since that there are technical works that are classics. Boyle wrote "The Sceptical Chymist." Darwin wrote a number of works that are excellent literature. Pasteur had a beautiful style when he wrote about chemicals and bacteria. Even a mathematical-physical subject can be made into good literature. I consider Lewis and Randall's "Thermodynamics" a beautifully written book.

Many an undergraduate would avoid, if he could, the required course in English composition. But escape it he cannot. It is one of the "musts" in every college and a very necessary "must." It seems to be considered more valuable every year. In his latest report the President of Harvard University has stated that it was felt that "the need for this type of instruction was so manifest" that fewer freshmen were allowed to earn exemption from it by way of the entrance examinations. As a result, seventy-one percent of the current Freshman class is enrolled in the course in English composition as compared with fifty-eight percent a year ago. And, while a Freshman course in English composition will not solve all our problems, it will help in improving an embarrassing situation where we find complaints from all sides of the inability of the average college graduate to write either fluently or correctly.

I once listened as a member of a small group while an educator talked about the changing of college entrance requirements as he had seen it over a long period. He caused considerable amusement by telling of a certain university that had listed for a long time a course in bookkeeping among its entrance requirements. Between his words one could feel that he was saying: "You may be sure we soon stopped that." At the time I could not see the reason for the mirth of his audience and I cannot now. I could have used a course in bookkeeping myself much more than some of the other courses I had taken. So, probably, could most of those who were listening to him. It is a study which gives one a conception of order, not in a far-fetched way, but very directly. Fundamentally, it is a matter of keeping records. That the records are in dollars and cents is merely incidental. The training can be carried over into any other department or into life in general. One of the duties of the engineer is to keep a record of his own work, even after he has made a report on it to some one higher up. This means filing it in an orderly way so that it can be reached in a few moments, not after a morning's search. I was talking some time ago with one of our recent graduates about this very matter. His experience was illuminating. His first assignment in

*(Please turn to page 27)*

# THE GENERAL QUADRATIC, OR CONIC, ANGLE AND ITS FUNCTIONS

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Trigonometrical functions are relationships that may be expressed in one or more, usually all three, of the following ways:

1. As a series.
2. As an exponential function.
3. As the ratio of two geometric elements of the circle or an hyperbola.

These two curves are special cases of the general second degree, or quadratic, curve in two variables, sometimes called a conic section. This is defined as the locus of a "point which moves so that its distance from a fixed point (called the Focus) bears a constant ratio (called the Eccentricity) to its distance from a fixed straight line" (called the Directrix)*. The eccentricity may have a wide range of values, zero and unity being critical. When the eccentricity is zero, the curve is a circle; all curves for which the eccentricity has a value between zero and unity are ellipses; all those for which the eccentricity is greater than unity are hyperbolas.

### *Elements of the General Quadratic Curve*

The straight line through the focus and perpendicular to the directrix is called the Principal Axis of the curve; in diagrams of these curves it is usually most convenient to locate the principal axis parallel to the X-axis or co-incident with it. Each curve cuts the principal axis twice, and has two foci.

In the three types of curves just mentioned, that portion of the principal axis between the two intersections is called the Major Axis, and its middle point is called the Center of the curve. One-half the length of the major axis, or the distance from the center to one of the intersections, is usually designated by the letter "a"; it is an important element of the curve, frequently serving as a unit of length for distances related to the curve.

The principal foci are on the principal axis, equidistant from the center of the curve. In the circle the distance between the foci is always zero, and, with a fixed major axis, the size or shape of the figure cannot be altered.

In the case of the ellipse, as the eccentricity increases from zero, the distance between the foci increases from zero to the length of the major axis; the transverse dimension of the figure, or the minor axis, decreases from the equality with the major axis found in the circle, to zero. The distance between the foci increases in such a way that its ratio to the major axis is equal to the eccentricity. Thus the circle on the major axis, and the major axis, itself, are the extreme cases of the ellipse.

In the case of the hyperbola, as the eccentricity increases, from the lower limit of unity, to infinity, the distance between the foci continues to increase in such a way that its ratio to the major axis is still equal to the eccentricity. The transverse dimension also increases in this case, from zero at the lower limit, to infinity. Thus the principal axis, outside of the fixed major axis, and two perpendicular lines through the latter's extremities, are the two extreme cases of the hyperbola.

By starting again with the circle, the foci can be separated symmetrically along the Y-axis instead of along the X-axis. This procedure results in an ellipse, as before, but the longer dimension is along the Y-axis instead of the X-axis. The short dimension of the figure, between the two X-intercepts, remains constant in length and may still be regarded as the major axis of the curve. (See Fig. 1.)

The ratio of the distance separating the foci to the major axis may still be regarded as the eccentricity which satisfies the equation of the ellipse, provided it is considered as an imaginary quantity. This is justified since the focal distances are now at 90° to the major axis. So regarded, the eccentricity may increase from 0 to $j\infty$, without critical values. When it becomes infinite,

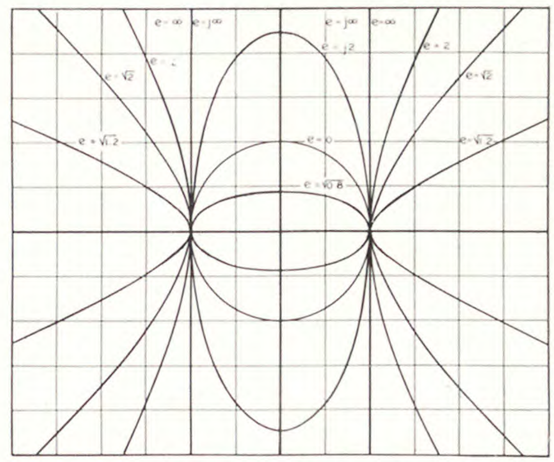


*Figure 1. Conic Sections for Various Eccentricities*

this conjugate ellipse reduces to the same two straight lines, perpendicular to the major axis at its extremities, which were the limiting hyperbola with a real value of infinity for the eccentricity.

It is now apparent that the circle is one of an infinite number of ellipses which may be constructed upon a given major axis by varying the eccentricity from 1 through 0 to $j\infty$. Also, that an infinite number of hyperbolas can be constructed upon the same major axis by varying the eccentricity from 1 to $\infty$.

It may now be observed that while circular trigonometric functions are definite in concept and value, hyperbolic trigonometric functions are quite indefinite unless the eccentricity is also specified. By long usage, hyperbolic functions are based upon the equilateral or rectangular hyperbola with an eccentricity equal to $\sqrt{2}$.

The question at once arises: can the concepts of hyperbolic angles and hyperbolic functions be generalized to apply to an hyperbola of any eccentricity? Since the circle is merely a specific ellipse, the question also presents itself: Can the concepts of circular angle and circular functions be generalized to elliptical angle and elliptical functions? Finally, can this generalizing process be carried a step further to what might be called the general quadratic, or conic, functions?

To attempt to answer these questions is the purpose of this discussion. The general quadratic angle will first be investigated, as the easiest and most logical approach to the other questions.

### *The General Plane Angle*

A plane angle may be defined in two ways which are sufficiently general to apply, not only to hyperbolic angles of

*Tanner & Allen—*Analytic Geometry*

$e = \sqrt{2}$, and to circular angles, but to elliptic angles and hyperbolic angles of any degree of eccentricity. The first reduces the ratio of arc to radius to a differential basis, and then integrates the resulting differential. Thus

$$\theta_Q = \int_0^S \frac{ds}{\rho} = \int_0^y \frac{\sqrt{\frac{dx^2}{dy^2} + 1}}{\sqrt{x^2 + y^2}}\, dy \quad \text{I}$$

The second way defines a plane angle as the ratio of the area of the sector of a conic section between the major axis and the radius, to half the square of the semi-major axis. Thus

$$\theta_Q = \frac{2A}{a^2} = 2\,\frac{\int_0^y xdy - xy}{a^2} \quad \text{II}$$

In attempting to evaluate the first equation with the use of the general equation for conic sections, the well-known Elliptic Functions appear. But the area of a sector of a conic section can readily be found, so that the second definition will be used to determine a general conic, or quadratic, angle and its functions.

*The General Conic, or Quadratic, Angle*

The general expression for a conic section having its center at the origin of co-ordinates and its major axis on the X-axis is:

$$(1 - e^2)x^2 + y^2 = a^2(1 - e^2) \quad \text{III}$$

$$\text{Whence } x^2 = \frac{a^2(1 - e^2) - y^2}{1 - e^2} = \frac{y^2 + (e^2 - 1)a^2}{e^2 - 1}$$

$$\text{and } \theta_Q = \frac{2A}{a^2} =$$

$$\frac{\frac{2}{\sqrt{e^2 - 1}}\int_0^y \sqrt{y^2 + (e^2 - 1)a^2}\, dy - \frac{y\sqrt{y^2 + (e^2 - 1)a^2}}{\sqrt{e^2 - 1}}}{a^2}$$

Performing the integration, and simplifying, it develops that

$$\theta_Q = \log \left(\frac{y + \sqrt{y^2 + (e^2 - 1)a^2}}{a\sqrt{e^2 - 1}}\right)^{\sqrt{e^2 - 1}}$$

$$= \log \left(\frac{y + x\sqrt{e^2 - 1}}{a\sqrt{e^2 - 1}}\right)^{\sqrt{e^2 - 1}} \quad \text{IV}$$

By using "a" as the unit length for evaluating the ordinate y, "a" becomes 1, and the expression for the angle becomes

$$\theta_Q = \log \left(\frac{y + \sqrt{y^2 + (e^2 - 1)}}{\sqrt{e^2 - 1}}\right)^{\sqrt{e^2 - 1}} \quad \text{V}$$

Hence, the general quadratic angle is the natural *logarithm* of a number which is a function of two partially independent ratios: the eccentricity, and the ratio of the ordinate of a point on the curve to the semi-major axis. The former determines the particular curve to use, and the latter determines the particular point that bounds the angle.

*Two Definitions of a Plane Angle Compared*

Having obtained an expression for a general quadratic angle, one can compare the two methods of defining an angle. This can be done by taking the derivative of the general angle, and comparing it with the differential angle of the first definition.

By differentiating equation IV and simplifying, and then squaring, it is found that

$$\left(\frac{d\theta_Q}{dy}\right)^2 = \frac{e^2 - 1}{y^2 + (e^2 - 1)a^2}$$

By evaluating the differential angle of the first definition, Equation I, it appears, after simplification, as

$$\left(\frac{d\theta_Q}{dy}\right)^2 = \frac{\frac{dx^2}{dy^2} + 1}{x^2 + y^2} =$$

$$\frac{e^2y^2 + (e^2 - 1)^2 a^2}{(y^2 + (e^2 - 1)a^2)\,(e^2y^2 + (e^2 - 1)a^2)}$$

By equating these two expressions, and simplifying, it is found that

$$e^2y^2(2 - e^2) = 0$$

For this equation to be true when y is anything but zero, either

$$e^2 = 0, \quad \text{or } e^2 = 2$$

Therefore, the two definitions of an angle are equivalent only when the angle is based on a circle or on an equilateral hyperbola.

In summation, then, consider the concept of the simple circular angle; it has a geometrical expression as the divergence between two intersecting straight lines, and an analytical expression as the ratio of two distances. By the application of a general analytical expression defining an angle to the equation for the general quadratic curve, the concept of a general quadratic angle is developed. In the generalizing process the geometric picture is lost, so that the only expression for the general quadratic angle is a logarithmic function.

*Functions of the Quadratic Angle*

The principal functions of the quadratic angle are the sine and the cosine, which may be defined as, respectively, the ordinate and the abscissa of the point on the curve which determines the angle, the semi-major axis being taken as unity. These functions may readily be determined from the expression for the general angle by putting it in the exponential form.

$$\varepsilon^{\frac{\theta_Q}{\sqrt{e^2 - 1}}} = \frac{y + \sqrt{y^2 + (e^2 - 1)a^2}}{a\sqrt{e^2 - 1}} = \frac{y + x\sqrt{e^2 - 1}}{a\sqrt{e^2 - 1}}$$

$$\varepsilon^{-\frac{\theta_Q}{\sqrt{e^2 - 1}}} = \frac{a\sqrt{e^2 - 1}}{y + \sqrt{y^2 + (e^2 - 1)a^2}} = \frac{y - x\sqrt{e^2 - 1}}{-a\sqrt{e^2 - 1}}$$

$$\text{Then } \varepsilon^{\frac{\theta_Q}{\sqrt{e^2 - 1}}} + \varepsilon^{-\frac{\theta_Q}{\sqrt{e^2 - 1}}} =$$

$$\frac{y + x\sqrt{e^2 - 1} - y + x\sqrt{e^2 - 1}}{a\sqrt{e^2 - 1}} = \frac{2x}{a}$$

$$\text{and } \varepsilon^{\frac{\theta_Q}{\sqrt{e^2 - 1}}} - \varepsilon^{-\frac{\theta_Q}{\sqrt{e^2 - 1}}} =$$

$$\frac{y + x\sqrt{e^2 - 1} + y - x\sqrt{e^2 - 1}}{a\sqrt{e^2 - 1}} = \frac{2y}{a\sqrt{e^2 - 1}}$$

So that

$$\sin \theta_Q = \frac{y}{a} = \sqrt{e^2 - 1}\,\frac{\varepsilon^{\frac{\theta_Q}{\sqrt{e^2 - 1}}} - \varepsilon^{-\frac{\theta_Q}{\sqrt{e^2 - 1}}}}{2} \quad \text{VI}$$

$$\text{and } \cos \theta_Q = \frac{x}{a} = \frac{\varepsilon^{\frac{\theta_Q}{\sqrt{e^2 - 1}}} + \varepsilon^{-\frac{\theta_Q}{\sqrt{e^2 - 1}}}}{2} \quad \text{VII}$$

*Functions of Particular Cases of the Quadratic Angle*

With the substitution of characteristic values for the eccentricity, expressions will appear that, in some cases, are familiar.

