VOLUME FIVE
NUMBER ONE
DECEMBER, 1941

Newark ... ENGINEERING NOTES

VOLUME V NUMBER 1
DECEMBER, 1941

Printed in U. S. A.

NEWARK ENGINEERING NOTES

Published by

The Newark College of Engineering, Newark, N. J.

Administered by

The Board of Trustees of Schools for
Industrial Education of Newark, N. J.

(FOUNDED MARCH, 1881)

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THE PRESIDENT'S DIARY

December 1, 1941

I think all of us in positions of leadership, no matter how humble, sometimes fail to realize the responsibility which is really ours, and we fail to see and appreciate how widespread our influence may become. Sometimes I am startled and a little frightened to realize that some things that I say not altogether seriously are taken to heart in places where I hardly realize my influence would have any weight at all.

To those of us who are in executive positions in the leadership of younger people the responsibility becomes considerable in an emergency such as we are facing now, and I think it rather tends to make a man humble and he has to be rather careful and keep his feet pretty solidly on the ground.

I remember when I first came to the Newark College of Engineering and the Newark Technical School—and those of you who came at the same time will remember—that over the door of the electrical laboratory was a notation which I very well remember and which expresses the idea much better than I can. The motto was this, "I would be true for there are those who trust me," and as this is part and parcel of the thinking of the old technical school I wish I could make the younger men as well as the older appreciate that a position of leadership in the nation, in the state, in the community, on the block or in your own home ought to vibrate to this particular string.

I think we ought to begin to realize, no matter who we are, that we have a personal responsibility all the way down the line and all the way up the line, to be true and to furnish an example which will steady those who trust us and are under our jurisdiction and care so that they can surmount the obstacles which lie in the way as effectively and efficiently as is possible.

December 8, 1941

Since writing the foregoing and after turning it over in my mind, it seems that we can even go further than this until we come to understand that this war cannot be won until each individual in the country in his thinking, in his planning, and in his actions puts himself on a strictly war basis. When this is done by every individual in the nation, the nation will truly have all its energies directed into productive channels, that is, productive for the national defense and for the prosecution of the war.

We can't all be commanders-in-chief, we can't all be head of defense councils, we can't all be fire wardens, but we can, every one of us, so arrange our thinking, plan our personal lives so that we become immediately effective with respect to the broader proposition. In any organization the fundamental units must be sound, must be dependable. Any organization is made up of these units, and in order to have one of these larger units function the individual must certainly be dependable.

There are so many things that may be done which are personal that it seems to me that we could well let the larger groups properly take care of themselves. We could concentrate on our own personal problems and when and if the commander-in-chief desires us to help, he will ask us, and if he doesn't, we will render such part as we can even though it involves no one except ourselves. How easy it would be on our block, for instance, to organize an effective group to protect all of the homes if all of us felt the same way and would adopt this personal responsibility. How easy it would be to abolish hoarding, how simple the whole question of defense would be if we could forget those petty selfishnesses, the desire to profit by the emergency and arrange matters in our own minds so that we not only physically but mentally tighten our belts, throw overboard all the surplus and useless material in our thinking, and get down to brass tacks.

We can't all be leaders, but we can all assure our leaders of loyalty, stability, and the willingness to sacrifice all that we have if necessary. The war will be won when the individual wins the war. The war will be won when the individual wins the war with himself, when he coolly, calmly and realistically makes the adjustments, the sacrifices in his own life and in the life of the family that the situation calls for. If I had any advice to offer to those young people that I find it necessary to lead and to help, I would say that the quicker and the more effectively we can get ourselves stripped for action the sooner we will have this horrible thing out of the way and begin to organize ourselves for peace.

I don't remember where I read it—I think it was in Emerson—when he spoke of Caesar's idea of a perfect army, where every man could take care of himself, grind his own corn, and was capable of inuring himself to all the hardships of a campaign—that only then could you have a perfect army and be self-sufficient. And our perfect army, if we ever have one, would have to be made up of perfect individuals and perfect units. So that we can say we will win the war when "we" win it; we are the country, we are the army, we are the navy, we are the civilian population, and "we" in a democracy means every single solitary individual with equal privileges and equal rights.

If we could only get the little, simple idea firmly fixed that we are the Government and we in a democracy are all in this thing together—sink or swim—tied as closely as we can be in everything we do under whatever name we please, if we could only get this idea, the job would be much easier. And I should like to go on record as personally declaring war against the axis powers on the eighth of December, 1941.

ALLAN R. CULLIMORE

THE THEORY OF RELATIVITY AND ITS APPLICATION TO ELECTROMAGNETISM

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Professor in Mathematics, Newark College of Engineering

(Presented in part at the Mathematics Colloquium held at the College on May 23, 1941)

The Necessity for, and Derivation of, the Lorentz Transformation

I want you first to imagine a certain physical experiment. A man on a very long ship measures the time it takes a flash of light to travel from the stern of the ship to its bow. The flash may come from an electric bulb attached to a pole on the stern, and arranged to occur at a known instant, and then the time is recorded at the instant when the flash is seen at the bow. Since we are interested not in the actual performance of this experiment but in the mathematical and physical laws which are involved, we will not go into detail as to how to secure the very accurate measurement of the two times which would be necessary. The man on the ship knows the ship's length, which we will call d. Dividing by the time t taken by the flash for its journey, he obtains the value d/t for the speed of light.

Now a second man has been watching the signal from a spot on the shore, and he points out that while the experiment was going on the ship was moving, say with a velocity v, to the right, and since the flash occurred when S′ was opposite the point S on the shore and was received at B′ opposite the point B, the speed with which it traveled should be given by $(vt + d)/t$, instead of d/t.

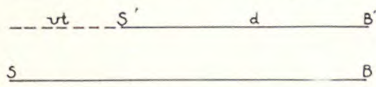

Fig. 1. Motion of ship as viewed from the shore

(Let us pause to remark that according to the general belief light moves out from its source in waves which are not affected by the motion of the source, and which always travel through space with the same speed, once they have been set in motion.)

The man on the ship agrees with the reasoning of the man on the shore and concedes that the value $(vt + d)/t$ would be correct if the shoreline itself were at rest, but he points out that this particular shoreline happens to extend from east to west (here the reader should imagine he is facing the south so that east to west extends from left to right on the figure), and due to the earth's rotation on its axis the shore is really moving faster than the ship, and is, in fact, moving away from the ship. Indeed, it would be possible for the ship to be at rest with respect to the center of the earth (if it happened to be at the right latitude) and the shore to be moving away from the ship with the velocity v. In this case the light waves would have traveled only from S′ to B′, since the point on the shore opposite S′ would have moved to the left the distance vt to the point S. Thus, the man on the ship would then be correct in his determination of the speed of light as d/t.

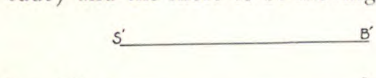

Fig. 2. Motion of shore as viewed from the ship

Now there is something rather disturbing to physicists and mathematicians about these two expressions for the always constant velocity of light, and especially so when they realize that because of the earth also traveling in its orbit about the sun it would take considerable astronomical information to determine which actually was moving faster, the shore or the ship. And moreover there is the motion of our whole solar system toward a certain position among the stars. Or is it the stars that are moving toward us?

Is there any point in the Universe that we know to be at rest, so that it can be taken as a fixed center of reference, to enable us to discern the true motions of all other bodies by means of their motions with respect to that point? If such a point exists, no one ever has been able to find it, and when we speak of motion we can mean only the *relative motion* between bodies, each having a motion with respect to the other, and we cannot say that one is at rest and the other is moving. This leads us to the first principle of the Theory of Relativity, that any point may be taken as a fixed center of reference, or origin, of a rectangular coördinate system, one point being just as good as another; and since no coördinate system is preferable to any other, mathematical and physical laws must have the same form in every coördinate system*. The second principle of Relativity concerns the speed of light and has already been mentioned—it is always the same (in a vacuum) in every direction, and is independent of the speed of the source of the light and of the observer.

Now what is wrong with our experiment? We did not obtain the same value for the speed of light when the ship was considered at rest as when the shore was considered at rest. Should they not agree, especially when we have no possible way of telling which is the case, i.e., whether the ship or the shore is moving? The trouble is where we would least expect it—with our mathematics. Making the problem more general, we have used the following relations between the distances in one coördinate system, which we considered as fixed, and those in a second system, which we supposed to be moving with a constant velocity in a straight line with respect to the first system.

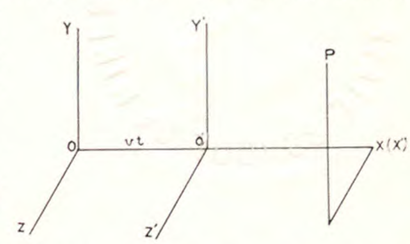

Fig. 3. Coördinate systems, stationary and moving, with respect to the observer

If x, y, and z refer to the stationary system, which we will also call the "unprimed system," and x′, y′, z′ refer to the moving "primed system," then, taking the motion to be along the x-axis, we have $y = y'$, $z = z'$, and $x = x' + vt$. These are the classical "equations of transformation" between the two systems of coördinates (called the Newtonian Transformation).

We seek now to replace these equations by others, for which the principles of the Theory of Relativity will hold. First, we want the speed of light, which we will denote by c, to be the same in both systems. This would be accomplished, considering the source of light to be located at the origin, and the two origins coincident at the time of the light signal, if whenever $\sqrt{x^2 + y^2 + z^2} = ct$, our equations of transformation make $\sqrt{x'^2 + y'^2 + z'^2} = ct'$. Here x, y, z, t are the coördinates and time in the unprimed system when the light signal reaches the point P, and x′, y′, z′ and t′ are the coördinates and time in the primed system. You will doubtless be surprised that we did

*We are referring here to the "Special Relativity Theory" which requires that physical laws have the same form in systems which have uniform rectilinear motion with respect to each other. The "General Relativity Theory" supposes that the laws are the same in all systems having any kind of relative motion.

not assume $t' = t$, but a more complete investigation of our original experiment, with regard to making certain of the agreement between clocks used to record the times of occurrence and reception of the signal on the ship and on the shore, shows that there is good reason for not assuming that $t' = t$ (or that clocks run at the same rate in the two systems).*

Since always $y = y'$ and $z = z'$ there will be no loss in generality if we take P on the x-axis and think of the light wave as advancing horizontally to the right. The above equations then become $x = ct$ and $x' = ct'$. (For a wave advancing to the left along the x-axis we would have $x = -ct$ and $x' = -ct'$.) Now the second equation above will be a consequence of the first if the variables are connected by an equation of the type $x' - ct' = \lambda(x - ct)$ where λ is a constant, and for the wave advancing to the left by $x' + ct' = \mu(x + ct)$. Solving by determinants,

$$x' = \frac{\begin{vmatrix} \lambda(x - ct) & -c \\ \mu(x + ct) & c \end{vmatrix}}{\begin{vmatrix} 1 & -c \\ 1 & c \end{vmatrix}} = \frac{\lambda(x - ct) + \mu(x + ct)}{2}$$

$$= \frac{\lambda + \mu}{2} x - \frac{\lambda - \mu}{2} ct$$

$$\text{and } t' = \frac{\begin{vmatrix} 1 & \lambda(x - ct) \\ 1 & \mu(x + ct) \end{vmatrix}}{\begin{vmatrix} 1 & -c \\ 1 & c \end{vmatrix}} = \frac{\mu(x + ct) - \lambda(x - ct)}{2c}$$

$$= -\frac{\lambda - \mu}{2c} x + \frac{\lambda + \mu}{2} t$$

If we put $\frac{\lambda + \mu}{2} = a$ and $\frac{\lambda - \mu}{2} = b$ these become

$$x' = ax - bct \quad \text{and} \quad t' = at - bx/c$$

Now when $x = vt$, $x' = 0$. From this we obtain

$$0 = avt - bct, \quad \text{or} \quad b = av/c$$

On substituting, our equations reduce to

$$x' = a(x - vt)$$
$$t' = a(t - vx/c^2)$$

If $x_2' - x_1'$ represents a certain distance, say the length of a yardstick, in the primed system, and x_2 and x_1 are the corresponding coördinates of the ends of the yardstick in the unprimed system, then as viewed from the unprimed system, x_2 and x_1 occur for the same value of the time, say $t = T$†, and we have $x_2' = a(x_2 - vT)$ and $x_1' = a(x_1 - vT)$, so that $x_2' - x_1' = a(x_2 - x_1)$, or $x_2 - x_1 = (1/a)(x_2' - x_1')$ and the length of the yardstick in the unprimed system is $1/a$ times its length in the primed system.