1. The conjugate ellipse, where $e = je$.

$$\theta_Q = \theta_E = \log \left(\frac{y + \sqrt{y^2 - (e^2+1)}}{j\sqrt{e^2+1}}\right)^{j\sqrt{e^2+1}} \tag{VIII}$$

$$\sin \theta_E = \sqrt{e^2+1}\; \frac{\varepsilon^{j\frac{\theta_E}{\sqrt{e^2+1}}} - \varepsilon^{-j\frac{\theta_E}{\sqrt{e^2+1}}}}{j2} \tag{IX}$$

$$\cos \theta_E = \frac{\varepsilon^{j\frac{\theta_E}{\sqrt{e^2+1}}} + \varepsilon^{-j\frac{\theta_E}{\sqrt{e^2+1}}}}{2} \tag{X}$$

2. The circle, where $e = 0$.

$$\theta_Q = \theta_C = \log \left(\frac{y + \sqrt{y^2 - 1}}{j}\right)^{j} \tag{XI}$$

$$\sin \theta_C = j\, \frac{\varepsilon^{\frac{\theta_C}{j}} - \varepsilon^{-\frac{\theta_C}{j}}}{2} = \frac{\varepsilon^{j\theta_C} - \varepsilon^{-j\theta_C}}{j2} \tag{XII}$$

$$\cos \theta_C = \frac{\varepsilon^{\frac{\theta_C}{j}} + \varepsilon^{-\frac{\theta_C}{j}}}{2} = \frac{\varepsilon^{j\theta_C} + \varepsilon^{-j\theta_C}}{2} \tag{XIII}$$

3. The ellipse, where $0 < e < 1$; say $e = \sqrt{0.5}$

$$\theta_Q = \theta_E = \log \left(\frac{y + \sqrt{y^2 - 0.5}}{j\sqrt{0.5}}\right)^{j\sqrt{0.5}} \tag{XIV}$$

$$\sin \theta_E = j0.707\, \frac{\varepsilon^{\frac{\theta_E}{j0.707}} - \varepsilon^{-\frac{\theta_E}{j0.707}}}{2}$$

$$= \frac{\varepsilon^{j\frac{\theta_E}{0.707}} - \varepsilon^{-j\frac{\theta_E}{0.707}}}{j2\sqrt{2}} \tag{XV}$$

$$\cos \theta_E = \frac{\varepsilon^{\frac{\theta_E}{j0.707}} + \varepsilon^{-\frac{\theta_E}{j0.707}}}{2}$$

$$= \frac{\varepsilon^{j\frac{\theta_E}{0.707}} + \varepsilon^{-j\frac{\theta_E}{0.707}}}{2} \tag{XVI}$$

4. The critical case, where $e = 1$.

$$\theta_Q = \log \left(\frac{y + y}{0}\right)^{0} = \log 1 = 0 \tag{XVII}$$

$$\sin \theta_Q = 0\, \frac{\varepsilon^{\frac{0}{0}} - \varepsilon^{-\frac{0}{0}}}{2} = 0 \tag{XVIII}$$

$$\cos \theta_Q = \frac{\varepsilon^{\frac{0}{0}} + \varepsilon^{-\frac{0}{0}}}{2} \tag{XIX}$$

or indeterminate, as a function of the angle.

This is a critical case, not only because it is a limiting case for both ellipse and hyperbola, but also because an eccentricity of unity is usually associated with a parabola. With a major axis of finite and constant length, the quadratic curve collapses into the axis when $e = 1$, and the parabola does not appear. The parabolic case of the general quadratic angle will be treated in a separate discussion.

5. The hyperbola where $1 < e < \sqrt{2}$; say $e = \sqrt{1.5}$

$$\theta_Q = \theta_H = \log \left(\frac{y + \sqrt{y^2 + 0.5}}{\sqrt{0.5}}\right)^{\sqrt{0.5}} \tag{XX}$$

$$\sin \theta_H = \sqrt{0.5}\, \frac{\varepsilon^{\frac{\theta_H}{0.707}} - \varepsilon^{-\frac{\theta_H}{0.707}}}{2} \tag{XXI}$$

$$\cos \theta_H = \frac{\varepsilon^{\frac{\theta_H}{0.707}} + \varepsilon^{-\frac{\theta_H}{0.707}}}{2} \tag{XXII}$$

6. The equilateral hyperbola, where $e = \sqrt{2}$.

$$\theta_Q = \theta_H = \log \left(\frac{y + \sqrt{y^2 + 1}}{1}\right)$$

$$= \log (y + \sqrt{y^2 + 1}) \tag{XXIII}$$

$$\sin \theta_H = \frac{\varepsilon^{\theta_H} - \varepsilon^{-\theta_H}}{2} \tag{XXIV}$$

$$\cos \theta_Q = \frac{\varepsilon^{\theta_H} + \varepsilon^{-\theta_H}}{2} \tag{XXV}$$

7. The hyperbola where $\sqrt{2} < e$; say $e = \sqrt{3}$.

$$\theta_Q = \theta_Q = \log \left(\frac{y + \sqrt{y^2 + 2}}{\sqrt{2}}\right)^{\sqrt{2}} \tag{XXVI}$$

$$\sin \theta_H = \sqrt{2}\, \frac{\varepsilon^{\frac{\theta_H}{\sqrt{2}}} - \varepsilon^{-\frac{\theta_H}{\sqrt{2}}}}{2} = \frac{\varepsilon^{\frac{\theta_H}{\sqrt{2}}} - \varepsilon^{-\frac{\theta_H}{\sqrt{2}}}}{\sqrt{2}} \tag{XXVII}$$

$$\cos \theta_Q = \frac{\varepsilon^{\frac{\theta_H}{\sqrt{2}}} + \varepsilon^{-\frac{\theta_H}{\sqrt{2}}}}{2} \tag{XXVIII}$$

*Evaluation of Quadratic Functions*

In evaluating the functions of the quadratic angle, it always appears as a pure number, regardless of what its graphical representation may be. This fact suggests that the emphasis may well be transferred from the variety of angle concepts to be associated with the several quadratic curves to the variety of functions of a fundamental variable which may be obtained through the agency of these same curves and their algebraic equivalents. Following the notation used to distinguish the usual hyperbolic functions from circular functions, the general equations VI and VII would then express the general quadratic functions as

$$\text{sinq}\theta = \sqrt{e^2-1}\;\frac{\varepsilon^{\frac{\theta}{\sqrt{e^2-1}}} - \varepsilon^{-\frac{\theta}{\sqrt{e^2-1}}}}{2} \qquad \text{XXIX}$$

$$\text{cosq}\theta = \frac{\varepsilon^{\frac{\theta}{\sqrt{e^2-1}}} + \varepsilon^{-\frac{\theta}{\sqrt{e^2-1}}}}{2} \qquad \text{XXX}$$

These two equations indicate that the value of 1 for the eccentricity, e, corresponding to the parabola, constitutes a critical case. Smaller real values of e, down to and including zero, corresponding to the circle, together with all the imaginary values up to $j\infty$, cover all the ellipses and make imaginary the exponents in the expressions for the sine and cosine functions. Real values of eccentricity from 1 to $\infty$, including $\sqrt{2}$, corresponding to the equilateral hyperbola, cover all the hyperbolas and make real the exponents in the sine and cosine functions. Thus the general quadratic functions divide themselves into two groups: one, with imaginary exponents based on ellipses, and one with real exponents based on hyperbolas.

The obvious designations for these two groups would be "elliptic functions" and "hyperbolic functions," respectively. Unfortunately, both terms already have other established meanings. The terms "general elliptical functions" (or "elliptical functions" if a particular value of e, other than zero, is implied) and "general hyperbolic functions" are suggested, with the symbols sinlg$\theta$ (or sinl$\theta$), coslg$\theta$ (or cosl$\theta$) and sinhg$\theta$ or coshg$\theta$, respectively.

### *General Elliptical Functions*

For all real values of e less than 1 and for all imaginary values of e, equations XXIX and XXX then become

$$\text{sinq}\theta_E = \text{sinlg}\theta = j\sqrt{1-e^2}\;\frac{\varepsilon^{\frac{\theta}{j\sqrt{1-e^2}}} - \varepsilon^{-\frac{\theta}{j\sqrt{1-e^2}}}}{2}$$

$$= \sqrt{1-e^2}\;\frac{\varepsilon^{j\frac{\theta}{\sqrt{1-e^2}}} - \varepsilon^{-j\frac{\theta}{\sqrt{1-e^2}}}}{j2} \qquad \text{XXXI}$$

$$\text{and cosq}\theta_E = \text{coslg}\theta = \frac{\varepsilon^{\frac{\theta}{j\sqrt{1-e^2}}} + \varepsilon^{-\frac{\theta}{j\sqrt{1-e^2}}}}{2}$$

$$= \frac{\varepsilon^{j\frac{\theta}{\sqrt{1-e^2}}} + \varepsilon^{-j\frac{\theta}{\sqrt{1-e^2}}}}{2} \qquad \text{XXXII}$$

$$\text{But}\quad \frac{\varepsilon^{j\frac{\theta}{\sqrt{1-e^2}}} - \varepsilon^{-j\frac{\theta}{\sqrt{1-e^2}}}}{j2} = \sin\frac{\theta}{\sqrt{1-e^2}} \qquad \text{XXXIII}$$

$$\text{and}\quad \frac{\varepsilon^{j\frac{\theta}{\sqrt{1-e^2}}} + \varepsilon^{-j\frac{\theta}{\sqrt{1-e^2}}}}{2} = \cos\frac{\theta}{\sqrt{1-e^2}} \qquad \text{XXXIV}$$

$$\text{Hence*}\quad \text{sinlg}\theta = \sqrt{1-e^2}\,\sin\frac{\theta}{\sqrt{1-e^2}} \qquad \text{XXXV}$$

$$\text{and coslg}\theta = \cos\frac{\theta}{\sqrt{1-e^2}} \qquad \text{XXXVI}$$

Then, by the usual definition

$$\text{tanlg}\theta = \frac{\text{sinlg}\theta}{\text{coslg}\theta} = \sqrt{1-e^2}\,\tan\frac{\theta}{\sqrt{1-e^2}} \qquad \text{XXXVII}$$

### *General Hyperbolic Functions*

For all real values of e greater than 1, equations XXIX and XXX become

$$\text{sinq}\theta_H = \text{sinhg}\theta =$$

$$\sqrt{e^2-1}\;\frac{\varepsilon^{\frac{\theta}{\sqrt{e^2-1}}} - \varepsilon^{-\frac{\theta}{\sqrt{e^2-1}}}}{2} \qquad \text{XXXVIII}$$

$$\text{cosq}\theta_H = \text{coshg}\theta = \frac{\varepsilon^{\frac{\theta}{\sqrt{e^2-1}}} + \varepsilon^{-\frac{\theta}{\sqrt{e^2-1}}}}{2} \qquad \text{XXXIX}$$

$$\text{But}\quad \frac{\varepsilon^{\frac{\theta}{\sqrt{e^2-1}}} - \varepsilon^{-\frac{\theta}{\sqrt{e^2-1}}}}{2} = \sinh\frac{\theta}{\sqrt{e^2-1}} \qquad \text{XL}$$

$$\text{and}\quad \frac{\varepsilon^{\frac{\theta}{\sqrt{e^2-1}}} + \varepsilon^{-\frac{\theta}{\sqrt{e^2-1}}}}{2} = \cosh\frac{\theta}{\sqrt{e^2-1}} \qquad \text{XLI}$$

$$\text{Hence*}\quad \text{sinhg}\theta = \sqrt{e^2-1}\,\sinh\frac{\theta}{\sqrt{e^2-1}} \qquad \text{XLII}$$

$$\text{and}\quad \text{coshg}\theta = \cosh\frac{\theta}{\sqrt{e^2-1}} \qquad \text{XLIII}$$

Then, by the usual definition

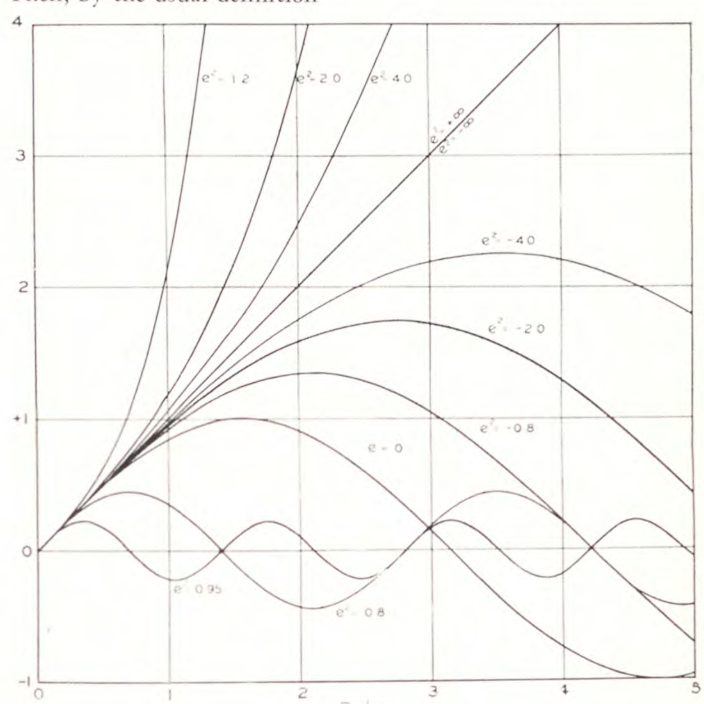


*Figure 2. Sine Curves for the General Quadratic Angle, with Designated Values of Eccentricity*

*First noted by F. A. Russell.

$$\tanh g\theta = \frac{\sinh g\theta}{\cosh g\theta} = \sqrt{e^2 - 1}\ \tanh g \frac{\theta}{\sqrt{e^2 - 1}} \quad \text{.......XLIV}$$

By means of equations XXXV, XXXVI, XXXVII, XLII, XLIII, and XLIV, the values of sinqθ, cosqθ, and tanqθ can be evaluated for any real or imaginary value of eccentricity except 1. Curves showing the resulting variation of the sine, cosine, and tangent functions of an independent variable, with the eccentricity as a parameter, are given in Figures 2, 3 and 4, respectively.

*Periodic Functions*

From these curves it is apparent that the functions of the circle and equilateral hyperbola occupy intermediate positions among the general elliptical and hyperbolic functions respectively. As was to be expected, all of the elliptical functions are periodic for a real variable, the length of period varying with the eccentricity in accordance with the equation

$$\theta_T = 2\pi \sqrt{1 - e^2} \quad \text{.......XLV}$$

When $e > 1$, $\sqrt{1 - e^2}$ becomes imaginary, so that the general hyperbolic functions exhibit periodic values only when the variable is imaginary. This suggests that the effect of an imaginary variable may well be investigated for the general functions. Substituting jθ for θ in equations XXIX and XXX gives

$$\operatorname{sinq} j\theta = \sqrt{e^2 - 1}\ \frac{\varepsilon^{j\frac{\theta}{\sqrt{e^2-1}}} - \varepsilon^{-j\frac{\theta}{\sqrt{e^2-1}}}}{2}$$

$$= j\sqrt{1 - e^2}\ \frac{\varepsilon^{\frac{\theta}{\sqrt{1-e^2}}} - \varepsilon^{-\frac{\theta}{\sqrt{1-e^2}}}}{2} \quad \text{.......XLVI}$$

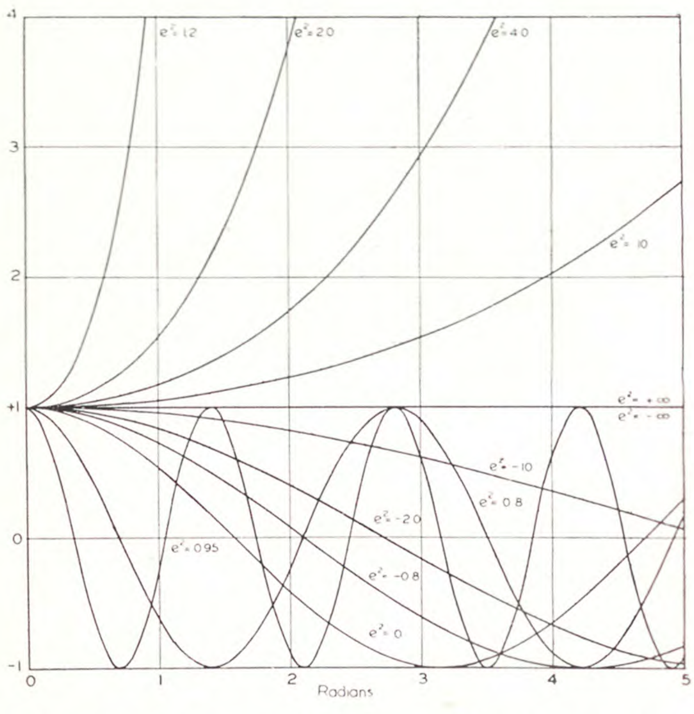


*Figure 3. Cosine Curves for the General Quadratic Angle, with Designated Values of Eccentricity*

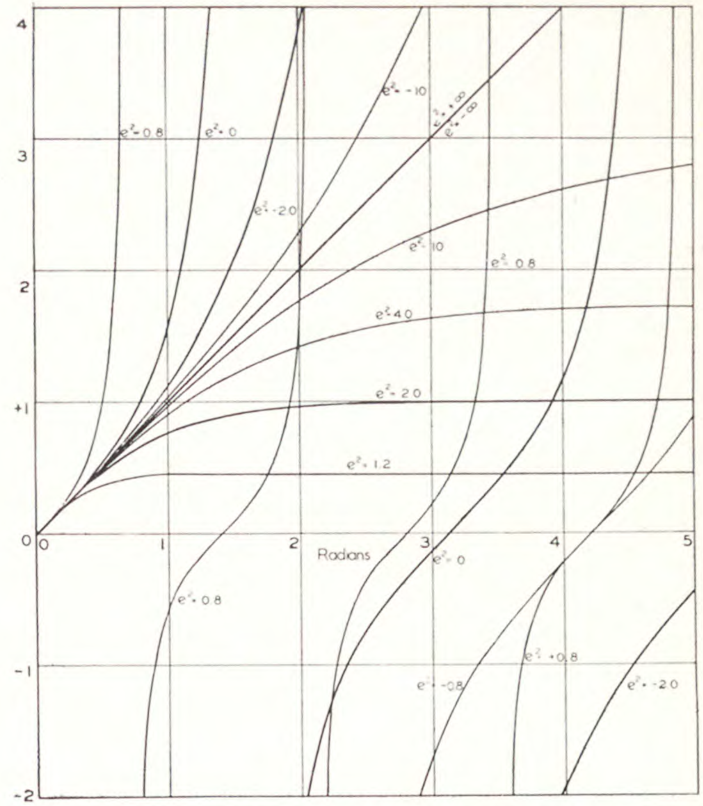


*Figure 4. Tangent Curves for the General Quadratic Angle, with Designated Values of Eccentricity*

$$\text{and } \operatorname{cosq} j\theta = \frac{\varepsilon^{j\frac{\theta}{\sqrt{e^2-1}}} + \varepsilon^{-j\frac{\theta}{\sqrt{e^2-1}}}}{2}$$

$$= \frac{\varepsilon^{\frac{\theta}{\sqrt{1-e^2}}} + \varepsilon^{-\frac{\theta}{\sqrt{1-e^2}}}}{2} \quad \text{.......XLVII}$$

*General Elliptical Functions of Imaginary Angles*

For all real values of e less than 1, and for imaginary values of e, equations XLVI and XLVII become

$$\operatorname{sinq} j\,\theta_E = \operatorname{sinlg} j\theta = j\sqrt{1 - e^2}\ \frac{\varepsilon^{\frac{\theta}{\sqrt{1-e^2}}} - \varepsilon^{-\frac{\theta}{\sqrt{1-e^2}}}}{2}$$

$$= j\sqrt{1 - e^2}\ \sinh \frac{\theta}{\sqrt{1 - e^2}} \quad \text{.......XLVIII}$$

$$\text{and } \operatorname{cosq} j\theta_E = \operatorname{coslg} j\theta = \frac{\varepsilon^{\frac{\theta}{\sqrt{1-e^2}}} + \varepsilon^{-\frac{\theta}{\sqrt{1-e^2}}}}{2}$$

$$= \cosh \frac{\theta}{\sqrt{1 - e^2}} \quad \text{.......XLIX}$$

$$\text{Whence } \operatorname{tanq} j\theta_E = \operatorname{tanlg} j\theta = j\sqrt{1 - e^2}\ \tanh \frac{\theta}{\sqrt{1 - e^2}} \quad \text{.......L}$$

*General Hyperbolic Functions of Imaginary Angles*

For all real values of e greater than 1, equations XLVI and XLVII become

$$\text{sinq}\ j\theta_H = \text{sinhg}\ j\theta = \sqrt{e^2-1}\ \frac{\varepsilon^{j\frac{\theta}{\sqrt{e^2-1}}} - \varepsilon^{-j\frac{\theta}{\sqrt{e^2-1}}}}{2}$$

$$= \sqrt{e^2-1}\ \sin\frac{\theta}{\sqrt{e^2-1}} \qquad \text{LI}$$

$$\text{cosq}\ j\theta_H = \text{coshg}\ j\theta = \frac{\varepsilon^{j\frac{\theta}{\sqrt{e^2-1}}} + \varepsilon^{-j\frac{\theta}{\sqrt{e^2-1}}}}{2}$$

$$= \cos\frac{\theta}{\sqrt{e^2-1}} \qquad \text{LII}$$

Whence $\text{tanq}\ j\theta_H = \text{tanhg}\ j\theta = j\sqrt{e^2-1}\ \tan\frac{\theta}{\sqrt{e^2-1}}$ ... LIII

From equations XLVIII to LIII, it is evident that the general sine and tangent functions of an imaginary quadratic angle have imaginary values, while the cosine functions have real values. Since the general hyperbolic functions of an imaginary angle depend upon the circular functions of a real angle of equal magnitude, it follows that the general hyperbolic functions are the periodic ones in the case of an imaginary angle. In terms of the magnitude of the imaginary angle, the length of the period is given by the equation

$$\theta_T = 2\pi\sqrt{e^2-1} \qquad \text{LIV}$$

*A Generalization of Euler's Theorem*

From equation XXIX

$$\frac{\text{sinq}\ \theta}{\sqrt{e^2-1}} = \frac{\varepsilon^{\frac{\theta}{\sqrt{e^2-1}}} - \varepsilon^{-\frac{\theta}{\sqrt{e^2-1}}}}{2} \qquad \text{LV}$$

Combining equations XXX and LV gives the following:

$$\text{cosq}\ \theta \pm \frac{\text{sinq}\ \theta}{\sqrt{e^2-1}} = \varepsilon^{\pm\frac{\theta}{\sqrt{e^2-1}}} \qquad \text{LVI}$$

Equation LVI holds in this particular form for the general hyperbolic functions, for all of which $e > 1$. For the general elliptical functions, where $e < 1$ or imaginary, a modification is desirable:

$$\text{coslg}\ \theta \mp j\frac{\text{sinlg}\ \theta}{\sqrt{1-e^2}} = \varepsilon^{\mp j\frac{\theta}{\sqrt{1-e^2}}} \qquad \text{LVII}$$

When $e = 0$, this expression reduces to the familiar relationship of Euler's Theorem for the circular angle.

*Functions of Sums and Differences of Angles*

Equations XXIX and XXX can be used to express the func- of two different angles $\alpha$ and $\beta$, both based on curves of the same eccentricity. By performing the indicated multiplications, additions, and subtractions, familiar expressions appear in generalized form.

$$\text{sinq}\ \alpha\ \text{cosq}\ \beta \pm \text{cosq}\ \alpha\ \text{sinq}\ \beta$$

$$= \sqrt{e^2-1}\ \frac{\varepsilon^{\frac{\alpha\pm\beta}{\sqrt{e^2-1}}} - \varepsilon^{-\frac{\alpha\pm\beta}{\sqrt{e^2-1}}}}{2}$$

$$= \text{sinq}\ (\alpha \pm \beta) \qquad \text{LVIII}$$

Also $\text{cosq}\ \alpha\ \text{cosq}\ \beta \pm \frac{1}{e^2-1}\ \text{sinq}\ \alpha\ \text{sinq}\ \beta$

$$= \frac{\varepsilon^{\frac{\alpha\pm\beta}{\sqrt{e^2-1}}} + \varepsilon^{-\frac{\alpha\pm\beta}{\sqrt{e^2-1}}}}{2}$$

$$= \text{cosq}\ (\alpha \pm \beta) \qquad \text{LIX}$$

Other generalizations of interest are

$$\text{cosq}^2\ \theta + \text{sinq}^2\ \theta = 1 + \frac{e^2}{2}\ (\text{cosq}\ 2\theta - 1) \qquad \text{LX}$$

$$\text{cosq}^2\ \theta - \text{sinq}^2\ \theta = \frac{2-e^2}{2}\ \text{cosq}\ 2\theta + \frac{e^2}{2} \qquad \text{LXI}$$

For the significant values of $e^2$, 0 and 2, these expressions take familiar forms.

*Summary and Application*

It has been shown that among all the ellipses which may be constructed upon a given straight line as an axis or diameter, and which have many geometrical and trigonometrical properties in common, there is one which has distinctive and unique properties, both geometrical and trigonometrical. This is the ellipse for which the eccentricity is zero, or the circle. It provides the basic trigonometrical functions from which are computed the general elliptical functions of real angles and the general hyperbolic functions of imaginary angles.

Similarly, it has been shown that among all the hyperbolas which may be constructed upon the same straight line as a transverse axis, that one which has an eccentricity equal to $\sqrt{2}$, or the equilateral or rectangular hyperbola, provides the basic trigonometrical functions from which are computed the general hyperbolic functions of real angles, and the general elliptical functions of imaginary angles.

Finally, it has been shown that all elliptical and hyperbolic sines can be generalized into a single exponential function in two variables. Each variable may have either real or imaginary values from $+\infty$ to $-\infty$, and in accordance with theory already established, that one of them which appears in the first power may have complex values.