Now the above transformation equations may also be written:

$$x - vt = x'/a$$
$$-vx/c^2 + t = t'/a$$

Solving these equations,

$$x = \frac{\begin{vmatrix} x'/a & -v \\ t'/a & 1 \end{vmatrix}}{\begin{vmatrix} 1 & -v \\ -v/c^2 & 1 \end{vmatrix}} = \frac{x' + vt'}{a(1 - v^2/c^2)}$$

$$t = \frac{\begin{vmatrix} 1 & x'/a \\ -v/c^2 & t'/a \end{vmatrix}}{\begin{vmatrix} 1 & -v \\ -v/c^2 & 1 \end{vmatrix}} = \frac{t' + vx'/c^2}{a(1 - v^2/c^2)}$$

And if we have a length $x_2' - x_1'$ in the primed system at rest in that system with $t' = T'$, then

$$x_2 - x_1 = \frac{x_2' - x_1'}{a(1 - v^2/c^2)}, \text{ or } x_2' - x_1' = a(1 - v^2/c^2)(x_2 - x_1)$$

So that, as viewed from the primed system, a length is $a(1 - v^2/c^2)$ times its length in the unprimed system.

Since by the first principle of Relativity one of the two systems cannot actually be any more at rest than the other, distances in one system as viewed from the other must be affected in the same way when the second system is viewed from the first. Hence the two factors used above must be equivalent, and we have $a(1 - v^2/c^2) = 1/a$. From this we obtain $a = 1/\sqrt{1 - v^2/c^2}$ (evidently the + sign should be taken for the radical, since $x_2' - x_1'$ and $x_2 - x_1$ would have like signs).

So our equations become

$$x' = \frac{x - vt}{\sqrt{1 - v^2/c^2}}$$
$$t' = \frac{t - vx/c^2}{\sqrt{1 - v^2/c^2}}$$

And in the form solved for x and t, we have

$$x = \frac{x' + vt'}{\sqrt{1 - v^2/c^2}}$$
$$t = \frac{t' + vx'/c^2}{\sqrt{1 - v^2/c^2}} \text{‡}$$

These equations make up what is called the *Lorentz Transformation*, and it is generally conceded that they must take the place of the simpler classical equations used by Newton. If we let the ratio v/c approach 0, appropriate in the case of objects moving with velocities small compared to that of light, the Lorentz equations reduce to the classical equations $x' = x - vt$, $t' = t$, as a limiting case.

The chief physical significance of the Lorentz Transformation is that an object when in motion with respect to an observer appears to have a length shorter than when at rest with respect to that observer, the length being multiplied by the factor $1/a$, or $\sqrt{1 - v^2/c^2}$.

We can now explain the two expressions for the speed of light in our ship and shore experiment. If we let d' and t' represent respectively the length of the ship and the time for the passage of the light signal as measured by the man on the ship, then the two expressions are d'/t' and $(vt + d)/t$. According to the Lorentz equations, the length of the ship is shortened to $d = d'\sqrt{1 - v^2/c^2}$ as viewed from the shore and the time taken by the signal is $t = \frac{t' + vd'/c^2}{\sqrt{1 - v^2/c^2}}$

Substituting, $(vt + d)/t$

$$= \left[\frac{vt' + v^2d'/c^2}{\sqrt{1 - v^2/c^2}} + d'\sqrt{1 - v^2/c^2}\right] \div \frac{t' + vd'/c^2}{\sqrt{1 - v^2/c^2}}$$

When simplified, this becomes $\frac{vt' + d'}{t' + vd'/c^2}$

Since d'/t' is the speed of light, c, we can put $d' = ct'$, which makes the above expression $\frac{vt' + ct'}{\frac{ct' + vt'}{c}} = c$; so that the two expressions are, after all, identical.

The Lorentz equations also explain the results of the famous Michelson and Morley experiment, based on the principle (from the wave nature of light) that whenever two beams of monochromatic light emanating from the same source travel over paths of different lengths and are subsequently joined together, there will be constructive or destructive interference, evidenced by increased or diminished brightness of the resulting image, with

*Note that time really appears here as a fourth dimension.

†Note that the two values of t' would not be equal.

‡Note that the form of the expressions for x and t differs from that for x' and t' only in having v replaced by $-v$.

an "interference pattern" of shadows and fringes due to any slight variation in the length of path traveled by parts of the same beam.

The apparatus for the experiment is roughly that shown in the figure. Light from the source S, say a sodium flame, strikes a mirror at A which is very thinly silvered, so that part of the light is reflected to M and part of it is transmitted to M′. At M and M′ mirrors reflect the beams back along the framework to A where part of each beam proceeds to give the resulting image viewed at E.

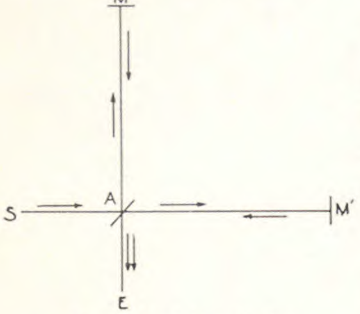

Fig. 4. Michelson-Morley Interferometer

If the apparatus were kept stationary, and the two arms AM and AM′ were kept exactly the same length, so that the light takes the same time for its journey along each, then we should expect no interference at E; or if a slight difference in the lengths produces an interference pattern at E, we should expect no change in the pattern when the apparatus is revolved about A in the plane of the figure.

However, the apparatus is not stationary, because it has the motion of the earth's rotation on its axis, and also the much greater motion of the earth's velocity in its orbit around the sun. Considering the latter only, if SM′ has the direction of the earth's motion, and AM the perpendicular direction, then the beam in the direction of the earth's motion must travel from A_1, the original position of the mirror A, to M′, a distance $vt_1 + d = ct_1$, where t_1 is the time for the journey to the right, and a distance $d - vt_2 = ct_2$ back to A_2, the final position of A. Solving for the two times and adding, $t_1 + t_2 = d/(c - v) + d/(c + v)$. Simplifying and multiplying by c, the total *distance* is $2c^2d/(c^2 - v^2) = 2d/(1 - v^2/c^2)$.

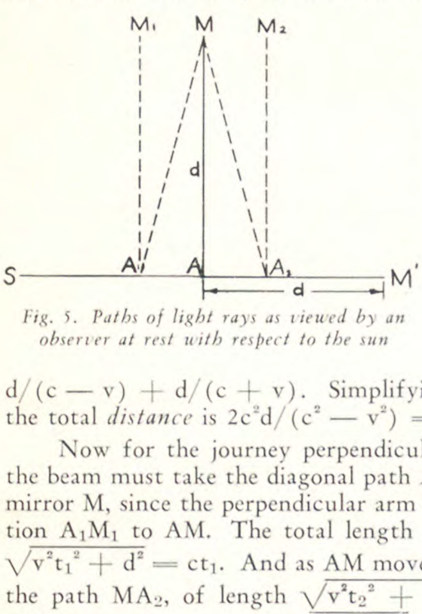

Fig. 5. Paths of light rays as viewed by an observer at rest with respect to the sun

Now for the journey perpendicular to the earth's motion, the beam must take the diagonal path A_1M in order to reach the mirror M, since the perpendicular arm has moved from the position A_1M_1 to AM. The total length of the path is, therefore, $\sqrt{v^2t_1^2 + d^2} = ct_1$. And as AM moves to A_2M_2 the light takes the path MA_2, of length $\sqrt{v^2t_2^2 + d^2} = ct_2$. Solving and adding, $t_1 + t_2 = 2d/\sqrt{c^2 - v^2}$, and the total *distance* is $2cd/\sqrt{c^2 - v^2} = 2d/\sqrt{1 - v^2/c^2}$.

But while the experiment has been performed many times with very refined methods to secure extreme accuracy, the expected result of a changing interference pattern has never been shown. Always the effect is as if the two distances remained of the same length, whether parallel to the earth's motion, or perpendicular to it, or in any intermediate position.

The negative result of this experiment is readily explained with the Lorentz Transformation by the shortening of the framework of the apparatus in the direction AM′ (as it would be seen by an observer at rest with respect to the sun). Thus, the value of d in the expression $2d/(1 - v^2/c^2)$ should be replaced by $d\sqrt{1 - v^2/c^2}$, which gives $2d/\sqrt{1 - v^2/c^2}$, so that the correction is just enough to make the lengths of the two paths equal.

An important consequence of the Lorentz Transformation is that it leads to a different result for the composition of two relative velocities than that with which we are familiar. If an object has a velocity u with respect to another object moving with velocity v, we would ordinarily say that the first is moving with velocity $w = u + v$. However, using the Lorentz equations, we obtain, for an object moving along the x-axis with speed u in the primed system,

$$x = \frac{x' + vt'}{\sqrt{1 - v^2/c^2}} = \frac{ut' + vt'}{\sqrt{1 - v^2/c^2}}$$

and substituting for t′,

$$x = \frac{(u + v)}{\sqrt{1 - v^2/c^2}} \; \frac{(t - vx/c^2)}{\sqrt{1 - v^2/c^2}}$$

This gives $(1 - v^2/c^2)x = (u + v)t - (u + v)vx/c^2$ or $x = (u + v)t/(1 + uv/c^2)$, and from $x = wt$, we have

$$w = \frac{u + v}{1 + uv/c^2}$$

which is the relativity formula for adding velocities.

If we solve the above equation for u, we obtain the formula for subtracting velocities, or

$$u = \frac{w - v}{1 - wv/c^2}$$

which is also the above formula for addition with v replaced by —v.

There are other physical consequences of the Lorentz Transformation which we will not undertake to discuss. They introduce corrections involving the term v^2/c^2, but in ordinary physical phenomena where velocities are extremely small in comparison with the velocity of light, these changes are negligible, and the Lorentz equations are adequately replaced by the time-honored equations of Newton. However, when we consider the enormously high figures met with in astronomy and in the study of atomic structure, where orbital velocities of electrons may be as high as $2(10)^8$ cm. per sec., or 1/150 of the velocity of light, it is conceivable that in these fields the Relativity correction may be important enough to become effective.

We will now investigate the effect of the Relativity modification on a certain problem in the study of electricity.

The Electric Field of Force Due to a Moving Charge

Consider a point charge of magnitude q located at O′, and let the magnitude of the electric field intensity, or force on a unit charge, at the point P* be represented by E′ in the moving or primed system, and by E as measured in the unprimed system.

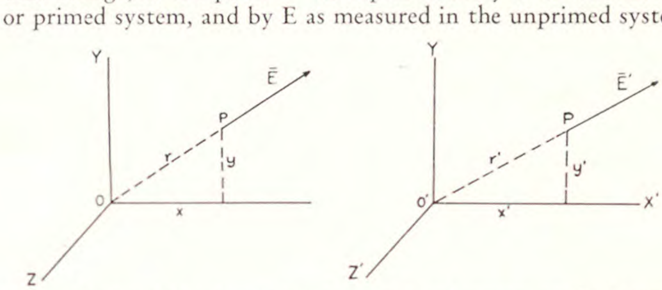

Fig. 6. Electric field intensity in "stationary" and moving coördinate systems

The field intensity is actually a vector quantity and may be represented completely by the symbols $\overline{E}$ and $\overline{E}'$.

Then to an observer at rest with respect to the primed system, $\overline{E}'$ is the usual electrostatic field determined by Coulomb's Law, force $= q_1q_2/kr'^2$.† Putting $q_1 = q$, the magnitude of

*There is no loss in generality if we take P as a point in the xy-plane.