It may be asked whether these conclusions have any value other than the academic satisfaction of someone's geometrical curiosity. Whether they constitute any real enlargement of our facilities for the attainment of any useful objective only time can tell. Many mathematical relationships which, in recent years, have become essential to the analysis and solution of problems in physics and engineering, were originally worked out by someone who was curious as to the results of a certain combination of conditions.

The relationships set forth in this discussion are original with the writer except as noted, and he has been led to believe that they are not matters of common knowledge, at least. It is his thought that if the generalization of trigonometrical functions into exponential functions in two variables is put on record, some trigonometrical relationships already known will be made clearer, and the reduction of some physical relationships to mathematical form may be simplified.

As an elementary step in the latter direction it may be noted that the various quadratic curves and their trigonometrical functions provide an additional means of designating the points of a plane. Rectangular and polar coördinates for this purpose are well known. The latter imply a series of circles concentric at the origin and of graduated radii. A specified point is then

*(Please turn to page 21)*

# AN AUTOMATIC SLIDE-BACK V.T. VOLTMETER

*By* Philip E. Volz

*Senior Student, Department of Electrical Engineering, Newark College of Engineering*

*Synopsis*

The use of the rectifying action of a diode as a means of measuring alternating voltages will first be considered. The fundamentals of the slide-back vacuum tube voltmeter will be presented. The advantages of both of these types of measuring instruments will then be combined in a slide-back voltmeter in which the slide-back action is automatic in operation. The advantages and the application of such an instrument are discussed.

*Introduction*

The first type of vacuum tube voltmeter to be considered will be one in which the rectifying action of a diode is used to change the alternating voltage being measured to a unidirectional, pulsating voltage. The static characteristic of a diode is shown in fig. 1. The portion of the curve from o to a is nearly

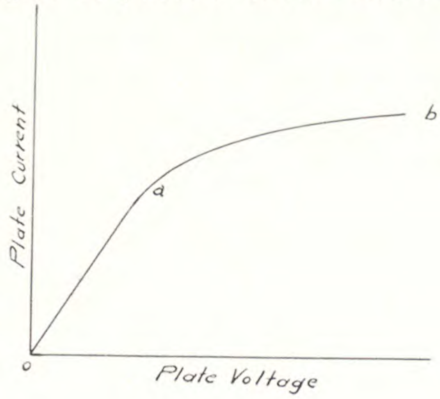


*Figure 1*

a straight line, and in this part of the curve the current is limited by the plate voltage. The portion of the curve from a to b is nearly flat, and in this part of the curve the current is limited by emission of the cathode.

The fundamental circuit in which the diode is used as stated above is shown in fig. 2. It is at once seen that the power required to operate the meter is drawn from the source being measured. The circuit being measured also supplies the losses in the diode. This is remedied in part by inserting a large resistance

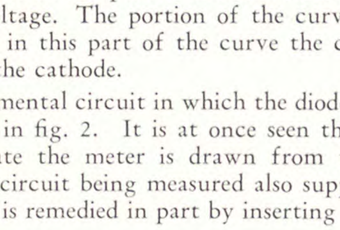


*Figure 2*

in series with the meter, or, in other words, by increasing the diode load resistance. This reduces the amount of power drawn from the source being measured, but the sensitivity of the meter must be increased because of the lower current flowing through the load resistance.

Let us now consider operation of the slide-back voltmeter. This consists briefly of measuring the change in grid bias needed to obtain plate current cut-off, first with no alternating voltage applied to the grid, and then with the voltage being measured applied to the grid.

In fig. 3 is shown the transfer characteristic of a triode. This is a plot of grid voltage against plate current for a constant plate voltage. The lines mn and oa represent the transfer characteristic for two constant plate voltages. For the purpose of discussion and explanation let us consider the operation at one constant plate voltage. The d. c. grid voltage $Ec_1$ will just

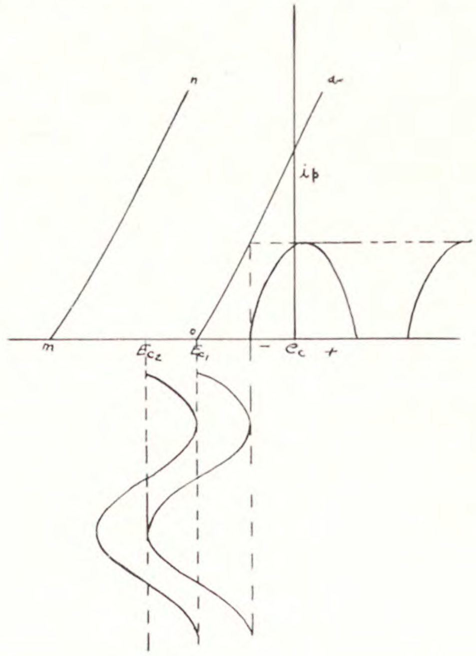


*Figure 3*

cause plate current cut-off with no other voltage applied to the grid. An alternating voltage is now applied in series with the d. c. grid bias, and is shown on the fig. as a wave having for its axis the fixed bias $Ec_1$. The tube will now draw plate current each time the fixed bias and the alternating voltage add up to less than the cut-off value of grid bias. This is shown in fig. 3 and it is seen that the plate current flows during alternate half-cycles of the input voltage. The bias voltage is now increased to the point c. The value of d. c. grid voltage is denoted as $Ec_2$, and it is seen that no plate current will flow in the tube, since the lowest value of total grid voltage is equal to the cut-off grid bias, or $Ec_1$. From the figure it is seen that at this second cut-off point, where plate current just ceases to flow, the peak of the voltage wave must just coincide with the cut-off bias $Ec_1$. It is also apparent that the peak value of the input voltage is equal to the difference between $Ec_2$ and $Ec_1$. If the input voltage wave were not symmetrical two peak voltages could be measured, one as explained above, and one with the input connections reversed. At this point it should be noted that the grid does not draw current, since at all times the potential of the grid with respect to the cathode of the tube is negative.

In fig. 4 the fundamental circuit of the slide-back vacuum tube voltmeter is shown. By inspecting the diagram it will be been that the power to operate the meter and to supply the tube loss is obtained from the battery in the plate circuit of the voltmeter tube. This is vastly different from the case of the diode rectifier.

Let us now consider the effect of the interelectrode capacitances of the triode, which is used as the voltmeter tube. From the diagram it is seen that the input is shunted by the grid cathode capacitance of the tube. The input is also shunted by the grid plate capacitance in series with the plate circuit impedance, which in this case is small. The input is then practically shunted by two capacitances in parallel, the grid cathode capacitance, and the grid plate capacitance. It will be noted that the tube need not handle any great amount of power, the required dissipation rating being zero at the cut-off point, and can be limited at the out-of-balance points by the addition of

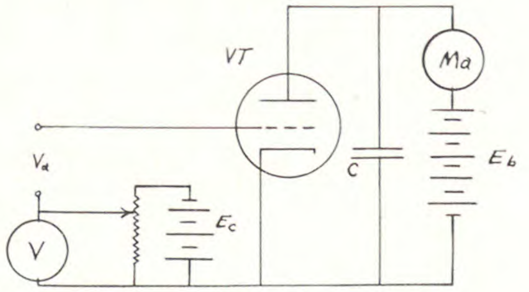


*Figure 4*

resistance in the plate circuit. Therefore, in a tube with very small electrodes and with proper spacing, very small interelectrode capacities may be used.

This effect varies with frequency. The capacitive reactance shunting the input terminals decreases as the frequency is increased. However, through the use of a triode having very small interelectrode capacitances, the effect of this input capacitance can be made negligible up to or above frequencies as high as 30 megacycles.

Both of the means described of measuring alternating voltages have distinct advantages. First consider the diode rectification. The power to operate the indicating meter is drawn from the source being measured, but the meter is instantaneous in its action. That is, the voltage to be measured is applied to the input terminals and the reading appears on the indicating instrument without further manipulation by the operator.

The slide-back type of voltmeter draws a negligible amount of current from the source being measured, but the instrument is not instantaneous or automatic in its operation. The operator must obtain the first cut-off point, then apply the voltage to be measured and obtain the second cut-off point, reading the peak value of the input voltage as the bias added in obtaining cut-off the second time.

If the instantaneous or automatic action of the diode type of voltmeter could be applied to the slide-back type of voltmeter to make the action of this instrument automatic, a very useful instrument would result. Alternating voltages of practically any frequency could be measured, without loading the circuit under measurement, and variations in this voltage could be readily obtained.

The rest of this paper will deal with such an instrument, which was developed by the author. It is a slide-back vacuum tube voltmeter in which the slide-back bias is obtained automatically.

### *The Automatic Slide-Back V. T. Voltmeter*

A brief description of the circuit will first be given. The circuit consists of a slide-back v. t. voltmeter in which the slide back voltage is slightly less than the peak voltage being measured. The small residual plate current in the voltmeter tube is pulsating, and this flowing through a high resistance develops a small pulsating voltage, which is amplified, then rectified and applied to the v. t. voltmeter as the slide-back bias.

The actual operation of the device is more easily understood by an explanation with a drawing. In fig. 5 the transfer characteristic of a triode is again shown. As before only one of the constant plate voltage curves will be used for the explanation. The fixed grid bias $Ec_1$ is again the cut-off bias with no alternating voltage applied to the grid. Then if the bias was increased until it was equal to the value $Ec_2$ and the alternating voltage applied in series with this, the tube would again be just at the cut-off point. Let the bias be increased to a point slightly less negative than $Ec_2$ denoted on the drawing as $E_a$. Then a small amount of plate current will flow during alternate half-cycles of grid voltage variation. This small pulsating current flowing through a large plate load resistance will produce a voltage across this resistance with the same wave shape as the current. This pulsating voltage is amplified and rectified. It is then passed through an RC filter and the d. c. obtained is applied as the slide back bias. This slide back bias has a value equal to $E_a$ minus $Ec_1$. It can be seen that if the voltage developed in the plate circuit of the voltmeter tube is amplified, rectified, and filtered as described, and produces a voltage just equal to $E_a$ minus $Ec_1$, the circuit will be in equilibrium if the d. c. obtained is applied as the slide-back bias.

Consider now what happens when an alternating voltage is applied in series with $Ec_1$. At once a relatively large voltage will be developed in the plate circuit of the v. t. voltmeter tube. This voltage will be amplified, rectified, filtered, and applied as slide-back bias. The value of this bias would be so high that no plate current would flow, and there would be no signal applied to the amplifier to produce bias. Therefore, the bias would decrease, and as it reduced the signal applied to the amplifier would increase. The two actions are seen to go in opposite directions: The action producing the bias, and bias produced by the action will come to equilibrium. Since it was shown that the circuit will bring itself to equilibrium, it is now necessary to find where the point of equilibrium is located. The point of equilibrium

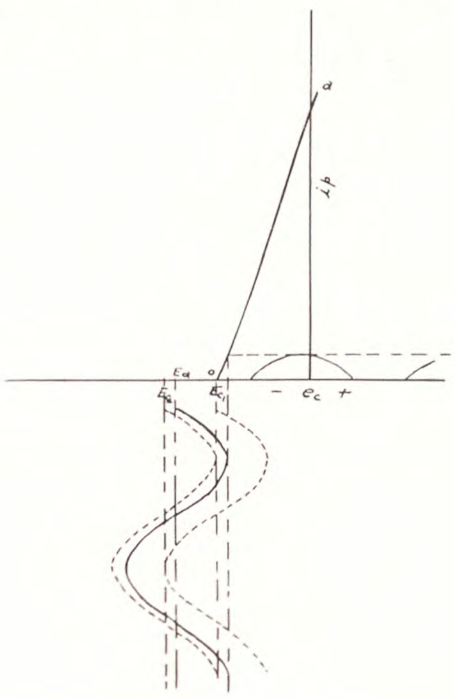


*Figure 5*

depends upon the voltage gain obtained from the voltmeter tube, the voltage gain of the amplifier, the relation between the input voltage to the rectifier, and the d. c. output from the filter.

For the purpose of illustration, let us make some reasonable assumption as to the value of these variables. Let us assume:

| | |
|---|---|
| Voltage gain V. T. voltmeter | 1.0 |
| Voltage gain amplifier | 200.0 |
| Peak input voltage/D. C. out of filter | 1.2 |

Slide-back bias obtained .......... 10.0 volts d. c.

Then

Peak input voltage to rectifier .......... $10 \times 1.2 = 12$ volts

Peak input voltage to amplifier .......... $\frac{12}{200} = .06$ volts

Peak grid voltage on v.t.v. above $Ec_1$ .......... $.06 \times 1 = .06$ volts

Actual peak voltage of applied wave .......... $10 + .06 = 10.06$ volts

Then if a wave of 10.06 volts were applied to the grid of the voltmeter tube, an automatic slide-back bias of 10.00 volts would appear from the filter. The percentage error in the measurement would be $\frac{.06}{10.06} = .566\%$.

Even with very conservative values for gain the error in the measurement is very small.

In fig. 6 is shown a diagram of the automatic slide-back v. t. voltmeter.

The power to operate the indicating instrument is obtained from the amplifier. An ordinary d. c. voltmeter is connected in parallel with the output of the filter to read the automatic slide-back bias. It is interesting to note that no calibration is needed.

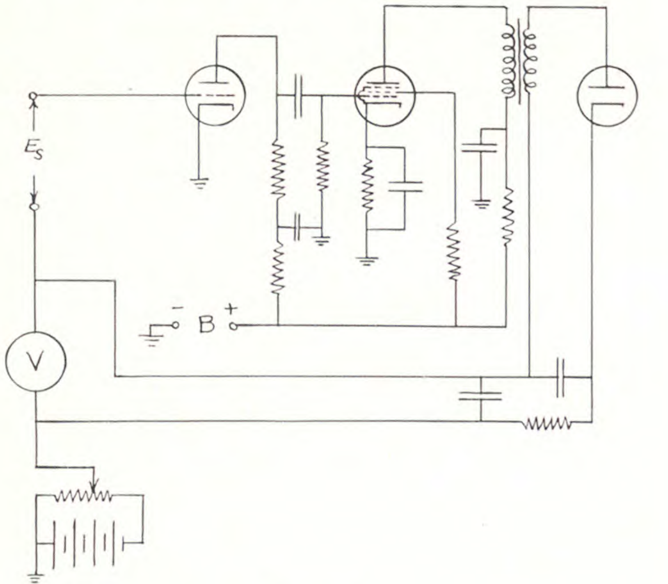


*Figure 6*

It was previously shown that the slide-back bias would always be slightly less than the actual peak value of the input voltage. The factors affecting the accuracy of the instrument were considered. The accuracy of the whole instrument depends also upon the accuracy of the d. c. voltmeter used. The coupling transformer shown cannot be used for all frequencies. An air core transformer would be used for radio frequencies. A rotary switch may be incorporated in the design to permit changing the transformer, and the elements of the filter for different frequency ranges. Actual construction features would, of course, depend upon the desired application of the instrument.

### *Conclusion*

A vacuum tube voltmeter of the slide-back type, in which the slide-back voltage was obtained automatically was described. This instrument permitted the measurement of a wide range of voltages, of any frequency, with negligible loading of the circuit under measurement, and the instantaneous, continuous indication of the peak value of this voltage by means of a standard d. c. voltmeter, without manipulation by the operator.

*Comments by Professor James C. Peet, in Charge of Electrical Engineering Department*

This paper is the type which has been unusually successful in student competition. It is a small research and experimental problem which is well within the capability of an undergraduate student.

In this case, Mr. Volz has taken a slide-back vacuum-tube voltmeter and made it automatic in operation by diverting part of the input signal to a rectifier-amplifier circuit and returning it to the vacuum-tube voltmeter as bias. The error of the reading is of the order of one-half of one per cent.

This paper won second prize at the fourteenth annual student convention of the American Institute of Electrical Engineers in Brooklyn, N. Y., on April 25, 1940, in competition with papers presented by students from twelve engineering schools in the metropolitan area.

## CIVILIAN PILOT TRAINING COURSE

The Pilot Training Program, given at the Newark College of Engineering under the direction of the Civil Aeronautics Authority, is nearing its successful conclusion. Of the 20 students entering the program, two have been disqualified and the remaining 18 are about ready for their final examination.

On Saturday, January 20, 1940, J. R. Bermingham and J. H. Parsons made the first solo flights of the course. Since then 17 men have successfully made their solo flights and are well on the advanced stages of the program. The program should be completed by the end of the school year.

Two student pilots, J. R. Bermingham and J. W. Swiencicki, have been accepted by the U. S. Navy as Cadet Pilots and start their Navy training in June.

The program, which consists of 72 hours of ground school instruction and 35 hours of flying instruction, will be repeated next year. The course is open to all students of the day college, preference being given to Seniors and Juniors. All candidates are required to have the consent of their parents. They also must pass a physical examination given by the medical staff of the Civil Aeronautics Authority. The flying instruction is being given at the Somerset Hills Airport, Basking Ridge, New Jersey. The airport and the various flying instructors are subject to rigid government inspection. The flight training is being given in small 50 H.P. training ships. The ships in use at present are Taylor Cubs.

Of the 10,000 students in training in the United States under this program, there has been only one accident to date.

*Members of the N. C. E. Pilot Training Course*
From left to right: Pilot Michael Gitt, Student J. R. Bermingham, Director Dr. F. D. Carvin, Student J. H. Parsons, Pilot G. Viehmann.

# AN OPTICAL METHOD OF VISUALIZING LOW VELOCITY AIR FLOW

*By* Stanley Corrsin, M.E. '40

*University of Pennsylvania*

*This paper was awarded First Prize at the Eighth Annual Eastern Student Group Meeting of the American Society of Mechanical Engineers at the Newark College of Engineering on Tuesday, April 29, 1940.*

Wind tunnel lift-drag tests and calculations are and always will be the main basis for the designing of airplane wing sections. Nevertheless, a wing designer is obviously helped if he can see a picture of the flow around a wing in operation. It keeps him from getting lost in equations and numbers, just the same as practical piloting or mechanic's experience helps the airplane designer.

So it is not surprising that, ever since aeronautics became a science, men have been interested in methods of making the air stream visible.

At the present time, the introduction of smoke into the windstream is the most common way of making the flow visible. However, the chemicals are expensive, and the equipment is awkward to use.

The apparatus I am going to describe to you is called the "schlieren" or "streak" apparatus, and it makes the air stream visible by benefit of the principle of the refraction of light. This particular arrangement is for low velocity air flow, but that means "low" in comparison with the speed of sound, and it can be used over the full wind tunnel range.

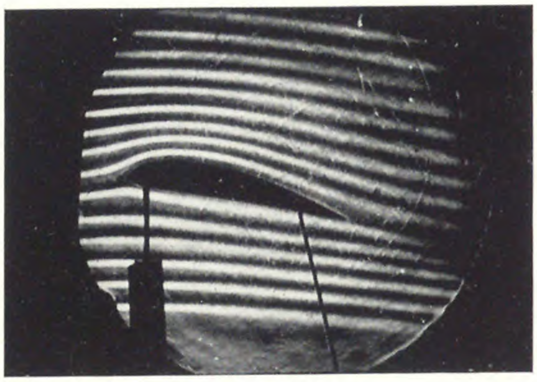

*Figure 1*

Figure 1 is a typical picture taken with the schlieren apparatus. It looks very much like a smoke picture. The advantages over smoke lie in ease and cheapness of operation, combined with an unlimited speed range. Only the horizontal lines have any significance; the irregular verticals and the long curved verticals merely show that our optical apparatus needs polishing.

You probably remember that a light ray, passing between media of different optical densities, is bent. If we have a particle of warm air in a field of cooler air, the light deflection will be as shown in figure 2, since the light is bent away from the normal on entering the rarer medium, and toward the normal on re-entering the denser medium. In the same way, light entering the lower half of the particle would be bent downward.

Figure 3 is a schematic diagram, showing the essential parts in this set-up of the streak apparatus.

Suppose, for the moment, we forget the particle of warm air on the right. There is a theoretical point source of light at the carbon arc at the bottom of the figure. This light is condensed on the mirrored knife edge. The edge is inclined so that the light is reflected to the sperical mirror on the right. Furthermore, the knife edge is placed at the geometrical center of the spherical mirror so that, if the field is optically uniform, the

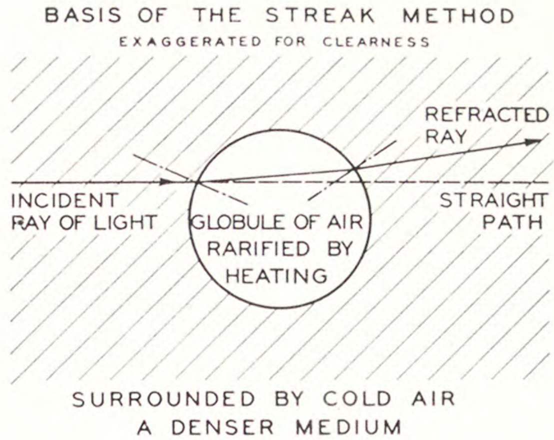


*Figure 2*

light is reflected from the spherical mirror, back along the same lines, and none of it gets past the edge to the viewing screen on the left.

Now suppose the particle of warmer (and therefore, rarer) air were introduced into the uniformly cool field of our apparatus. The light passing through the upper half is bent over the

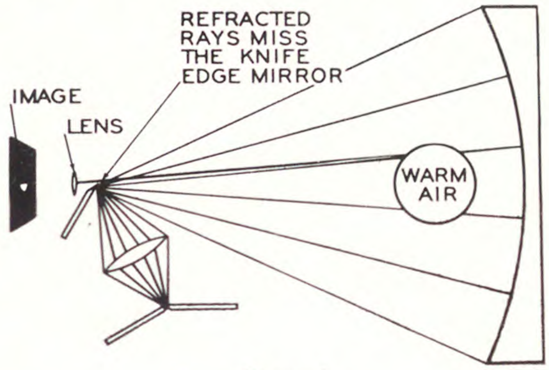


*Figure 3*

knife edge, and the image of the top section of the less dense particle appears on the screen as shown. In this way we have made the air visible, and a thin stream of warm air would appear as a light streak on the screen.

When we "integrate" the particle of warm air into a row of streaks, we get a picture showing the direction of the air flow in any region, with alternating dark and light lines, as in the first figure. The bands of heated air air produced by a row of hot wires just upstream from the field being viewed. Figure 4 is a perspective drawing of the arrangement. The circle in the background represents the spherical mirror.

Figure 5 is a general view of the apparatus. The wind tunnel is on the left, with the camera and other equipment on the right. The long tube is for cutting down stray light. The spherical mirror is inside the tunnel, on the other side of the field —which is, of course, the working section of the wind tunnel.

In figure 6 we are looking into the mouth of the tunnel, with the entrance swung aside to the left. Just to help you orient yourselves—you can see part of the entrance cone on the left, and the exit cone is in the right background. The spherical mirror is mounted out of the windstream, on the far side; in front is the hot wire grid, and behind that is the wing section.

Instead of heating the streaks of air with hot wires, we can use a row of electric arcs. Then, we put the spark gaps in series on the high voltage side of a spark coil, with an interrupter in the primary. The interrupter is rotated at uniform speed, and each time the circuit is broken, sparks jump the gaps. This is the same as an automobile ignition system except that all the sparks jump simultaneously.

The result of heating the air intermittently with sparks is that we get dotted lines as in figure 7 instead of streaks. The interrupter is synchronized with the stroboscope disk, so that the particles of warm air appear to stand still, and we can take photographs like you see here at as long an exposure as necessary.

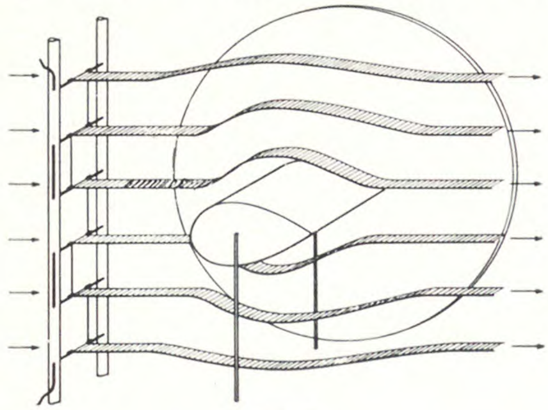

*Figure 4*

This was taken at about a quarter of a second, which partly explains the apparent ripid diffusion of the warm air particles as they go downstream. During that quarter-second, the stroboscope has rotated several times, the particles have advanced one jump a corresponding number of times. Because of some oscillation of the windstream and vibration of the spherical mirror, successive particles at any given position vary somewhat.

The use of sparks instead of hot wires in the schlieren apparatus is due to Dr. H. C. H. Townend of the National Physical Laboratories in England. Apparently there has been nothing along this line done in this country yet.

The obvious advantage of the spark apparatus over hot wires, is that it permits quantitative results. The distance between successive dots is a direct measure of the air velocity. Thus we can measure the speed at any point relative to the speed at any other point. Furthermore, the air pressure is a function of the velocity, and we have another way of checking the pressure is a function of the velocity, and we have another way of checking the pressure distribution over a wing. In the illustration, the difference in velocity between the upper and lower surfaces of the wing is obvious, since there are five particles below in the same distance as the four particles above the wing. Note also the particle adjacent to the lower surface, which is slowest of all. The distance between successive particles can be reduced by merely speeding up the interrupter and stroboscope.

These examples will give you an idea of the possibilities of schlieren photography.

Up to the present time, apparatus similar to this has been used mainly to get flow characteristics of projectiles and nozzles at velocities above that of sound. No hot wires are necessary, since at these speeds, the air is so compressible that pressure waves

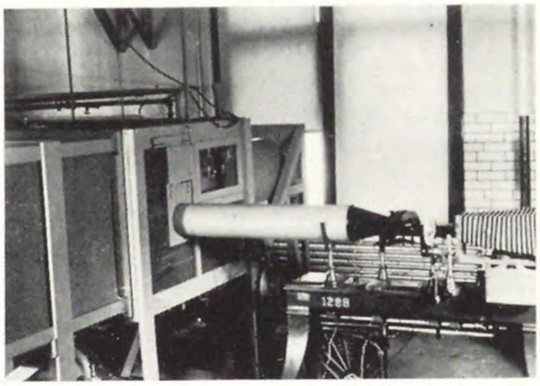

*Figure 5*

become visible with the schlieren apparatus because of the variation in density.

Thus, the use of hot wires or sparks to vary the air stream density artificially in subsonic flow, extends the field of schlieren photography to the full range of air velocities.