†k, called the "dielectric constant, is numerically 1 in a vacuum, and very approximately 1 in air. It is, however, a dimensional quantity as used here.

the moving charge, and $q_2 = 1$, we have $E' = q/kr'^2$.

We will take the instant when the field is to be compared in the two systems as the time when their origins are coincident. Then x and x′ will be corresponding lengths in the two systems, and by the contraction of distances parallel to the direction of motion which results from the Lorentz equations, we will have $x = x'\sqrt{1 - v^2/c^2}$. Since distances perpendicular to the motion are unchanged, $y = y'$.

Before proceeding further we must inquire rather closely into the meaning of the quantity which the electricians and physicists call "flux." By the flux of the vector $\overline{E}$ through any plane surface which is perpendicular to $\overline{E}$ we mean the product of the magnitude of $\overline{E}$ at the surface by the area of the surface; but if the surface is not perpendicular to $\overline{E}$ we must substitute for the area its projection on a plane perpendicular to $\overline{E}$.

With a *curved* surface we use infinitesimally small parts of the surface dS, which may be considered plane, since any curved surface may be thought of as coinciding with the infinitesimal parts of its tangent planes. The different parts of the area would then be projected in different directions, and we would use integration, obtaining $\int_S\int E \cos\theta\, dS$ (called a "surface integral") with the angle θ usually different for each elementary area dS.

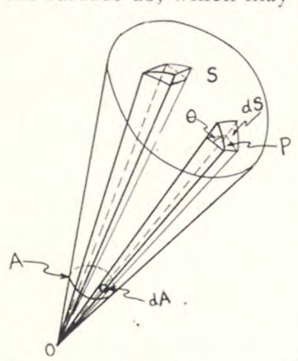

Fig. 7. Flux through a curved surface; projections of surface elements on concentric spheres

Now the projection, dS cos θ, being perpendicular to $\overline{E}$, and so to the line joining O with the point P on the surface, is part of a tangent plane to the sphere with center O and radius OP, and may be taken as part of the surface of this sphere, which is itself thought of as coinciding with infinitesimal parts of its tangent planes. We may consider the projection, then, to be the area intercepted on this sphere by the cone-shaped figure joining O with the boundary of dS. Since the magnitude of E′ at P is $q/kr'^2 = q/k(OP)^2$, the flux is $\frac{q}{k}\int_S\int \frac{dS\cos\theta}{(OP)^2}$.

Now the areas intercepted by the cone-shaped figures on different spheres with centers at O will be proportional to the squares of the radii of the spheres, and if dA is the area intercepted on a sphere of unit radius, we have $(dS\cos\theta)/(OP)^2 = dA/1^2 = dA$. The total flux through the surface is, therefore, equal to qA/k where A is the total area intercepted on the unit sphere.

If we follow the convention of drawing lines of force in such a way that their number through a unit area is equal to the strength of the field in the location of the area, then the number of lines of force through the area A sq. cm. would equal $q/k(1)^2$ (the strength of the field on the unit sphere) times A, or qA/k. Since the same lines extend out through the cone-shaped figure, this gives also the number of lines through the surface S. But this same expression was previously obtained for the flux through S, and so it appears that the flux through any surface is numerically equal to the number of lines of force passing through the surface. As an example, for a closed surface, say a sphere or ellipsoid, with the point O anywhere inside, the total flux would be $q(4\pi)/k$, and in a vacuum there would be $4\pi q$ lines emanating from a point charge of magnitude q. Now the space of the moving system appears to an observer in the unprimed system to be contracted in the direction of motion, in which case a sphere would become an ellipsoid (prolate spheroid), and the lines of force, representing the way the impulse from the moving charge is transmitted through the contracted space, will be distorted as shown in the figure.

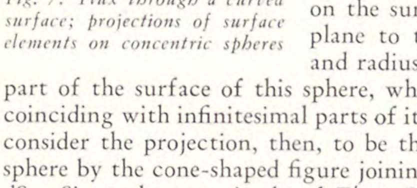
Fig. 8. Lines of force emanating from a moving charge, observed in the two systems

Now let us consider a zone of width r′dθ′ on the sphere of radius OP′, which is bounded by two circles in planes perpendicular to the x-axis and with the radius of the smaller circle y′. As this zone is distorted into a corresponding zone on the ellipsoid in the unprimed space, the lines of force through the zone will also be distorted, and while the area of the zone will obviously be decreased, there will be no change in the number of lines of force passing through it, and hence no change in the flux through the zone. Now the flux through the zone on the ellipsoid is the same as the flux through a sphere through P with radius r (= OP), as can be seen from the figure (the spherical zone would be the projection of that on the ellipsoid). Therefore, equating the flux through the zones of infinitesimal width in the two coördinate systems (over which the magnitude of the field intensity would be constant), we have

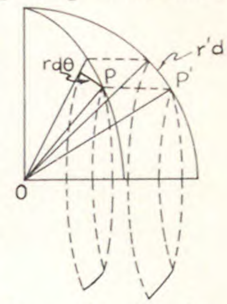

Fig. 9. Flux through zones of radius y in the two systems

$$E(2\pi y r d\theta) = E'(2\pi y' r' d\theta')$$

Since the area is smaller in the unprimed system, the magnitude of E must be greater than that of E′.

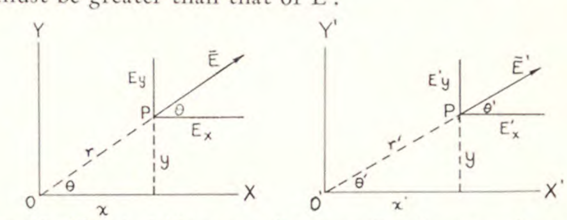

Fig. 10. Electric field vector to "stationary" and moving observers

We had from the Lorentz equations $y = y'$ and $x = x'\sqrt{1 - v^2/c^2} = x'\sqrt{1 - \beta^2}$, where we have put $\beta = v/c$ for brevity.

Substituting for the y's, $r'\sin\theta' = r\sin\theta$;

and for the x's, $r'\cos\theta' = r\cos\theta/\sqrt{1 - \beta^2}$.

Dividing, $\tan\theta' = \tan\theta\sqrt{1 - \beta^2}$

from which $\theta' = \arctan(\sqrt{1 - \beta^2}\tan\theta)$

and $$d\theta' = \frac{\sqrt{1 - \beta^2}\sec^2\theta\, d\theta}{1 + (1 - \beta^2)\tan^2\theta}$$

Also from the right triangle,

$$\sin\theta' = \frac{\sqrt{1 - \beta^2}\tan\theta}{\sqrt{1 + (1 - \beta^2)\tan^2\theta}}$$

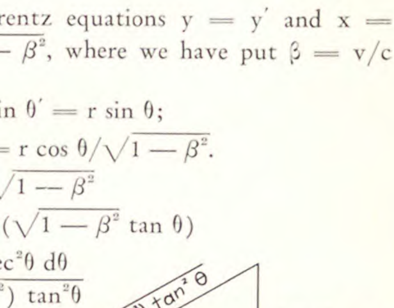

Fig. 11

From the flux equation we obtain $Erd\theta = E'r'd\theta'$, and substituting from the above relations,

$$E'r'd\theta' = \frac{E'r\sin\theta\sqrt{1 + (1 - \beta^2)\tan^2\theta}}{\sqrt{1 - \beta^2}\tan\theta}\left[\frac{\sqrt{1 - \beta^2}\sec^2\theta\, d\theta}{1 + (1 - \beta^2)\tan^2\theta}\right]$$

Equating this to $Erd\theta$, and making use of the right triangle, we obtain

$$E = \frac{E'\sec\theta}{\sqrt{1 + (1 - \beta^2)\tan^2\theta}} = E'\sec\theta\cos\theta'$$

For E_x, the component of E along the direction of motion of the charge, we have $E_x = E \cos\theta$, and from the above equation this equals $E' \cos\theta' = E'_x$; and so the component of the field in this direction is unchanged.

For E_y, the component of E perpendicular to the direction of motion, we have $E_y = E \sin\theta$, and substituting the expression obtained for E, this is $E' \tan\theta \cos\theta' = E' \tan\theta \sin\theta'/\tan\theta' = E' \tan\theta \sin\theta'/(\sqrt{1-\beta^2}\tan\theta) = E'_y/\sqrt{1-\beta^2}$; and, therefore, this component is increased by the factor $1/\sqrt{1-\beta^2}$, where $\beta = v/c$.

For the value of E itself we have $E = q \sec\theta \cos\theta'/kr'^2$. Substituting $r' = r\cos\theta/\cos\theta'\sqrt{1-\beta^2}$ gives $E = q \sec\theta \cos^3\theta'(1-\beta^2)/kr^2\cos^2\theta$, and substituting for $\cos\theta'$,

$$E = \frac{q(1-\beta^2)\sec^3\theta}{kr^2[1+(1-\beta^2)\tan^2\theta]^{3/2}}$$

An alternate form is obtained by multiplying numerator and denominator by $\cos^3\theta$. This is readily seen to give

$$E = \frac{q(1-\beta^2)}{kr^2(1-\beta^2\sin^2\theta)^{3/2}}$$

We have shown that the motion of an electric charge relative to an observer increases its electric field, that the increase occurs only in the direction perpendicular to the motion, and that the field experienced by the observer has the components $E_x = E'_x$ and $E_y = E'_y/\sqrt{1-\beta^2}$. The magnitude of the field no longer satisfies the inverse square law, but its value is given by the more complicated expressions shown above, being very nearly equal to the inverse square value when the speed of the moving charge is small compared with the speed of light.

The Forces Between Charges at Two Points in Parallel Conductors

Now suppose we have two parallel straight wires carrying currents. We will analyze the electrostatic forces between a positive charge and an equal negative charge at a typical point in one wire and a second pair of equal and opposite charges at a typical point in the other wire.

The positive charges A and C are considered at rest, and the negative charges B and D constitute the currents and move with drift velocities v_1 and v_2. (Either v_1 or v_2 may be opposite to the directions shown, in which case they would have negative values.) We will let the magnitude of each of the charges A and B be q_1, and that of charges C and D be q_2 electrostatic units.

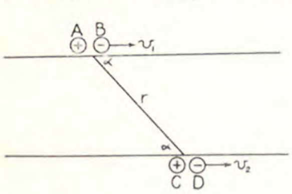

Fig. 12. Pairs of charges in parallel conductors

The force exerted by A on C will be a repulsion, equal to q_1q_2/kr^2, and we will denote it simply by F. Its component parallel to the wires is $F\cos\alpha$, and its component normal (perpendicular) to the wires is $-F\sin\alpha$ (minus, because it acts downward in the figure).

The field of the moving charge B has the same parallel component to an observer at rest with respect to A or C as with respect to an observer moving with B, but its normal component will be altered by the factor $1/\sqrt{1-\beta_1^2}$, since B is moving with velocity v_1 relative to C. The parallel component of the force of attraction on C will then be $-q_2E'_x$ (minus, because it acts to the left) and the normal component is $q_2E'_y/\sqrt{1-\beta_1^2}$, where $E'_x = q_1\cos\alpha'/kr'^2$ and $E'_y = q_1\sin\alpha'/kr'^2$. (Here α' represents the angle in the primed system corresponding to α in the unprimed system.)