The principal advantages of the hot wire schlieren method as compared to smoke generation, are its cheapness of operation, its simplicity and flexibility of operation, and the possibility of use at much higher speeds—and therefore higher Reynolds number.

In conclusion, I'll predict that more general use of the schlieren apparatus in conjunction with wind tunnels is a sure thing; and that the possibilities of quantitative results by using sparks instead of hot wires, should be enough to keep quite a few people busy during the next several years.

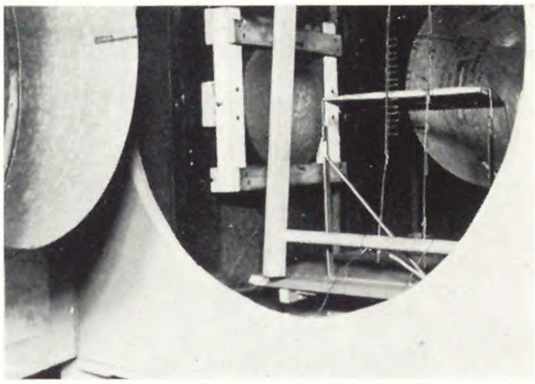

*Figure 6*

*Comments by Lee Gulick, Professor of Mechanical Engineering, University of Pennsylvania*

In 1936 Dr. H. C. H. Townend of the National Physical Laboratories in England published an article in the *Journal of Aeronautical Sciences* showing photographs taken with a schlieren apparatus.

This aroused the interest of Assistant Professor John A. Prior and Mr. Kenneth B. Conner, the latter a graduate student at the University of Pennsylvania. They built a hot wire (streak) schlieren apparatus for the Towne School wind tunnel which it worked, although the poor definition of the streaks left much to be desired.

Corrsin became interested in the apparatus in the spring of 1939, and in his spare time began working with Professor Prior. Since then, further refinement of the apparatus has led to improved definition in the streak photographs.

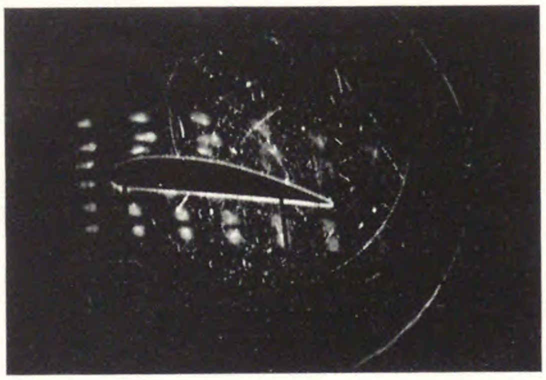

*Figure 7*

Their main interest, however, has been in the arrangement for heating the air intermittently with sparks so that rows of dots, instead of streaks, show the direction of air flow. Since there is no available reference for the spark set-up, Professor Prior, with Corrsin assisting, had to start from scratch in designing the apparatus. They still feel that the spark photographs need a great deal of improvement before the intended quantitative results will be worth while.

The present problem is the use of spark illumination as well as spark heating. This will guarantee absolute synchronization, and should improve the definition of the warm air particles as compared with the results using the disk stroboscope—not to mention the possibility of faster photographs with a single illuminating spark.

Stanley Corrsin was born in Philadelphia, in 1920. His grammar school education was followed by a four-year course at West Philadelphia High School, from which he graduated in June, 1936. He ran the gamut of hobbies from collecting coins and stamps, to fancy seashells. Model airplane building entered the picture about 1930, and was the start of his vocation-to-be, aeronautics.

He came to the University of Pennsylvania to take mechanical engineering on a four-year Mayor's Competitive scholarship, believing that a complete mechanical engineering course is a desirable prerequisite for aeronautical engineering.

Present activities at Penn include *Triangle* staff (engineering), associate editor *The Critic* (literary), occasional columnist in the *Daily Pennsylvanian*, Tau Beta Pi, A.S.M.E., Pi Mu Epsilon (mathematics society), and the golf squad. Other interests are reading, writing and photography.

Scholastically, he has maintained top position of the Towne School class for 3½ years.

As for the future, things look exceedingly bright. He has been awarded a Departmental Research Assistantship in Aeronautics at the California Institute of Technology, where he will work for a Ph.D.

*Comments by Professor James C. Peet, in Charge of Electrical Engineering Department, Newark College of Engineering*

The paper on the general quadratic angle and its functions by Professor Nims suggests a large degree of mathematical curiosity combined with some prophetic insight which is a very real reason for much of the rapid advance in higher mathematics during recent years. Kennelly with his hyperbolic functions and Fortescue with his development of symmetrical components are good examples of this nature. It has taken from ten to twenty years for the work of these men to find acceptance and useful application; but pioneer work must always precede practical use.

## THE GENERAL QUADRATIC, OR CONIC, ANGLE AND ITS FUNCTIONS

*(Continued from page 15)*

reached by selecting the circle of the specified radius and, along its circumference, describing an arc which measures the specific angle.

If a segment of the X-axis is selected to serve as a common major axis, with the origin at its center, any point in the plane can be designated by a value of eccentricity and a sine, cosine, or tangent function. The eccentricity specifies the particular curve to be erected on the major axis, and the functions specify, respectively, a horizontal, vertical, or radial line to intersect the curve. It is to be noted that all points between lines through the extremeties of the major axis and parallel to the Y-axis will be designated by elliptical eccentricities and functions of real angles, while points outside these parallel lines will be designated by hyperbolic eccentricities and functions of real angles.

## PROMOTIONS AND APPOINTMENTS

Mr. Allan R. Cullimore, President of Newark College of Engineering, has announced the following promotions and appointments:

*William S. LaLonde, Jr.*, has been appointed Professor in Civil Engineering. He was formerly Associate Professor in Civil Engineering.

*James Melvin Robbins* has been appointed Associate Professor in Civil Engineering. He was formerly Assistant Professor in Civil Engineering.

*George D. Wilkinson, Jr.*, has been appointed Associate Professor in Industrial Engineering. He was formerly Assistant Professor in Industrial Engineering.

*Chester J. Lake*, formerly Deparamental Assistant, has been appointed Assistant Instructor.

New appointments include the following:

*Orrin Clark*, Ph.D. in Physics, New York University, has been named Assistant Instructor in Physics.

*Beatrice A. Hickstein*, B.S. in Chemical Engineering, 1939, Newark College of Engineering, has been named Research Assistant in the Weston Museum.

*Edward W. Rice*, B.S. Columbia University, M.Ed. Boston University, has been named Research Assistant in the Industrial Relations Department.

## CO-OPERATIVE PLAN FOR GRADUATE WORK

By agreement between Stevens Institute of Technology and Newark College of Engineering, certain graduate courses given by the Newark College of Engineering are coördinated with the offerings of the Graduate School of Stevens. Graduate engineers who satisfy the admission and academic requirements of the Newark College of Engineering and of Stevens Institute of Technology may register and earn graduate credit in these courses, administered and given by members of the Faculty of the Newark College of Engineering, and this credit may be applied toward meeting the requirements for the advanced degree at Stevens; a maximum of 10 credits may be received by any student for such courses.

# GENERAL MOTORS ASSEMBLY OF COLLEGE STUDENTS

*By* HAROLD E. WALTER, B.S., M.S.

*Associate Professor in Mechanical Engineering, Newark College of Engineering*

On Monday, May 6, the General Motors Corporation in inaugurating their World's Fair activities for 1940, invited some four hundred college students from eighty colleges, and other guests to a dinner at their Fair exhibit. The affair, conceived and carried out by the General Motors Corporation, was designed to picture to a representative group of young American manhood "The Opportunity for Youth in Building the World of Tomorrow." Certainly, neither a more appropriate time nor a more appropriate subject could possibly have been chosen.

The representatives of this school, namely, Messrs. J. R. Bermingham, W. J. O'Connor, and J. C. Stillwaggon, from the student body, and the writer, joined similar groups from other colleges at the Pennsylvania Station and left for the Fair grounds by special train at 3:30 P. M. Upon arrival at the Fair we boarded buses and went on a tour of inspection of the Fair grounds, the trip terminating at General Motors Highways and Horizons Exhibit, where the main festivities were scheduled to take place. We spent some time viewing the large assortment of exhibits in the enormous building and we then assembled in the Science Auditorium to witness a motion picture produced by our hosts and a stage presentation, both of which featured "Previews and Reviews of Scientific Progress." Some excellent scientific demonstrations accompanied this part of the program. We subsequently gathered at the ramp of the Futurama and viewed in comfort and with pleasure Norman Bel Geddes' creation of the Highways and Horizons of Tomorrow.

One of the real treats of the entire day was now in store for us, for as we stepped from the ramp at the completion of the tour, we were greeted by Mr. Sloan, Chairman; Mr. Knudsen, President; and Mr. Kettering, Vice-President of the General Motors Family. The warmth of their greeting associated with the fact that each of those busy men remained during the entire affair was the subject of considerable comment by the young men present and an experience which will be remembered by all.

We were then conducted to the automobile salon, where dinner was to be served and there found some seventy tables which were to seat the more than five hundred who were present. The seating arrangements were in themselves a feature, since at each table were gathered an official of the General Motors Corporation, several members of the faculty of the colleges whose representatives attended, three or four students (no two of whom were from the same institution), and a representative of the press or other invited guest. Numbered among the latter were some of the outstanding men of American Industry, Education and Public Affairs.

After dinner, Mr. Sloan gave a warm welcome to those present and stressed the reason for the assembly, that through an affair of this sort it was possible for industry to learn what the young generation was thinking about, and at the same time, industry could picture to a cross-section of American youth something about what it thought about the possibilities of the future. Mr. Sloan developed forcefully that "The America of the future is man's to make and that this was the challenge to youth today. With proper management and proper opportunities for business, industrial progress in the future should be even greater than that of the past."

Mr. Knudsen said: "I can't tell young men where to get a job, but industry has need for them. Young men are divided into three classes, searchers, teachers and doers, and there was need for all three."

Mr. Kettering in his talk referred to the unemployment situation when he said: "Men say we can never absorb our ten million unemployed. I say that this problem of population is a purely relative thing. The discovery of a few fundamental facts might easily be the basis for new industries which will keep us all busy for years to come." He propounded twenty-five things which he would like to know, and these are appended to this article.

Finally, the feature of the dinner was a panel discussion of social questions, which were submitted by the students in attendance. The students' questions were answered by Karl T. Compton, President of Massachusetts Institute of Technology; Ernest M. Hopkins, President of Dartmouth College; General Hugh S. Johnson, columnist, and Kettering. Clifton Fadiman, book critic of *The New Yorker*, asked the questions. The questions dealt with controversial matters such as: a fit substitute for the profit motive in business; the effect of war on free enterprise; whether shorter hours and higher pay were the answer to unemployment; could industry absorb all the unemployed; would there be more jobs for youth if industrial activities were planned under government supervision, etc. The answers to these and similar questions proved to be one of the highlights of the evening, and the answers were definitely in keeping with the calibre of the men constituting the panel.

Frankly, the writer has never experienced a more enjoyable or profitable afternoon and evening. The affair was well conceived, adequately directed, and supremely worthwhile. There was a definite lift to the occasion; one could sense that the group was participating in a new experience. I believe this to be the first attempt by a large corporation to discuss youth problems directly with the youths. Surely, all those who were fortunate enough to be present are thankful for the privilege and appreciate the effort made in their behalf.

## THE PRESIDENT'S DIARY

President Cullimore's Diary has been a feature of the NEWARK ENGINEERING NOTES since the first issue. In general, the comments contained in the Diary through the various issues have been very favorably received by our readers. One letter recently submitted suggested that the material in the Diary be reprinted in pamphlet form. Other readers take the time and trouble to write letters of appreciation for this feature of our publication. The editor is taking the liberty of publishing the following letter, which is typical of many that have been received in his office, commenting on the Diary.

Dear Mr. Cullimore:

It was with great interest that I read your Diary in the March NEWARK ENGINEERING NOTES, and feel that your thoughts of establishing evening courses in some lines of industrial engineering are very good.

Speaking for myself, I have long felt the need of classroom study in the subjects that you mention. Naturally, I have studied some management control and cost accounting, but know that with classroom discussion and an instructor's advice, the mind would be much more stimulated as you say.

If any of these courses are instituted next fall I would be glad to avail myself the privilege of attending them.

Sincerely yours,

PHILIP H. BALDWIN, JR.

The B. J. Riley Manufacturing Co.

Newark, N. J., April 3, 1940.

# THE PHYSICS DEPARTMENT ADDS PHOTOELASTICITY

*By* FRANK N. ENTWISLE, C.E.

*Professor in Physics and in Charge of Physics Department, Newark College of Engineering*

Having resolved to include photoelastic stress analysis in the course in Strength of Materials Laboratory, we encountered several problems. First, to devise experiments of such a nature that students with no special preparation can perform the experiments in the laboratory in three hours and make a quantitative determination of stress from the laboratory data. Another problem was that of cost. It was felt that since the apparatus would be used for only two periods by each group, the cost of the apparatus should be kept within very reasonable limits.

The problem of low cost was met by using only the essential elements in the optical system. Several elements usually included in research investigation, water cell, quarter wave plates and photographic equipment were omitted. These omissions in no way render the apparatus inferior for the purposes for which it is used. Monochromatic light was secured by using an ordinary six volt lamp, such as is used for automobile headlights, and a red filter. The elements of the optical system were, in order, lamp, lens, red filter, Polaroid disc, lens, specimen, lens, Polaroid disc, and a white screen. The lenses were uncorrected spherical lenses. All the elements were mounted on an inexpensive optical bench of the type used in elementary physics laboratories. The working aperture of the apparatus is nearly equal to the diameter of the lenses used on either side of the spcimen, to obtain parallel rays, in this case, four inches. To avoid the necessity of photographic apparatus the screen was designed so that a pencil tracing of the projected image can be made. This saves not only expense, but the student's time as well. The time required to make a pencil tracing of that part of the image containing the measurements necessary for the interpretation of the data is much less than that required to set up and make photographs. For instance, to determine the distribution of stress on a cross-section of a beam it is necessary only to mark the center of each fringe as it crosses the section. This can be done in a very few minutes.

The loading frame was of a simple design, as shown in Figure 2 and was made in a local machine shop. It has a capacity of three hundred pounds and can accommodate a variety of types of specimens, such as, members in tension, compression and bending, by using different fixtures to attach the specimen to the hook suspended from the balance beam. In Figure 2 is shown in place, a simple beam with two equal concentrated loads.

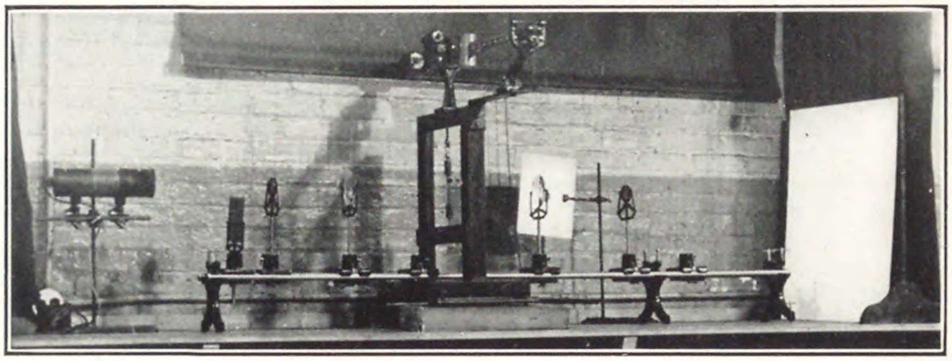

*Figure 1. Photoelastic Apparatus*

The experiments must be such that the students can obtain quantitative results with no preparation in the thory of elasticity or differential equations. This limits the field to cases in which one principal stress at every point is equal to zero. In any other case it would be necessary to obtain a second relation involving the principal stresses since the polarized light analysis gives only a relation involving the difference between the principal stresses at each point. Any of the methods used

*(Please turn to page 27)*

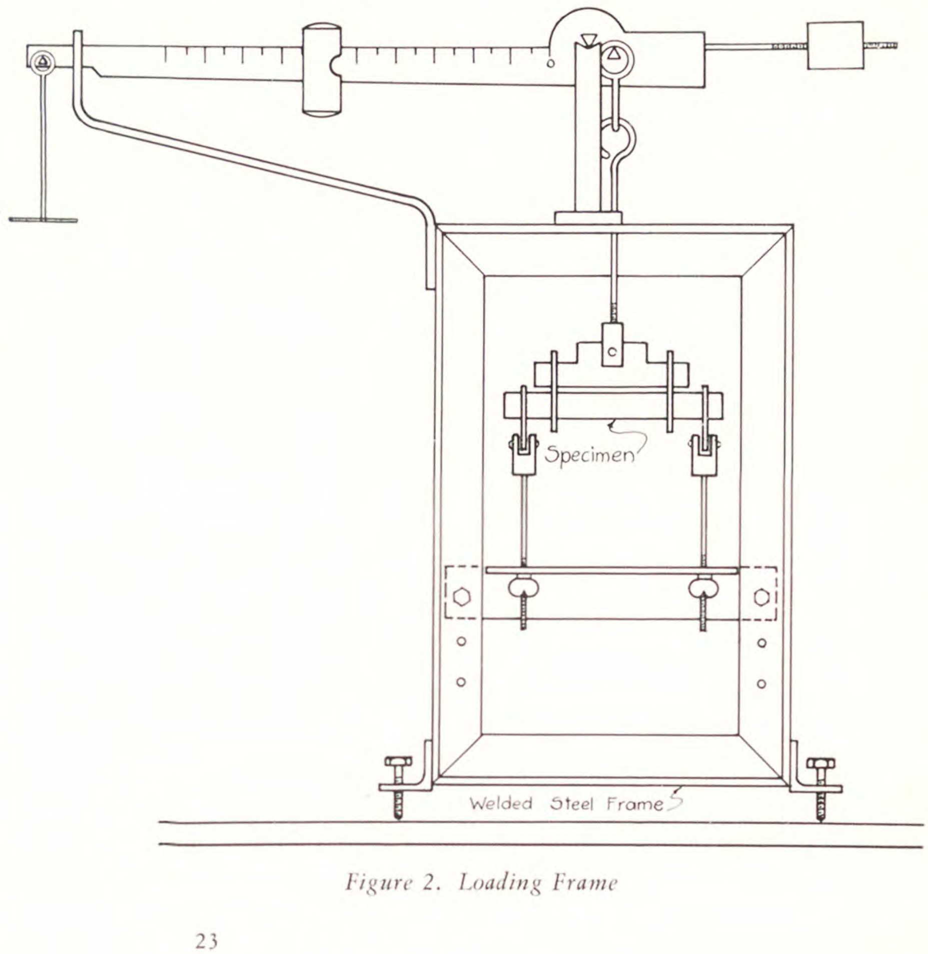


*Figure 2. Loading Frame*

## OUR PROFESSORS AND INSTRUCTORS

Professor James H. Fithian, head of the Department of Mathematics, is now completing the manuscript of a treatise on vector analysis used with the advanced course offered as optional work for Juniors.

Elmer C. Easton, instructor in Mathematics, will spend the summer at Harvard University working in the high voltage laboratory on a study of the time lag of break-down of an electric spark. This work is intended to lead to the degree of Doctor of Science, and is a continuation of a research program begun in 1938.

William Hazell, Jr., Assistant Professor in Physics, is now taking a course in "Improvement of Teaching in Colleges and Universities" at the Graduate School of Education, New York University. This is toward the degree of Master of Arts in Education.

Dr. Paul M. Giesy, Professor in Chemical Engineering, attended the meeting of the American Chemical Society at Cincinnati during the week of April 8.

Dr. Edward C. Baker, Assistant Professor in Mathematics, has been re-elected President of Nutley Symphony Society of Nutley, New Jersey.

Paul C. Shedd, Associate Professor in Electrical Engineering, is taking a course in Communication Networks in the School of Engineering of Columbia University. This is toward the degree of Master of Science.

William Jordan, 3rd, Assistant Professor in Electrical Engineering, is taking a course in Communication Networks and Electric Wave Filters in the Graduate School at Stevens Institute of Technology. This is toward the degree of Master of Science.

Frederick A. Russell, Teaching Fellow in Electrical Engineering, is taking a course in Communication Networks and Electric Wave Filters and also a mathematical course in Operational Analysis at the Graduate School at Stevens Institute of Technology. This is toward the degree of Master of Science.

John C. Hoffman, Instructor in Industrial Engineering, is working for a Master's degree in the Department of Industrial Engineering at the New York University, School of Engineering, Graduate Division.

George D. Wilkinson, Jr., Associate Professor in Industrial Engineering, plans to spend his summer investigating the social structure of the workers in a small factory. Professor Wilkinson is working toward the degree of Doctor of Philosophy in the Graduate School of Columbia University, and will use the results of his summer work as the basis of a thesis in Industrial Engineering.

Professor Harold N. Cummings, in Charge of the Civil Engineering Department, has been reappointed by Supreme Court Justice Charles W. Parker as a member of Essex County Mosquito Extermination Commission. At the Commission's annual meeting Professor Cummings was elected treasurer of the Commission.

Frederick C. Burt, Jr., Assistant Instructor, is taking courses in Chemical Engineering in the Graduate Engineering School at New York University. Mr. Burt also attends the summer session at Montclair State Teachers' College. He is working for master's degrees at both schools.

Paul E. Schweizer and Francis J. Burns, Assistant Professors in Mechanical Engineering, are now rewriting the "Laboratory Manual for Metals Laboratory."

James A. Bradley, Dean and Associate Professor in Chemistry, is now writing a "Laboratory Manual of General Chemistry."

Dean Bradley recently gave a talk before the Essex County Torch Club on Salem, Massachusetts. This talk was illustrated by lantern slides loaned by the Essex Institute of Salem, Massachusetts.

William S. La Londe, Jr., Professor in Civil Engineering, during the summer vacation will be engaged as a Structural Engineer with the Phelps Dodge Corporation, New York City.

Dr. T. Smith Taylor, Associate Professor in Physics and in Charge of Research, is now working on a book on "Heat Transmission."

Dr. Taylor has again been elected Chairman of Committee D-9 on Electrical Insulating Materials of the American Society for Testing Materials.

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Morris Goodkind of New Brunswick was recently appointed to serve on the Advisory Committee to the Board of Trustees of the Newark College of Engineering in the Civil Engineering Department. Mr. Goodkind is Bridge Engineer for the New Jersey State Highway Department and is prominent in engineering societies and organizations throughout the State.

The other members of the Board are Howard T. Critchlow, Engineer in charge of the New Jersey State Water Policy Commission; J. Ralph Van Duyne, Chief Engineer of the Passaic Valley Sewer Commission in Newark; and Edward S. Rankin, Division Engineer with the Division of Sewers in Newark.

## N.C.E. GRADUATES WORKING FOR MASTER'S AND DOCTOR'S DEGREES AT VARIOUS INSTITUTIONS

The Committee on Transfers for Graduate Work has released the following statement through its Secretary Henry H. Metzenheim, Associate Professor and Comptroller, Newark College of Engineering.

In the period of one year, ending May 10, 1940, the graduates of Newark College of Engineering have applied for admission to advanced work in other institutions in numbers which exceed our experience of other years. Eighty-five individuals made applications for admission to graduate schools in twenty-two institutions.

The largest number of records being sent to one school was thirty-five to Stevens Institute. Fourteen records went to Brooklyn Polytechnic Institute, and ten each to Columbia University and to New York University. The balance were scattered in one to six units between the eighteen other institutions.

The locations of the institutions preferred by our graduates are shown by the following:

Six institutions in the State of New York, of which three are in New York City. Three institutions were chosen in each of New Jersey, New England States, and Pennsylvania. Other states, in each of which one institution was selected, are: Florida, Michigan, Ohio, Tennessee, Virginia and the District of Columbia.

With few exceptions the graduates referred to expect to continue in advanced work to the Master's degree, and the plans of a number of them include the prospect of earning the Ph.D.

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## PROFESSIONALITIES

Charles P. Deutsch, B.S. in Civil Engineering, 1931, who was formerly Assistant Librarian, has now been appointed Manager of the Newark College of Engineering Book Store.

Ivan J. Amo, B.S. in Mechanical Engineering, 1939, is now employed with the Worthington Pump & Machinery Corporation in the Methods Planning Department, Harrison, N. J.

Henry P. Boczar, B.S. in Mechanical Engineering, 1939, is a Junior Engineer at the U. S. Government Arsenal at Raritan, N. J.

"Ken C. Beckett, who has been associated with Schweitzer & Conrad, Inc., since 1930, has organized his own company, the K. C. Beckett Co., with offices in Chicago, to represent electrical manufacturers in that district. The new company now represents Schweitzer & Conrad in Michigan, Electroline Co. in Indiana, and G. & W. Electric Specialty Co. in northern Indiana.

"A native of Belle Center, Ohio, Mr. Beckett was graduated from the Bliss Electrical School, Washington, D. C., in 1920 and received a bachelor of science degree in electrical engineering from Newark College of Engineering, Newark, N. J., in 1931. Entering the employ of the General Electric Co. in 1920, he spent six months on test, three years on design work in the d. c. motor engineering department and seven years as salesman in the industrial department in New York.

"In 1930 Mr. Beckett became New York district manager for Schweitzer & Conrad, was called back to the factory in 1932 and from 1932-40 served as sales engineer, covering Michigan, Indiana, Illinois and part of Wisconsin."

(Taken from *Electrical World*, April 13, 1940.)

Wings of the United States Army Air Corps soon will be worn by a former Newark College of Engineering man, member of a class of 210 Flying Cadets, who have completed their basic flight training at Randolph Field, Texas, the "West Point of the Air."

Flying Cadet Carlyle C. Hoch, of Newark, left his studies here to join the air force in 1939. He had been studying civil engineering when his application was accepted.

At the college, Hoch played intramural football and acted as coach of a freshman team. Now he is among the members of class 40-C, who have transferred to Kelly Field for a three-months period of advanced flying instruction before receiving their coveted pair of wings, emblematic of a military pilot, and their commissions as Second Lieutenants in the Air Corps Reserve.

Charles H. Clark, B.S. in Chemical Engineering, 1939, is an Electrochemist in the Storage Battery Division of the Edison Industries, Inc., West Orange, N. J.

Charles W. Den Hollander, B.S. in Chemical Engineering, 1938, is with the Hoffman La Roche Company in Nutley, N. J.

John W. Garratt, B.S. in Civil Engineering, 1938, is a district Engineer at Houston, Texas, with the Wallace & Tiernan Company of Belleville, N. J.

Irving P. Scott, B.S. in Electrical Engineering, 1937, is a Sales Engineer with the Union Carbide and Carbon Company in Chicago, Ill.