The force of A on D, to an observer moving with D, is an attraction, with unchanged parallel component $-q_2E_x = -F\cos\alpha$, and with normal component $q_2E_y/\sqrt{1-\beta_2^2}$ where E_y is the normal component of A's field to an observer at rest with respect to A and C (this is because A has a velocity of $-v_2$ relative to D). Now to an observer at rest with respect to C, the force on D, temporarily at the same location as C, is found by multiplying the field for this observer by the magnitude of the charge D, and, hence, has the components $-F\cos\alpha$ and $q_2E_y = F\sin\alpha$. Thus, in finding the force as it appears to this observer from the force to an observer moving with D we would need to multiply the normal component of the latter by $\sqrt{1-\beta_2^2}$. This is an example of the general rule that if we know the value of a force in one coördinate system which is moving with velocity v with respect to another coördinate system, then the normal component of the force in the second system is $\sqrt{1-\beta^2}$ times the normal component in the first; the parallel component, of course, is unchanged.*

For the repelling force of B on D we consider first its components as experienced by an observer moving with D. These are $q_2E'_x$ and $-q_2E'_y/\sqrt{1-\beta_{12}^2}$, where β_{12} is $1/c$ times v_{12}, the velocity of B relative to D. By the Relativity formula for compounding velocities this is $(v_1 - v_2)/(1 - v_1v_2/c^2)$, and hence β_{12} is $(\beta_1 - \beta_2)/(1 - \beta_1\beta_2)$. To an observer at rest with respect to C, relative to which D has a velocity of v_2, the parallel component is still $q_2E'_x$, but to find the normal component we must multiply by $\sqrt{1-\beta_2^2}$, by the rule stated in the preceding paragraph; and so the normal component is $-q_2E'_y\sqrt{1-\beta_2^2}/\sqrt{1-\beta_{12}^2}$.

Adding the four parallel components, we have

$$F\cos\alpha - q_2E'_x - F\cos\alpha + q_2E'_x = 0.$$

Adding the four normal components, we have

$$-F\sin\alpha + q_2E'_y/\sqrt{1-\beta_1^2} + F\sin\alpha - q_2E'_y\sqrt{1-\beta_2^2}/\sqrt{1-\beta_{12}^2}$$

$$= q_2E'_y\left[\frac{1}{\sqrt{1-\beta_1^2}} - \frac{\sqrt{1-\beta_2^2}}{\sqrt{1-\beta_{12}^2}}\right]$$

$$\text{Now } \sqrt{1-\beta_{12}^2} = \sqrt{1 - \frac{(\beta_1-\beta_2)^2}{(1-\beta_1\beta_2)^2}}$$

$$= \frac{\sqrt{1 - 2\beta_1\beta_2 + \beta_1^2\beta_2^2 - \beta_1^2 + 2\beta_1\beta_2 - \beta_2^2}}{1-\beta_1\beta_2}$$

$$= \frac{\sqrt{1-\beta_1^2}\,\sqrt{1-\beta_2^2}}{1-\beta_1\beta_2}$$

Substituting in the above expression, we obtain

$$\frac{q_2E'_y}{\sqrt{1-\beta_1^2}}(1 - 1 + \beta_1\beta_2) = q_2E_y\beta_1\beta_2,$$

where we use E_y now to represent the normal component of the field of the moving charge B as measured in a coördinate system at rest with respect to C. We have $E_y = E\sin\alpha$, and we found previously that the value of E, instead of following the inverse square law, is $q_1(1-\beta_1^2)/kr^2(1-\beta_1^2\sin^2\alpha)^{3/2}$. Therefore, the final expression for the resultant of all the forces on C and D is

$$\frac{q_1q_2\beta_1\beta_2\sin\alpha}{kr^2}\left[\frac{1-\beta_1^2}{(1-\beta_1^2\sin^2\alpha)^{3/2}}\right]$$

This is very nearly equivalent to the formula generally given for the force between two infinitesimal current elements in parallel wires based on the experimentally established rule (Ampere's Law) for the magnetic field surrounding a current-carrying wire. Expressed in the above units, the Ampere's Law formula would be written $\dfrac{q_1v_1q_2v_2\sin\alpha}{kr^2c^2}$

[The force is usually given as $\mu I_1ds_1I_2ds_2\sin\alpha/r^2$. To change

*The derivation of this general rule from the Lorentz Transformation is given by W. R. Smythe in *Static and Dynamic Electricity*, pp. 487-488.

this to the above form, we think of the current as a procession of charges of magnitude q spaced a small distance ds apart.

q q q ds q q q

If these are moving with drift velocity v, the number which will have passed any point in the wire in one second is v/ds, and the total charge passing any point in one second is qv/ds. This, by definition, is the current I, and so Ids = qv. The currents in the formula for the force, however, are expressed in electromagnetic units, whereas the q's are in electrostatic units. Since a current of I abcoulombs per second is Ic′ statcoulombs per second, where c′ is the number of statcoulombs in an abcoulomb, the above equation should be written Ids = qv/c′. Here c′ is a pure number; it has the value, but not the dimensions, of the speed of light in a vacuum, usually represented by c. Now the quantity $c'/\sqrt{\mu k}$ is known (from the form of Maxwell's electromagnetic wave equations) to represent the velocity of light in any medium (the quantity $1/\sqrt{\mu k}$ having the dimensions of a velocity). Since the permeability μ and dielectric constant k are defined as 1 for a vacuum (and are approximately 1 for air), we see that $c'/\sqrt{\mu k}$ is equivalent to the quantity c, which we used before for the velocity of light. Squaring, we have $c'^2/\mu k = c^2$, or $\mu/c'^2 = 1/kc^2$. Substituting $I_1ds_1 = q_1v_1/c'$ and $I_2ds_2 = q_2v_2/c'$, and putting $\mu/c'^2 = 1/kc^2$, we obtain the form $q_1v_1q_2v_2 \sin\alpha/kr^2c^2$.]

If we write the denominator of the above expression in brackets with a negative exponent and expand by the binomial theorem, the expression becomes $(1 - \beta_1^2)[1 + (3/2)\beta_1^2\sin^2\alpha + \text{- - - -}] = 1 - \beta_1^2 + (3/2)\beta_1^2\sin^2\alpha + \text{- - - -}$. Substituting this series for the expression in brackets and neglecting terms of the fourth degree and higher in the β's, which are normally very small fractions, we obtain $\frac{q_1q_2\beta_1\beta_2 \sin\alpha}{kr^2}$, which equals $\frac{q_1v_1q_2v_2 \sin\alpha}{kr^2c^2}$, i.e., the value given by Ampere's Law.

We see that the result gives an attraction when v_1 and v_2 have like signs, and a repulsion when the v's have opposite signs. Thus, the force which draws together two wires carrying currents when the currents flow in the same direction, and pushes them apart when the currents flow in opposite directions, has been shown to be a consequence only of the electrostatic forces between the charges in the wires and the Relativity modification of these forces due to the motion of the charges.

We may note that the usual form of Ampere's Law for the magnetic field due to a moving charge or current element Ids, which is $\mu Ids \sin\alpha/r^2$, assumes the inverse square law, but as we saw in the case of the electrostatic field, this does not hold for an observer not moving with the charge; hence, it seems logical that the inverse square formula is an approximation and should be subject to a Relativity correction. The effect of such a correction, however, would be negligible in the usual cases where Ampere's Law is applied.

We will now apply the formula which we have derived for the force between pairs of charges to find the total force between two parallel conductors, and then we will evaluate the force for a particular case and show how it agrees quantitatively with the results obtained by the usual familiar methods.

The Total Force Between Two Parallel Conductors

We will first find by integration the total force exerted by all the charges in one wire upon a pair of charges q_2 and $-q_2$ (corresponding to C and D in figure 12) in the other wire. The current is conceived of as a slow "drift" of electrons along the atoms of the wire in the direction opposite to that conventionally taken as the direction of the current. If n denotes the number of drift electrons in a unit volume of the wire, e is the charge of each electron, and A is the cross section area, then Ane is the amount of charge in a portion of the wire 1 cm. long. (This is the amount of movable negative charge, an equal positive charge being present at the same location in the stationary protons in the atoms of the wire.) The charge in an infinitesimal length of the wire, dy, is Anedy and we may consider this to be concentrated at a point and substitute it for the charge q_1 in the formula. (The electrons have high velocities in their orbits within the atoms and are actually moving very rapidly in all different directions. What we call the drift velocity, here v_1, is really the average of the velocities of all the current-carrying electrons, i.e., the average speed at which they travel along the wire.)

We can then let Anedy represent the value q_1 of the charges A and B (of figure 12), and on substituting in our formula, the force on C and D is

$$\frac{\text{Anedy}\, v_1 q_2 v_2 (1 - \beta_1^2)\sin\alpha}{kr^2c^2(1 - \beta_1^2\sin^2\alpha)^{3/2}}$$

If we let K represent the quantity $\text{Ane}v_1q_2v_2(1 - \beta_1^2)/kc^2$ and replace the expression $1/(1 - \beta_1^2\sin^2\alpha)^{3/2}$ by the alternate form which we obtained first in finding E of a moving charge (derived from the above expression by multiplying numerator and denominator by $\sec^3\alpha$), we obtain

$$\frac{K \sin\alpha \sec^3\alpha\, dy}{r^2[1 + (1 - \beta_1^2)\tan^2\alpha]^{3/2}}$$

To find the total force on the pair of charges C and D due to the entire length of the wire on the right (figure 13), we will let C, D be located on the x-axis and integrate from a negative value y_1 to a positive value y_2.

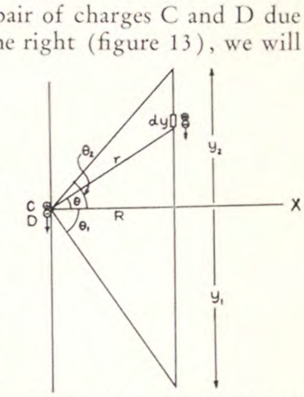

Fig. 13. Determination of total force on pair of charges C, D

In the derivation of the formula for the force, α was the acute angle between either wire and the line joining the charges A, B and C, D (figure 12), and our proof requires that it be taken as positive whether A, B are to the left or to the right of C, D. Now in figure 13 we use, instead of α, the angle θ which the line between the pairs of charges makes with the normal to the wire. Above the x-axis, $\theta + \alpha = \pi/2$, and so $\alpha = \pi/2 - \theta$; but below the x-axis θ is to be taken as negative, and so there we have $\alpha + (-\theta) = \pi/2$, or $\alpha = \pi/2 + \theta$.

In the above expression for the force we substitute $\sin\alpha = \cos\theta$, $\tan\alpha = \cot\theta$, and $\sec\alpha = \csc\theta$ when y is positive; and $\sin\alpha = \sin(\pi/2 + \theta) = \cos\theta$, $\tan\alpha = \tan(\pi/2 + \theta) = -\cot\theta$, and $\sec\alpha = \sec(\pi/2 + \theta) = -\csc\theta$ when y is negative. We will, therefore, need to use two separate integrals, and thus, letting f_c be the total force on C and D, we have

$$f_c = K\int_{y_1}^{0} \frac{-\cos\theta \csc^3\theta\, dy}{r^2[1 + (1 - \beta_1^2)\cot^2\theta]^{3/2}}$$

$$+ K\int_{0}^{y_2} \frac{\cos\theta \csc^3\theta\, dy}{r^2[1 + (1 - \beta_1^2)\cot^2\theta]^{3/2}}$$

Now $r = R\sec\theta$, $y = R\tan\theta$, $dy = R\sec^2\theta\, d\theta$. Also, when $y = y_1$, $\theta = \theta_1$, and when $y = y_2$, $\theta = \theta_2$. Substituting, we have

$$f_c = \frac{K}{R}\int_{\theta_1}^{0}\frac{-\cos\theta\csc^3\theta\,d\theta}{[1+(1-\beta_1^2)\cot^2\theta]^{3/2}}$$

$$+\frac{K}{R}\int_{0}^{\theta_2}\frac{\cos\theta\csc^3\theta\,d\theta}{[1+(1-\beta_1^2)\cot^2\theta]^{3/2}}$$

$$=\frac{K}{2R(1-\beta_1^2)}\left\{\int_{\theta_1}^{0}\frac{(1-\beta_1^2)(-2\cot\theta\csc^2\theta\,d\theta)}{[1+(1-\beta_1^2)\cot^2\theta]^{3/2}}\right.$$

$$\left.-\int_0^{\theta_2}F(\theta)\,d\theta\right\},$$

where the second integrand, $F(\theta)$, is identical with the first. Integrating, we have

$$\frac{K}{2R(1-\beta_1^2)}\left[\frac{-2}{\sqrt{1+(1-\beta_1^2)\cot^2\theta}}\right]_{\theta_1}^{0}$$

$$-\frac{K}{2R(1-\beta_1^2)}\left[\frac{-2}{\sqrt{1+(1-\beta_1^2)\cot^2\theta}}\right]_{0}^{\theta_2}$$

$$=\frac{K}{R(1-\beta_1^2)}\left[\frac{1}{\sqrt{1+(1-\beta_1^2)\cot^2\theta_1}}\right]$$

$$+\frac{K}{R(1-\beta_1^2)}\left[\frac{1}{\sqrt{1+(1-\beta_1)^2\cot^2\theta_2}}\right]$$

(since $\cot 0 = \infty$).

Multiplying numerator and denominator of the first fraction in the brackets by $-\sin\theta_1$ (a positive quantity since $\sin\theta_1$ is negative) and numerator and denominator of the second fraction by $\sin\theta_2$, we have, after simplifying and substituting for K,

$$f_c = \frac{Anev_1q_2v_2}{kRc^2}\left[\frac{\sin\theta_2}{\sqrt{1-\beta_1^2\cos^2\theta_2}} - \frac{\sin\theta_1}{\sqrt{1-\beta_1^2\cos^2\theta_1}}\right]$$

(The result derived from Ampere's Law differs from this in that it has simply $\sin\theta_2 - \sin\theta_1$ in the brackets.)

If we take $\theta_2 = \pi/2$ and $\theta_1 = -\pi/2$ and so find the force on C, D due to the current in an infinitely long wire, we obtain

$$\frac{2Anev_1q_2v_2}{kRc^2},$$

a result which agrees exactly with that obtained by Ampere's Law.

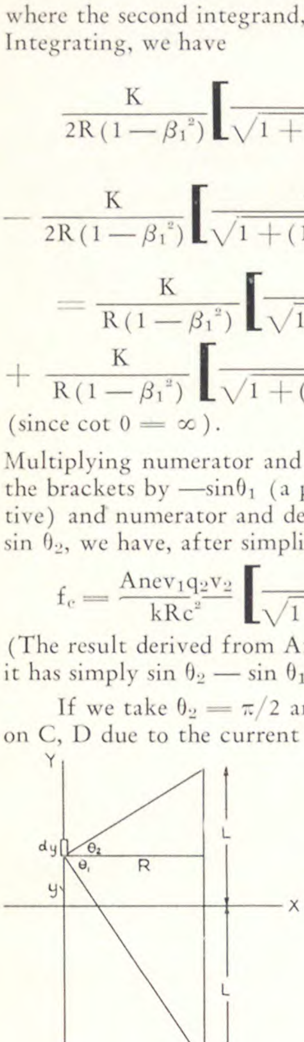

Fig. 14. Determination of total force between conductors

Now we will integrate again to find the total force on all the parts dy of the wire at the left. The charge in the element dy is to be substituted for q_2 and we can take this to be A'n'edy.

Since $\theta_2 = \arctan(L-y)/R$, and $\theta_1 = -\arctan(L+y)/R$, we have, using the form for f_c which contains the cotangents of the angles,

$$f_c = \frac{(Anev_1)(A'n'edyv_2)}{kRc^2}\left[\frac{1}{\sqrt{1+(1-\beta_1^2)R^2/(L-y)^2}}\right.$$

$$\left.+\frac{1}{\sqrt{1+(1-\beta_1^2)R^2/(L+y)^2}}\right]$$

Substituting K' for $(Anev_1)(A'n'ev_2)/kRc^2$ and integrating from $-L$ to L, we find that the total force on the wire at the left is

$$F = K'\int_{-L}^{L}\left[\frac{L-y}{\sqrt{(L-y)^2+(1-\beta_1^2)R^2}}\right.$$

$$\left.+\frac{L+y}{\sqrt{(L+y)^2+(1-\beta_1^2)R^2}}\right]dy$$

$$=K'\left[-\sqrt{(L-y)^2+(1-\beta_1^2)R^2}+\sqrt{(L+y)^2+(1-\beta_1^2)R^2}\right]_{-L}^{L}$$

$$=K'[-R\sqrt{1-\beta_1^2}+\sqrt{4L^2+(1-\beta_1^2)R^2}]$$

$$+K'[\sqrt{4L^2+(1-\beta_1^2)R^2}-R\sqrt{1-\beta_1^2}]$$

$$=K'R[2\sqrt{4L^2/R^2+1-\beta_1^2}-2\sqrt{1-\beta_1^2}]$$

Substituting for K',

$$F = \frac{(Anev_1)(A'n'ev_2)}{kc^2}[2\sqrt{4L^2/R^2+1-\beta_1^2}-2\sqrt{1-\beta_1^2}]$$

(This agrees with the result obtained with the inverse square form for Ampere's Law, except that the β_1^2 terms are missing in the latter.)

Numerical Evaluation in a Particular Case of the Force Between Conductors

Let us suppose that we have two parallel copper wires 1 square millimeter in cross section (.01 square centimeter). Let the wires be 10 cm. long and located 1 cm. apart, and suppose that a current of 1 ampere is flowing in each wire.

The current is defined as the amount of charge passing through a cross section of the wire in one second. When the drift velocity is 1 cm. per sec., this is Ane, the moving charge in a centimeter length of wire, since it will all have moved to the next centimeter of length. When the drift velocity is v, the charge in v cm. of length will have moved through a cross section in one second, and so the expressions of the form Anev in the formula for F represent the respective currents.

In our problem the current in each wire is to be 1 ampere, and since we are using electrostatic units and 1 ampere is $3(10)^9$ statamperes, we will put $Anev_1 = A'n'ev_2 = 3(10)^9$. Also the value of k in air is approximately 1, and c, the velocity of light, is $3(10)^{10}$. Since the wires are 10 cm. long and 1 cm. apart, we have $L = 5$ and $R = 1$. This gives

$$F = \frac{[3(10)^9]^2}{[3(10)^{10}]^2}[2\sqrt{4(25)+1-\beta_1^2}-2\sqrt{1-\beta_1^2}]$$

Here β_1^2 is extremely small, v_1 for the size wire and the current used in our problem being of the order of 10^{-2} cm. per sec.* On dividing by c and squaring we would obtain a quantity which, in view of the way it enters into the above formula, is so small as to defy consideration in our calculations.†

Putting $\beta_1 = 0$, then, we have

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*Evidence points to one conduction electron from each atom of copper, and since the density of copper is 8.9 grams per cc., and there are $6.06(10)^{23}$ atoms in a gram atom (which weighs 63.57 grams) the value of n is $8.9(6.06)(10)^{23}/63.57 = .85(10)^{23}$ electrons. Also A is .01 sq. cm. and e is known to be $1.59(10)^{-19}$ coulomb. Therefore, $v_1 = I/Ane = 1/Ane = .0074$ cm. per sec.

†We note, however, that the formula for F is not symmetrical in β_1 and β_2, and that if we had sought to find the force on the wire at the right we would have obtained a like expression, but with β_1 replaced by β_2. The law of action and reaction evidently does not hold here, for the force which acts upon one wire is not observed to be exactly equal to that which acts upon the other.

$$F = \frac{9(10)^{18}}{9(10)^{20}}[2\sqrt{4(25)+1}-2] = .01[20.1-2] =$$
.18 (dyne).

A rough check on the above may be had by means of the familiar formula $B = 2\mu I/R$. (Here μ is the permeability, which in air can be taken numerically equal to 1.) If we imagine one of the wires to be infinitely long, this gives the magnetic field (flux density) at the center of the other wire, and from $F = Bl I$, we can approximate the total force between the wires. Such an approximation will give a closer result than might at first be expected, because it can be shown that the field at the center is only 2% less for a 10 cm. wire than it would be for a wire of infinite length, and the field 2 cm. from the end of the 10 cm. wire is only 4% less than it is at the center. In the above formula I is in abamperes, and so I = 1 ampere becomes .1 abampere; and since R is 1, B is numerically .2. Thus F is approximately .2(10)(.1) = .20, which compares favorably with our calculated value of .18.

The result is quite small, but this is not surprising when we consider the tremendous difference between the amount of electricity required to produce an electrostatic force of a given strength and that required for a magnetic force of the same strength. E. G. Cullwick points out that "If it were possible to locate two isolated stationary charges each of one coulomb, one meter apart - - - - the mutual force would be roughly a *million tons* weight, whereas if the same charges were moving in parallel conductors, one meter apart, with velocities of one meter per second, their contribution to the force of attraction between the conductors, due to this motion, would be only about $2(10)^{-8}$ lb. wt., - - - -. The fact is, of course, inherent (but obscured) in the well-known ratio of the c. g. s. electro-magnetic and electrostatic units of charge, this ratio being equal to c."*

The Resulting Conclusion as to the Cause of a Magnetic Field

The resultant force which we have found between conductors affords a ready explanation of the whole phenomenon of magnetism. How do we know that a magnetic field exists about a current-carrying wire? Only when we observe its effects, as on a compass needle, or when a bar magnet is suspended near the wire and is found to take a certain position. The bar, because it is magnetized, has its molecular currents† all running in the same

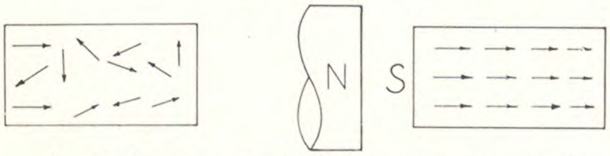

Fig. 15. Lining up of molecular magnets in a piece of iron when placed in a magnetic field

direction. (In the unmagnetized state the currents are imagined to produce molecular "magnets" which would be variably oriented as represented by the arrows in the figure on the left, and the bar would have no external magnetic effect. But when it is brought near a magnet, the magnet's north pole will repel the north poles of the molecular magnets and attract their south poles so that the result is as in the figure on the right.) The currents in adjacent molecular circuits, shown here as they are viewed from the south pole end of the magnet, will neutralize each other everywhere except at the boundary. The circuits in a cross section would then combine to form a single circuit

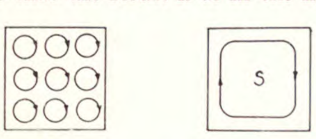

Fig. 16. Molecular currents and their composite effect

(figure at the right). This is the case with the molecular currents in other cross sections, and so the whole bar has the effect of a long solenoid or helical coil of wire carrying a current.

Now when the magnetized bar, acting as a solenoid, is placed near a current-carrying wire, the currents on one side of the bar will be moving in the same direction as the current in the wire, so that the force between their charges and the charges in the wire is an attraction. (In the figure the larger arrows show the direction of the currents and the small ones show the direction of the oppositely moving electrons.) On the other side the currents in the "solenoid" are in the opposite direction and the force is a repulsion. There is, therefore, a torque on the magnet which causes it to turn so that the side with currents running in the same direction as those in the wire is the nearer to the wire, and the opposite side is the farther away from it. The magnet is thus constrained to take a certain position, and we describe the phenomenon, as men have done throughout the ages, by saying the bar is suspended in a magnetic field. If we move the bar, or a compass, to other locations at the same distance from the wire, it will be turned each time to a certain position, always in the direction of a tangent to the circle with center on the wire; and so the circle constitutes what we call a magnetic line of force in the magnetic field which surrounds the wire.

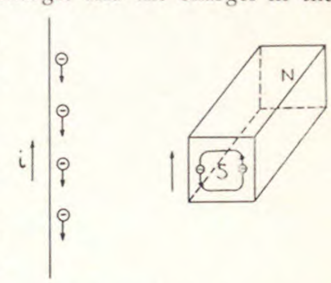

Fig. 17. Bar takes direction of magnetic field

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Easy Way to Blackout Windows in Home Is Outlined by Engineering School Head

Reprinted from the NEW YORK TIMES *of December 21, 1941*

NEWARK, N. J., Dec. 20—An effective, easily removable and inexpensive method of blacking out suburban windows has been devised by Dr. Allan R. Cullimore, president of Newark College of Engineering.