Milton H. November, B.S. in Chemical Engineering, 1937, is a Designer with the Breeze Corporation, Newark, N. J.

Harold A. Rothbart, B.S. in Mechanical Engineering, 1939, is a junior Marine Engineer at the Philadelphia Navy Yard.

# THE EASTERN STUDENT GROUP MEETING OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

*By* Francis J. Burns, B.S., '31

*Assistant Professor in Mechanical Engineering, Newark College of Engineering*

On Monday and Tuesday, April 29 and 30, the Newark College of Engineering had the honor of acting as host to nearly 300 students comprising the Eastern Student Group of members of the American Society of Mechanical Engineers at the eighth annual meeting.

The following colleges were represented at the meeting: Columbia University, Cooper Union, University of Delaware, Drexel Institute, Lafayette College, Lehigh University, College of the City of New York, New York University (Day and Evening Divisions), University of Pennsylvania, Polytechnic Institute of Brooklyn, Pratt Institute, Princeton University, Rutgers University, Stevens Institute of Technology, Swarthmore College, Villanova College, and Newark College of Engineering.

Monday morning was devoted to inspection trips through the plants and facilities of Newark Airport and the 119th Observation Squadron, to the Hall of Records' power plant, and to Feigenspan's power plant.

Tuesday afternoon also was devoted to inspection tours—this time to the Airport, Kearny power station of the Public Service Gas and Electric Company, the power plant of Bamberger's Department Store, and to Feigenspan's brew-house.

During the technical sessions, held on Monday afternoon and on Tuesday morning, fourteen papers were presented by students representing winners of elimination contests previously held at the various colleges and universities comprising the group. The results of the competition follow: first, Stanley Corrsin of the University of Pennsylvania, whose paper was on "An Optical Method of Visualizing Low Velocity Air Flow"; second, Richard S. Lovelace of Princeton University, whose paper was entitled "Ship Stabilization by the Activated Tank"; third, Alfred L. Trumpler of Lehigh University, on "Gas Turbines"; fourth, Jacob Pineles of Stevens Institute of Technology, on "Effect of Sintering Temperature on Tensile Strength of Compacted Swedish Sponge Iron Powder"; and fifth, John A. Oppel of Newark College of Engineering, on "A Free-hung Centerboard for Sailboats." These men were in competition for the following awards and the honors contingent upon them. First prize was $45 in cash; second, $25; third, $15; fourth, $10, and a fifth prize, a slide rule donated by the S.K.F. Industries, was also awarded. Of interest here is the cash award of $15, known as the "Old Guard" award, one that is given yearly by the "Old Guard," a group of exempt-from-dues members who continue to pay into the parent society, and whose funds are allowed to accumulate for this purpose. In addition, these gentlemen have, in recent years, made it a practice to secure a position for the winner of this award in the event he does not have one at the time. This year an "Old Guard" from this section, Mr. J. S. Foster, gave an etching to be used as a door prize. The etching was his own handicraft.

Judges of the presentations were Robert L. Sackett, Dean Emeritus of Pennsylvania State Sollege, Mr. Vincent M. Frost of the Public Service Gas and Electric Company, and Mr. George A. Stetson, editor of *Mechanical Engineering*. Awards were made on the basis of delivery, effectiveness, pronunciation, enunciation, choice of words, and literary style, timing, material, arrangement, originality, and acquaintance with the subject. Fifteen minutes were allowed for each paper and five minutes for a discussion immediately following. To avoid unfair advantage, students from the same college as the speaker were barred from discussion of that particular paper.

Guest Chairmen for the Monday and Tuesday technical sessions, respectively, were Mr. William J. Abokair, who is the Chairman of the Polytechnic Institute of Brooklyn student group, and Mr. R. Larribure, who is the Chairman of the Rutgers University student group.

About 120 persons attended the dinner at the Newark Athletic Club on Monday evening, at which Mr. John Bermingham, Chairman of the Newark College of Engineering student group, acting as toastmaster, first introduced President Allan R. Cullimore who welcomed and complimented the group, then Mr. Francis Hodgkinson, Vice-President of the parent society, who represented President MacBryde and read a message from him. Last on the program was some entertainment by the Great Professor Edwards, who gave an exhibition of humor and legerdemain.

Another 120 persons attended a luncheon at the same place on Tuesday noon, at which time the guest toastmaster, Mr. Richard A. Enion, of the Swarthmore student group, introduced Professor Paul B. Eaton of Lafayette College, representing the parent society's Committee on Relations with Colleges, who made the prize awards.

# WHAT OUR READERS SAY

## A DEMONSTRATION MODEL FOR RIGID FRAME THEORY

The above article by Professor William S. La Londe, Jr., in the March issue of NEWARK ENGINEERING NOTES has evidently been read with great interest. A great number of letters with comments have been received. Some of them follow:

My dear Professor La Londe:

I have examined with interest the March 1940 copy of NEWARK ENGINEERING NOTES which was received recently. Of particular interest was the description of "A Demonstration Model for Rigid Frame Theory." This appears to be a most ingenious device and should be a distinct aid in assisting the student to visualize the action of a structure.

Very truly yours,
ELMER K. TIMBY
Assistant Professor of Civil Engineering
Princeton University
Princeton, N. J., April 5, 1940.

Dear Professor La Londe:

I want to thank you for the copy of NEWARK ENGINEERING NOTES that you sent me containing your article on "A Demonstration Model for Rigid Frame Theory." I enjoyed your article and believe I will have one of the graduate students make up such a demonstration model, because it seems simple and effective . . .

Very truly yours,
A. A. JAKKULA
Professor of Structural Engineering
Agricultural and Mechanical College of Texas
College Station, Texas, April 11, 1940.

Dear Professor La Londe:

I hope you will pardon this belated acknowledgment of the copy of NEWARK ENGINEERING NOTES which you were so thoughtful as to send me. I have examined this with interest, particularly your description of the demonstration model, which is quite ingenious and helpful.

With best regards, I am

Very sincerely yours,
A. T. GRANGER
Professor of Civil Engineering
The University of Tennessee
Knoxville. Tenn., May 3, 1940.

To the Editor:

I would appreciate the addition of my name to the mailing list of NEWARK ENGINEERING NOTES.

I have seen a few copies of your magazine and was very much impressed, even to the extent of asking for any back number that may be available.

Thanking you for your attention.

Yours very truly,
S. CUNHA, *Electrical Engineer*,
Montreal Light, Heat & Power Consolidated
Montreal, Canada, March 23, 1940.

To the Editor:

I have enjoyed reading the recent issue of the NEWARK ENGINEERING NOTES and by means of this letter I should like to make certain that my name is on your mailing list for future issues.

Sincerely yours,
L. K. Downing, *Dean*,
School of Engineering and Architecture,
Howard University.
Washington, D. C., April 8, 1940.

To the Editor:

I should be glad to be placed on your mailing list for the NEWARK ENGINEERING NOTES.

I appreciate your courtesy.

Very truly yours,
C. T. BISHOP,
Associate Professor of Civil Engineering,
School of Engineering,
Yale University.
New Haven, Conn., April 8, 1940.

To the Editor:

Please forward a copy of the NEWARK ENGINEERING NOTES whenever it is published. We will appreciate any material which you wish to send us on research or other publications.

Very truly yours,
DUDLEY NEWTON, *Head*,
Civil Engineering,
Wayne University.
Detroit, Mich., April 9, 1940.

To the Editor:

In the article, "We Cast Out 9's, or 3's," Mr. Easton has done a good job of explaining a system of checking addition without using any undefined nomenclature or so-called "high powered" methods. Mr. Easton's claim that the mere suggestion that any process of reasoning involves higher mathematics intimidates many students and investigators is well founded. It is also true that a demonstration of the fact that much higher mathematics is nothing but a language (sometimes a lingo) will go far towards establishing the student's self-confidence.

There is, however, another factor: there is a definite limit to the number of new ideas a student can absorb at one sitting, even if those ideas are merely definitions. For instance we can teach addition and we can teach subtraction, but a problem involving both operations is not as simple to the student as the two operations independently.

Now in Mr. Easton's article many new ideas or definitions are offered to the reader in rapid succession. For instance we run into: "where the Z's represent the units column . . ." "we get $\Sigma Z$ which will be our symbol for . . ." and so on. Such definitions are not absorbed instantaneously but take time for their understanding. Therefore the danger is not that the method is not grounded on familiar definitions but that the student will despair of mastering all the new definitions even if they are quite simple.

Nevertheless Mr. Easton has accomplished his purpose, and the interested student must supply the answer to the above suggestion by repeated study of the article until it becomes clear.

Mr. Easton says in his opening paragraph, "The fear of ignorance is the greatest handicap which a user of mathematics can have." I would go him one better and say that many professions and branches of science inspire awe if not respect by the use of unfamiliar and often unnecessary terminology.

Very truly yours,
ERIC A. WALKER,
Head, Dept. of Electrical Engineering,
Tufts College Engineering School,
Tufts College.
Ledford, Mass., Jan. 16, 1940.

To the Editor:

. . . Professor Paul C. Shedd in his paper, Repulsion Motor Calculations, published in NEWARK ENGINEERING NOTES, December, 1939, has done a fine job in setting forth so concisely the fundamental voltage and current relations in the circuits of a repulsion motor. It is particularly to be noted that the theoretical deductions are presented in forms that lend themselves readily to laboratory verification. In the sample problems, the agreement between predicted and test value is, in general, satisfactory. While Professor Shedd disclaims credit for making an original contribution to repulsion-motor theory, his paper is an admirable example of the expert selection of pertinent materials . . .

Sincerely,
DR. C. A. PIERCE,
Professor in Theoretical and Electrical Engineering,
Worcester Polytechnic Institute,
Worcester, Mass., January 22, 1940.

To the Editor:

A copy of the March, 1940, issue of your publication has come across my desk en route to my employer, and I find it a most interesting piece of literature—one which I shall wish to read assiduously.

My attention was first attracted by the article on page 5, entitled, "The Vector Idea in Trigonometry," the reading of which recalled to my mind the feeling frequently expressed by my mathematics and physics professor in college, that college math courses should be made much more practical and usable. He iterated to us that having finished any mathematics course, no matter how elementary or advanced, a student should have more to show than a few hours' credit in said course: that engineers should be able to use their mathematics easily in their specialized fields of work; and that even in the home these courses, including introductory physics, have their place and should be an aid to the housewife.

All of which brings me to the purpose of this letter. I have noted on page 3 that it is possible to receive regularly copies of NEWARK ENGINEERING NOTES, and would like to take advantage of your invitation by asking you to place on your mailing list, if it is not now there, the name of Dr. Paul E. Martin, Professor of Physics and Chemistry, Muskingum College, New Concord, Ohio, who is the professor mentioned above. I am sure Dr. Martin would be keenly interested in this publication.

Very truly yours,

BETTIE JANE FAIR

Pittsburgh, Pa., April 3, 1940.

To the Editor:

I received the December issue of NEWARK ENGINEERING NOTES, and was very much interested in the material which it included. I am now working for the Hawaiian Electric Co. in the mechanical engineering department and my work now deals with the building of a new power plant. I am a draftsman, and my work covers the piping of the plant and the structural steel of the building. I was interested in the article by Odd Albert on eccentric welded connections as a large part of our plant design is based on welded joints.

A rather new type of construction, the welded arch beams which are used in building construction, are rather difficult to solve and if an article could be printed on that subject some time it would interest me very much.

I would appreciate it very much if you would put me on your mailing list for the NEWARK ENGINEERING NOTES.

Yours truly,

JOHN H. HIND, '38

Honolulu, T. H., February 1, 1940.

To the Editor:

We have received in the library NEWARK ENGINEERING NOTES, Vol. 2, Nos. 5 and 6, and Vol. 3, Nos. 1 and 2.

We should like to ask if it would be possible for you to present us with copies of all other earlier or later numbers which are still available, and to have the name of the Rutgers University Library placed on your complimentary mailing list to receive copies of future numbers as they are issued.

We shall greatly appreciate anything you may be able to do in aiding us in this matter.

Very truly yours,

C. LOUISE BENEDICT,
Head, Periodical Department,
Rutgers University Library.

New Brunswick, N. J., March 18, 1940.

## THE PHYSICS DEPARTMENT ADDS PHOTOELASTICITY

*(Continued from page 23)*

to secure the second relation would require too much time or knowledge beyond the scope of the course.

Considerable success has been obtained by the students in the problem, to verify the flexure formula by polarized light analysis. In doing this the student is required to calibrate the specimen, that is, determine the stress value of one fringe, then, using this value determine the distribution of stress on a cross section of the beam. The same stress distribution is then computed and the two results compared. In most cases the student is able, very definitely, to conclude that the flexure formula and the polarized light analysis indicate very nearly the same stress at every point in the cross section.

The new equipment is admirably suited to its purpose and is a valuable addition to the Strength of Materials Laboratory.

## "WHY SHOULD I STUDY THIS?"

*(Continued from page 9)*

his first position was to file a box full of letters and reports which had been collecting in the laboratory for five months. A sense of bookkeeping would have avoided that possibly dangerous condition.

We might go on, taking up one by one the courses which, to the unthinking seem superfluous and which an older generation got along without: Economics, which enables us to understand something of the complexities of the world of business and finance; history, which might at least teach us to avoid the same old mistakes; the study of human behavior, which makes us realize that industry is not merely a matter of car-loadings and British thermal units. To be alert to these matters, to consider them important, is to be among the elect.