Dr. Cullimore's instructions are as follows:

Drive a nail into the window trim at each of the two top corners. Hang an old rug or blanket over the entire window, using safety pins to suspend the material from the nails. Once this has been done the problem remains of preventing slits of light from shining outside along the sides of the window. To prevent this, cut several old broom handles or any similar strips of wood to lengths one-eighth of an inch longer than the inside width of the window frame. Wedge the strips at intervals across the window, inside the frame and against the old rug or blanket, at the same time stretching the latter snugly in place. The rug or blanket will be held by the pressure of the ends of the strips of wood against the frames.

(Please turn to page 15)

**The Fundamentals of Electro-magnetism*, pages 139-140.

†Due to electrons revolving about the nuclei of atoms, and possibly also to the spinning of the electrons.

TAU BETA PI

The Society of the Trunnion of the Newark College of Engineering became New Jersey Gamma Chapter of the Tau Beta Pi Association on November 29, 1941. As New Jersey Gamma, it becomes the 75th chapter of Tau Beta Pi.

President C. H. Spencer of Washington, D. C., was the installing deputy with the ritual team comprised of Secretary R. C. Matthews of the University of Tennessee, Vice-President Myron Creese of the University of Maryland, Professor J. C. Peet, New York Beta '03, Professor A. A. Nims, Massachusetts Alpha '08, Dr. Frank D. Carvin, Pennsylvania Delta '16, and Fred H. Pumphrey, Ohio Gamma '21. Professors Nims, Peet, and Carvin are of the Newark College of Engineering, Professor Pumphrey is on the Rutgers University faculty.

The group of members was the largest ever initiated into Tau Beta Pi at one time. One hundred and sixty-nine men were inducted, consisting of 21 charter members, 19 undergraduate members, 121 alumni members and eight members of the faculty.

Actually 172 men were to be initiated, but last minute occurrences prevented the attendance of three. The alumni traveled considerable distances to attend. The cities represented besides those within a short distance of Newark were, Kent and Cincinnati, Ohio; Washington, D. C.; Boston, Massachusetts; Fairfield, Connecticut; Schenectady, New York; Reading and Erie, Pennsylvania; and Cumberland and Annapolis, Maryland. The 172 men are from a group of 247 eligible men. Of this achievement the new chapter is justly proud. Several more men could be tallied, but they are at too great a distance and will be initiated by Tau Beta Pi Chapters near their present homes.

Robert Ruddick, New Jersey Alpha; Robert Kennedy, Samuel Mason, and William Rushmore, of New Jersey Beta, assisted in the ritual ceremony.

The following were initiated:

President Allan R. Cullimore, Dean James A. Bradley, Professor Harold N. Cummings, Professor Frank N. Entwisle, Dr. Paul M. Giesy, Professor V. T. Stewart, Dr. T. S. Taylor, Professor Harold E. Walter.

Class of 1927: Soloman Fishman, William J. Opdyke.

Class of 1928: Karl S. Geiges, Robert Edward Mayer, Louis Pickett, Vincent Vitale.

Class of 1929: Marshall Clark Bassford, Alex C. Becker, William B. Morningstern.

Class of 1930: Lawrence F. Adams, Alford B. Anderson, Roy H. Anderson, Archie H. Armstrong, Werner K. Baer, William Hazell, Jr., Frederick P. Highfield, Carl Max Steuhler, Robert W. Van Houten.

Class of 1931: Horace B. Blore, Francis L. Schmidt.

Class of 1932: William H. Gaeckle, Carl H. Huebner, Robert F. Obermann, Lawrence F. Parachini, Irwin L. Phillips, Clarence H. Stephans.

Class of 1933: Herbert S. Close, James J. Coakley, Alfred W. Comins, Andrew L. Dobrovich, Jr., Harry A. Frederick, Paul O. Hoffmann, Leonard A. Karr, Wilbur J. Kupfrian, Pompey Mainardi, Russell C. Neider, Arthur L. Otto, Allen A. Rosenkrans, Melvin R. Schroeder, George D. Wilkinson, Jr., John G. Woehling.

Class of 1934: George L. Curtis, Arthur Dalphond, Frederick Fontanella, John C. Hoffman, Stanley W. Horrocks, Anthony J. Mostello, Arthur E. O'Brien, O. J. Sizelove, Robert R. Sizelove, Martin L. Resnick, August E. Zentgraf.

Class of 1935: P. Frank De Gennaro, Charles William Kabis, Alfred C. Linkletter, Edgar J. Luerich, Marcus N. Mainardi, Charles H. Mayer, Mark E. Otterbein, Stephen E. Pilione, Harry F. Ritterbusch, Raymond E. Roehrenbeck, John W. Willard, Robert J. Winters.

Class of 1936: Charles Baksa, Jr., Arthur K. Burr, Roger L. Campbell, John Cataldo, Cornelius J. Crowley, Jr., John E. Hanle, Donald D. Jones, John K. Mitchell, Robert T. Olsen, Robert R. Schaaf, Camillo M. Veccheotti, Clayton H. Williams.

Class of 1937: Frank A. Busse, James R. Clark, T. August Herman, Leo Kadison, George A. Lenaeus, Arthur P. Mazzuchelli, Milton H. November, Howard T. Shannon, Charles B. Sheridan, Frank S. Stanilewicz, William E. Stephens.

Class of 1938: Howard R. Booth, Otell M. Cocciarella, Walter H. Esselman, Paul J. Giordan, Richard W. Grundman, Samuel E. Johnson, Jr., Frank C. Kreitler, Jr., Elliott Melerbach, Edward A. O'Mara, Herman Ritter, George P. Roeder, Harold Shauger, Irving Stokes.

Class of 1939: Robert E. Anderson, Charles H. Clark, Robert N. Dobbins, Lars E. Erickson, Fred H. Fellows, Richard B. Foster, Ralph M. Knight, Thomas Lopicollo, John C. Lum, Joseph C. Nycz, Charles H. Weber, Jr.

Class of 1940: Bernard L. Baker, Robert E. Coleman, Jr., Joseph F. Daley, George S. Felber, Robert F. Heinzerling, Peter Homack, Irving D. Kruger, Seymour Lewis, Dominick A. Paradiso, George E. Stailing, C. Enrico Viscione, Morris N. Yablonsky.

Class of 1941: Horace L. Bickford, Jr., Joseph F. Conway, Jr., Rudolph A. Dehn, Ronald L. Faber, Francis G. Ginder, Jr., Gordon Nesbitt Hodge, Ernest R. Hugenbruch, Michael M. Mauriello, Robert L. Menegus, Gregory M. Moelter, Harold C. Oakley, William J. O'Connor, Owen B. Olson, Max Carl Schramm, Frank Slamar.

Class of 1942: John C. Alpaugh, Jr., Samuel F. Ciricillo, Alfred R. Crosby, Charles W. Dingle, Jr., David S. Donald, Frank J. Hart, John A. Herrmann, Thomas W. Johnson, Roland L. Laugel, Nelson S. Lawrence, Martin H. Lipton, Chris E. Loeser, Jack M. Rausch, John H. Redmon, Edward J. Sand, James J. Savarese, Joseph Siciliano di Rende, William H. Van Derhoef, Joel P. Wallenstein.

Class of 1943: William E. Jensen, Joseph Leary, William O. Lynch.

Following the installation the chapter held its first meeting, electing as officers Alfred R. Crosby, '42, President; Roland Laugel, '42, Vice-President; Frank J. Hart, '42, Recording Secretary; Martin H. Lipton, '42, Corresponding Secretary; and Joseph Siciliano di Rende, '42, as Treasurer. Elected to the Advisory Board were Professor William Hazell, Jr., '30, Assistant Dean Robert W. Van Houten, '30, Professor A. A. Nims, Massachusetts Alpha '08, and Mr. O. J. Sizelove, '34.

President Spencer handed the President's Book and Recording Secretary's Book to the respective officers and then in a brief message charged the new chapter with its obligations.

The installation dinner which followed was attended by 204 members and guests.

The new chapter entertained as guests the following:

Board of Trustees of the Newark College of Engineering: William L. Morgan, President, Fred L. Eberhardt, Vice-President, Edward F. Weston, George W. McRae.

At the speakers table (left to right): Professor Myron Creese, Dean H. I. Masson, Dr. Allan R. Cullimore, Dr. Robert H. Morrison, Mr. Alfred R. Crosby, Professor William Hazell, Jr., President Charles Spencer, Professor R. C. Matthews, Mr. William L. Morgan, Rev. Arthur Lichtenberger. (Professor and Vice-President Harold N. Cummings, in lower right corner.)

Advisors to the Board of Trustees: August Merz, W. Stuart Landes, Frederick O. Runyon, Howard T. Crichtlow, Hervey S. Vassar.

Special Lecturers: Archie H. Ormond, Angelo M. Pisarra, Assistant Commissioner of Education John A. McCarthy, Rev. Arthur C. Lichtenberger, Dean of Trinity Cathedral, Arnold L. Sorensen, Scout Executive, Robert Treat Council, Dean Frank C. Stockwell, Graduate School, Stevens Institute of Technology.

Faculty of the Newark College of Engineering: Professor James H. Fithian, Associate Professor H. H. Metzenheim, Associate Professor Frank A. Grammer, Assistant Professor Charles J. Kiernan, Assistant Professor Odd P. L. Albert.

The new chapter's President presided at the dinner, and gave a brief history of the Society of the Trunnion and of Tau Beta Pi and then introduced Professor William Hazell, Jr., '30, who acted as toastmaster.

Mayor Vincent Murphy of the City of Newark extended his greetings and congratulations to the new chapter.

President Spencer addressed his opening remarks to the Mayor, telling him that he should recognize in Tau Beta Pi a group of men that could be depended upon for service and citizenship. He continued in this vein, turning to the demands that Tau Beta Pi made on its membership, not in scholarship alone, but in character and leadership. These demands are perpetual and not limited to College life alone.

Secretary Matthews felt that his job was to "oil the bearings" and maintain smooth operation. He is the "chauffeur" and merely follows directions, while men like President Spencer do the guiding.

Dr. H. I. Masson, Dean of the Graduate School of Engineering, New York University, President of the New York Alumni Association, appealed to the newly initiated alumni to maintain their interest in Tau Beta Pi after college by participation in the New York Alumni activities or in other Tau Beta Pi Alumni Associations.

President Allan R. Cullimore of the Newark College of Engineering spoke briefly of the significance and importance of the new chapter in the life of the College and then introduced Dr. Robert H. Morrison, State Director of Higher Education. Since Dr. Morrison's son was president of Michigan Gamma and a delegate to the Lexington Convention, Dr. Morrison has a personal interest in Tau Beta Pi. Dr. Morrison spoke on "Scholarship and Civic Progress." He defined the role of Tau Beta Pi in promoting scholarship and showed that always have scholarship, freedom, and progress been so closely interlinked that none can endure without the other. Scholarship cannot provide freedom, but it is necessary to maintain it and in its maintenance progress follows naturally.

The dinner closed with "Tau Beta Pi to You" led by a faculty quartet that had sung earlier in the program.

A feature of the banquet hall was a five-foot scale model of the Bent which had been made by three pledgees as their pledge obligation. These men were Alpaugh, Loeser, and Redmon, all of the Class of 1942. The Bent will be placed permanently in the College Library.

JAMES A. DARLING WRITES FROM THE CANAL ZONE

In connection with the recent correspondence regarding the installation of the Society of the Trunnion as the New Jersey Gamma Chapter of Tau Beta Pi, many interesting letters have been received. One of the most interesting was from James A. Darling, a Civil Engineering graduate of the Class of 1937. Following are excerpts from his letter to Professor Van Houten:

"It has long been in my mind to write you and Frank Busse but that tropical spirit of mañana must have gotten into me.

"My immediate purpose in writing is to send some money to the Trunnion Society as an aid to financing the Society's new venture. A letter came to me several months ago stating that the campaign to join Tau Beta Pi would close about this time. Within the last two weeks there have been two more, indicating that the program is moving fast.

"The enclosed money order is intended to be my contribution toward defraying expenses. In addition, I am sending the application card but not the initiation fee, as it is not clear to me whether the initiation fee is required of all or just of those who will attend the meeting. Some time in the near future the Secretary might advise me on that point. I can appreciate that a good deal of time and effort have been spent in bringing about this affiliation with Tau Beta Pi and it is a credit to all who have a part in it. This is another step forward for N. C. E.

"I have been here in the Canal Zone just thirteen months today. As I look back over that time it is with mixed feelings. To begin with it takes at least half a year to become acclimated, I think. This, of course, is because of the higher average temperature and humidity. The average annual rainfall for our locality, Balboa (Pacific side), is 70 or more inches.

"In a sense we practically live out-of-doors for the houses are almost entirely open. It is seldom that a window is closed, being scarcely ever cool enough to warrant it. The wide eave overhang, about five and one-half feet, prevents the rain from coming in.

"Life, as far as climate and housing are concerned, is most pleasant. However, everything we buy has to be sent in on ships, so there are many things we cannot obtain.

"Taken by and large, I believe I enjoy life here better than in the States with the possible exception of Pennsylvania.

"The job has proved to be an interesting one. When I first came here, I went to work under Allston Dana for whom I had worked at the Port Authority. At that time we were to do all of the new bridges, and tunnels if any.

"Owing to the difficulty of getting qualified men, it was decided to farm out the bridges to consultants in the States. The only tunnel then under consideration turned out to be another bridge. The Bridge Section was practically abolished and Dana went home.

"My general civil engineering experience qualified me for work in the Protection Section to which I transferred. Our work is that of protecting the Third Locks against all forms of damage by attack. This includes bomb proofing, gas and fire proofing, shock proofing machinery, wiring, etc., and any other form of protective device such as torpedo nets, emergency dams, chain fenders, etc., that would be needed to safeguard the third set of locks.

"Many of our problems are new and we resort to model testing to try to solve them. Sometimes the answers are to be found in secret files of the Army or Navy, or possibly reports by American observers with the British forces in the field.

"After about six months of this work a vehicular tunnel (which has long been proposed) across the Canal at Balboa became active. It seems that I am the only man here with experience in the design of vehicular tunnels. So, along with the other work, I was assigned to prepare reports and preliminary design studies for the project for consultants to look over. Ole Singstad was down, as were two others. Estimates for the job indicated the cost to be between ten and fifteen millions for a single tube approximately a mile between portals, plus approaches.

"There is a great deal of work here and practically everything under the sun is being done to get men to come down. It is an opportunity for the right men.

"I have rambled enough, so will quit. Please give my best regards to Frank and others of our mutual friends there. I would be more than happy to hear from you or anyone who has time to write."

Sincerely,

James A. Darling

It was felt that many of Jim's friends would enjoy reading the above letter. He would greatly appreciate hearing from any of them.

PROFESSOR HAROLD N. CUMMINGS APPOINTED VICE-PRESIDENT

Professor Harold Neff Cummings, recently appointed Vice-President of the Newark College of Engineering, richly merits this new honor and advancement which has come to him in recognition of his outstanding ability and many years of unassuming and conscientious service and markedly efficient accomplishment as an educator and administrator.

Born in Oxford, Maine, in 1884, Professor Cummings received his early education in the schools of that state and obtained his A.B. degree from Bates College in 1906. Membership

Professor Harold N. Cummings

in Phi Beta Kappa and the award of the highest general honors on graduation attest to his early educational accomplishments.

His interests lay in teaching and in civil engineering. Upon graduation he served for two years as instructor and house master at Worcester Academy. To further his engineering education he then attended Harvard University Summer School and the Massachusetts Institute of Technology, taking his S.B. degree in civil engineering at the latter institution in 1910.

Field experience in civil engineering occupied the next three years; first with Buck and Sheldon of Hartford on the New York-Connecticut boundary survey, and later as principal assistant engineer for the Great Northern Paper Company in Millinocket, Maine.

Returning to educational work, Professor Cummings served successively as Head of the Civil Engineering Department of Mechanics Institute in Rochester and in the Mathematics Department of Lynn, Massachusetts, English High School.

During the last war he was instructor in mathematics and mechanics at Wentworth Institute, in Boston, giving courses to the military personnel stationed at the school.

In 1918 he was appointed Associate Professor of Civil Engineering and acting Head of the Department at the University of Delaware.

His connection with the Newark College of Engineering began in 1920 with his appointment as Professor of Applied Mathematics and Head of the Department of Mathematics. In 1927 he was appointed Professor of Civil Engineering and Head of the newly formed Civil Engineering Department of the College, which position he still holds.

His administrative duties have long extended beyond those of his professional department. For some years he has served as Supervisor of Evening Courses in the College. Upon the appointment of President Cullimore as Regional Director of the Engineering Defense Training Program, Professor Cummings acted for President Cullimore in much of the administrative work of the College. At present he is Institutional Representative here for the defense program sponsored by the United States Office of Education.

Aside from his educational accomplishments this ever-busy man has done considerable private work as a surveyor and engineering consultant, particularly during the early years in Delaware and at Newark. At present he is serving as Treasurer of the Essex County Mosquito Extermination Commission. Civic affairs have received much of his time and attention.

When not hard at work, he is hard at play. Fond of travel, he has wisely taken advantage of vacation opportunities. An enthusiastic fisherman, he is as successful as most of us, and less prone to exaggeration. Above all, his hobby is camping, and many of us have found him a boon companion in the woods or on the stream. It is difficult to say more.

Professor Cummings is a member of the American Society of Civil Engineers; the Society of American Military Engineers; the Society for the Promotion of Engineering Education; the American Society for the Advancement of Science; the American Association of University Professors; a fellow of the American Geographical Society; and a Professional Engineer registered in New Jersey. His honorary society memberships include Tau Beta Pi and Phi Beta Kappa.

To us in the Department of Civil Engineering this new appointment brings much pleasure. It also involves a sense of loss on the part of students and staff alike. This department has been his creation. He has nurtured it and guided it and, by his example, has spurred us all to give our best. We hope and trust that he may continue as our Skipper for many years. But, as his administrative duties have mounted, his teaching schedule has necessarily been lightened. We have, in this, lost our ablest and best loved teacher. We have also missed in recent months those close contacts with staff and students which have meant so much in the past. We are proud, however, to feel that the loss of these intimate associations must be offset by the gain to the institution as a whole.

(Reported by James M. Robbins, Associate Professor in Civil Engineering.)

EASY WAY TO BLACKOUT WINDOWS

(Continued from page 12)

If the covering material is thick enough, Dr. Cullimore said, it is effective in a blackout regardless of color. In addition, he emphasized, shattered glass is prevented from falling into the house. He said that he had set aides to work at making the coverings for the college's windows.

He pointed out that the method has an especial usefulness in the light of a recent announcement by the National Retail Dry Goods Association that the government wants citizens to use materials already on hand in blackouts. The Office of Production Management has advised the association that "it is the intention of OPM that no new yardage be used for blackout purposes."

PROMOTIONS AND APPOINTMENTS

Dr. Allan R. Cullimore, President of the Newark College of Engineering, has announced the following promotions at the College: Professor Harold N. Cumming, Professor in Civil Engineering and Head of the Department of Civil Engineering, was appointed Vice-President of the College; Professor Harold E. Walter, formerly Associate Professor in Mechanical Engineering, was appointed Professor in Mechanical Engineering; Professor Robert W. Van Houten, formerly Assistant Professor in Civil Engineering, was appointed Assistant Dean and Associate Professor in Civil Engineering; Professor Frederick W. Bauder, formerly Instructor in Chemistry, was appointed Assistant Professor in Chemistry; Professor George C. Keeffe, formerly Instructor in Chemical Engineering, was appointed Assistant Professor in Chemical Engineering; Professor John C. Hoffman, formerly Instructor in Industrial Engineering, was appointed Assistant Professor in Industrial Engineering; Professor Paul E. Nielsen, formerly Instructor in Physics, was appointed Assistant Professor in Physics; Professor Harry F. Ritterbusch, formerly Instructor in Mechanical Engineering, was appointed Assistant Professor in Mechanical Engineering; Professor Walter E. Selkinghaus, formerly Instructor in Mechanical Engineering, was appointed Assistant Professor in Mechanical Engineering; Mr. Oliver J. Sizelove, formerly Assistant Instructor, was appointed Instructor in Industrial Engineering; Mr. Frederick C. Burt, formerly Assistant Instructor, was appointed Instructor in English; Mr. Jerome L. Polaner, formerly Assistant Instructor, was appointed Instructor in Mechanical Engineering; Mr. Carl Konove, formerly Assistant Instructor, was appointed Instructor in Mathematics; Mr. Frederick A. Russell, formerly a Teaching Fellow, was appointed Instructor in Electrical Engineering; Mr. Robert K. Haubner, formerly a Departmental Assistant, was appointed Assistant Instructor; Mr. Luigi Z. Pollara, formerly a Teaching Fellow, was appointed Assistant Instructor; Mr. John R. Snow, formerly a Departmental Assistant, was appointed Assistant Instructor; Mr. Gus E. Viscione, formerly a Departmental Assistant, was appointed Assistant Instructor.

New appointments include the appointment of Dr. Lillian M. Gilbreth as Professor in Personnel Relations. Dr. Gilbreth was graduated from the University of California with a B.Litt. degree in 1900 and received her M.Litt. degree from the same college in 1902. In 1915 she obtained her Ph.D. degree and in 1931 her Sc.D. degree from Brown University. The degree of M.E. was conferred by the University of Michigan in 1928; the D.Eng. degree by Rutgers University in 1929; the Sc.D. degree by Russel Sage in 1931 and the LL.D. degree by the University of California in 1933. Dr. Gilbreth is an internationally recognized authority in the field of Management.

Additional appointments include: Mr. Robert L. Vannote, in Charge of Industrial Relations. Mr. Vannote has for the past twelve years been Superintendent of the Morris County Mosquito Extermination Commission and Secretary and Field Superintendent of the Four County Committee for Mosquito Control in the Upper Passaic River Valley. Mr. Ronald L. Faber, to Instructor in Mechanical Engineering. Mr. Faber was graduated from the Newark College of Engineering in 1941 with a B.S. degree in Mechanical Engineering. Mr. Theodore O. Reyhner, to Instructor in Physics. Mr. Reyhner received his B.S. degree in Civil Engineering from the Newark College of Engineering in 1937 and his M.A. from Columbia University in 1938. During the past several years he has been a teacher of science in the high schools of Hackensack and Little Falls. Mr. W. Bennett Sharp, Jr., to Instructor in Industrial Engineering. Mr. Sharp was graduated from the Massachusetts Institute of Technology in 1936 with the B.S. degree in Business and Engineering Administration. Since 1937 Mr. Sharp has been employed by the General Electric Company in Schenectady, first in their Testing Department and more recently in their Rate Setting and Planning Department. Mr. Joseph A. Rich, Jr., graduated from Rutgers University in 1941 with a B.S. degree in Education, has been appointed Assistant Instructor.

The following graduates of the Newark College of Engineering were appointed Departmental Assistants: Joseph C. Baldauf, B.S. in Industrial Chemistry, 1941; Adolph Fischer, B.S. in Industrial Chemistry, 1941; J. Russell Ludwig, B.S. in Chemical Engineering, 1936; Manfred Morgenthau, B.S. in Industrial Chemistry, 1941; Joseph E. Sayre, B.S. in Electrical Engineering, 1940.

Other Departmental Assistants appointed were: Lucien Bowé, who was graduated from Montclair State Teachers College in 1941 with a B.A. degree in Mathematics; and Aaron Breslow, who received a B.A. degree in Chemistry from Newark University in 1939 and an M.A. degree in Education from New York University in 1940.

	1938	1939	1940	1941
President	1	1	1	1
Vice-President	—	—	—	1
Professor Emeritus	—	—	—	1
Professors	9	10	12	15
Associate Professors	7	9	9	8
Assistant Professors	16	16	16	21
Instructors	20	18	20	23
Assistant Instructors	10	12	7	10
Teaching Fellows	—	—	3	1
Research Fellows	—	—	—	1
Research Assistants	—	—	2	2
Special Lecturers	7	8	9	11
Departmental Assistants	9	11	10	10
Others	2	2	2	4
Totals	81	87	91	109

N. T. S. IN THE WORLD WAR

By Professor James C. Peet, E.E.

In Charge of Electrical Engineering Department, Newark College of Engineering

In 1917-1918 the United States was at war. Her resources as well as her man power were recruited for all kinds of service in the front lines and in defense industries. Some of those who for one reason or another were not suitable as soldiers were registered in an engineers' reserve. The writer was one of these men.

Late in June of 1918 a telegram was received at Toledo, Ohio, asking me to come to Newark, New Jersey, to teach forty soldiers, starting on the 5th of July. There was nothing in the telegram to indicate what I was supposed to teach those forty soldiers. However, I took it as a call to do my bit. Besides, I had confidence in the man who telegraphed.

Upon my arrival I was told that I was to make good electricians of these men in the short period of eight weeks.

Promptly at 9 a. m. on July 5th, 1918, a sergeant marched 40 men into the electrical laboratory and turned them over to me for the first half-day of training. They were all registered and classified for training, and squad leaders were appointed. They came from all walks of life. One, I remember, was a conscientious objector, a graduate of Pratt Institute in electricity, who made a very acceptable floor assistant. Another was a lawyer who remarked that it was a far cry from equity, pleading, and torts of the law to volts, amperes, and watts of electricity. The son of one of these men is or was a student in Newark Technical School.

These recruits did not get all parts of their uniforms at one time. One day they all stamped into the laboratory with new army shoes, heavy and stiff, and in most cases a whole size too large. Another particularly hot day they got their O. D. shirts and trousers. These were of wool. As soon as the sergeant had left the laboratory the O. D. shirts came off, and the men did their work in some comfort. There were no special summer uniforms for our recruits at that time.

In order to have equipment upon which these men might work, the Public Service Company of New Jersey, at our request, gave us some old motors, generators, and other equipment, which were overhauled and, where possible, made to operate. Wire, conduit, BX, etc., were requisitioned. With this supply, a variety of wiring problems was worked out and tested. Classes were held in fundamental theory, and many mathematical problems were solved. The work was varied from day to day, and the men took hold of it with a will. The morale of this group was particularly good.

Another group of the detachment was given forge shop instruction; still another, wood shop work; and other groups, general machine shop practice.

At Newark Technical School, the basement of the laboratory building, which is now the Mechanical and Strength Laboratories, was used as an auto-mechanics shop, where some of the men were instructed in the care, maintenance, and repair of automobiles and trucks. Autos and trucks were brought in for servicing and repair, just as in a garage at the present time. The work required was done on the machines, and they were checked by the instructors in charge. A nominal charge was made for materials used.

In 1918 it was found difficult to occupy all the recruits' time effectively in army discipline and drill. The government, therefore, organized the Soldiers Army Training Corps (S. A. T. C.). It planned to give the soldiers special vocational training during the early part of their enlistment. It was expected that this training would be useful to the army, and if not, it would be useful to the men themselves in finding employment after the war. At Newark this training was divided as follows: Forge shop, wood working, machine shop, automobile mechanics, and electrician training.

About the first of July, 1918, 370 recruits assembled at Central High School, next door to us. Central High School at that time was a new building, and all its facilities were used to house the detachment. Some of the rooms on the third floor, which had not been fitted up as classrooms, were supplied with cots and made into bunk rooms. The new cafeteria on the top floor was fitted up as a mess hall. The shops were used for the instruction of a part of the detachment.

The plaza in front of the school was used every morning for the setting-up drill, personally conducted by Captain Van Velsor. The writer recalls vividly that one hot morning during the early part of the training the hospital corps was busy carrying away some of the men who had fainted because they had been required to stand at attention too long.

As Central High School could not supply all the instruction needed, The Boys Vocational School on Sussex Avenue took groups from each of the divisions which have been mentioned. The Newark Technical School had three groups: machine shop, auto-mechanics shop, and electrician training.

As a side line, a small group of the recruits published a magazine called *The Worker*, which was a very creditable publication.

After a lecture given by the writer to some of the College Sophomores in 1939, one of the students brought me a copy of this magazine. He stated that his father was a member of the detachment and pointed with pride to his father in the group picture of the whole detachment.

All of this training was included in eight-week courses. This sounds very familiar to those who have to do with the defense courses of the present. It is to be noted, however, that the courses of that time were given for the benefit of the *men in training*, while today the work is turned toward the *up-grading of civilians in industry*.

The morale of the group trained here in 1918 was at a very high level. It would appear to the writer that the experience of the first World War might well be followed, and that more and better special training might well be offered in our camps to take up spare time that is now sometimes employed in unimportant pursuits.

PROFESSOR ROBERT W. VAN HOUTEN APPOINTED ASSISTANT DEAN

Predictions of the probable future of a young man can be made occasionally by plotting the curve of his past performances and then extending the curve by extrapolation. The appointment of Professor Robert W. Van Houten to the position of Assistant Dean and his promotion from Assistant Professor to Associate Professor of Civil Engineering — or some such change in his status — was indicated by the combined record of his academic and his extra-curricular activities while a student in the civil engineering course here at the Newark College of Engineering.

Professor Robert W. Van Houten

Professor Van Houten graduated from the college in 1930 with the Highest Academic Honor in Course — which means that he led his civil engineering class— and with the Highest General Faculty Honor —which means that in the opinion of the faculty he, most closely of all the class of 1930, represented the type of man the faculty would take pride in awarding the diploma of the college. His extra-curricular activities, if such things could be "plotted," would clearly indicate the probability that he would be found doing progressively more administrative and less teaching work. The record shows the following activities: once Class President; twice Class Treasurer; first President of the Society of the Trunnion, now New Jersey Gamma Chapter of Tau Beta Pi (served for two years); first President of the Civil Society, now Student Chapter of the A. S. C. E.; President once and Treasurer once of social fraternity, Sigma Pi; Treasurer once of the Athletic Association; senior editor of the Year Book; played four year varsity basketball and two years of varsity track; served on various committees.

Since he graduated, Professor Van Houten has served on the faculty of the Newark College of Engineering as Instructor in Mathematics, Instructor in Civil Engineering, Assistant Professor and now Associate Professor in Civil Engineering. He is an Associate Member of the American Society of Civil Engineering, Member of American Road Builders Association, Society for promotion of Engineering Education, and the honorary fraternity Tau Beta Pi, and the social fraternity Sigma Pi.

(Reported by Professor Harold N. Cummings, Vice-President, Newark College of Engineering.)

SUPERSONIC VIBRATIONS

By John E. Freehafer, B.S., M.S., Ph.D.
Instructor in Mathematics, Newark College of Engineering

In 1880, the Curie brothers discovered that many crystals when subjected to mechanical stresses develop electric charges on their faces, a phenomenon which has since become known as the piezoelectric effect. In the following year, they discovered the reciprocal piezoelectric effect; namely, that crystals which exhibit the direct piezoelectric effect when placed between oppositely charged plates suffer a mechanical contraction or dilation depending upon the polarity of the charges. The vast importance of these discoveries has been recognized only within the last few years.

During the period from 1914 to 1918, when a scheme for locating submarines was of utmost importance, Langevin was experimenting in France with a means of detection based on the reflection by a submerged object of a beam of compressional waves set up in the water. In order to concentrate the radiation into a beam, it is necessary to avoid diffraction effects by using waves whose length is small compared with those of the source. To attain this end, Lanegvin generated high frequency waves by means of a mosaic of quartz slabs mounted in sandwich fashion between steel plates. The plates, one of which was in contact with the water, were then connected to a Poulsen arc oscillator and made to vibrate at the frequency of the oscillator by the reciprocal piezoelectric properties of the quartz. Frequencies up to about 50 kc/sec were employed for this work, which was one of the first attempts to utilize the properties of elastic waves whose frequencies are above the audible region. The term "supersonic" is now commonly used to denote vibrations in elastic media at higher-than-audible frequency.

Improvements in high frequency technique which were brought about by the rapid development of radio communication in the 1920's were applied by Wood and Loomis to the generation of supersonics. The publication in 1927 of the results of their preliminary survey of the physical, chemical, and biological effects of this radiation attracted so much attention that supersonic research has become within the last decade one of the most fruitful fields for investigation by physicists, chemists, and biologists alike.

Some of the most interesting physical experiments involve the interaction between supersonic and light waves. With a piezoelectric tourmaline plate, a fundamental frequency of 200,000 kc/sec has been reached. Since the velocity of sound in many organic liquids is approximately 1400 m/s, waves may be produced in those liquids whose length is of the order of 7×10^{-4} cm. This is only about ten times as great as the upper limit of the visible spectrum. Since a train of supersonic compressional waves in a liquid represents a variation in the density, and thus in the index of refraction, with a period not much greater than a wavelength of light, it should produce the same effect on a beam of light waves travelling at right angles to its direction of propagation as a diffraction grating, the distance between the rulings of which is equal to the wavelength of the supersonic wave. Debye and Sears actually performed this experiment in 1932, and the phenomenon is now generally known as the Debye-Sears effect. The relationship between λ_l, the wavelength of the light, λ_s, the wavelength of the sound, and θ, the angle through which the light is diffracted, is given by the familiar grating formula

$$k\lambda_l = \lambda_s \sin \theta,$$

where k is the order of the diffracted beam. If the wavelength of the light is known, the wavelength of the sound can be obtained by measuring the angle of diffraction. Since the frequency is that of the radio frequency current driving the piezoelectric vibrator, the velocity of the sound in the liquid may be readily calculated. Velocity of sound measurements are important because they are the starting point in the determination of the adiabatic compressibility, from which are obtained many of the thermodynamic properties of the fluid.

Not only travelling wave trains but also systems of standing waves act as diffraction gratings. It is interesting to note that in this case, the grating is formed and destroyed once in each half period of the sound wave. Thus the light which emerges is modulated with a frequency twice that of the sound. This arrangement may, therefore, be made to serve as a supersonic stroboscope. One application of the high frequency stroboscope is to furnish illumination for studying supersonic phenomena themselves.

When a narrow beam of monochromatic light is passed through a transparent solid, which, either because of its own piezoelectric properties, or because of its being in mechanical contact with a vibrating crystal, is supporting supersonic waves, the emerging light forms a diffraction pattern on a photographic plate which is superficially similar to the Lane patterns produced by x-rays. The form of the pattern is independent of the external shape of the sample and is characteristic of the internal structure. For instance, a vibrating sample of an isotropic material such as glass always produces a pattern consisting of spots arranged in two concentric circles whether the matreial is in the form of a cube, cylinder, rhombus, or prism. In the case of anisotropic bodies, the pattern depends upon their orientation in respect to the incident light. If, for example, the light passes through a quartz crystal in the direction of the optic axis, the six-fold nature of the axis is revealed by the six-fold symmetry of the resulting pattern. Similarly, light passed through the crystal in the direction of one of the two-fold polar axes produces a pattern with a two-fold center of symmetry.

The theory of the diffraction of light by transparent solids has been so thoroughly worked out that the form of the patterns may be predicted from a knowledge of the elastic constants of the solid. Conversely, it is possible to determine the elastic constants of a material from the dimensions of the pattern. The two elastic constants of a glass may easily be calculated from the radii of the two circles constituting its pattern, the frequency of the sound, the wavelength of the light and the distance from the sample to the photographic plate. The great convenience of the supersonic method is clearly illustrated by the fact that one sample and three photographs were sufficient to obtain the elastic constants of barytes, which had previously been obtained by static methods using no less than 15,000 measurements on several crystals.

Ever since the original observations by Wood and Loomis, much importance has been attached to the emulsifying properties of intense high-frequency waves. If a flask containing mercury and water be lowered into an oil bath which is supporting supersonic waves, the water becomes first milky, then brown, and finally black, indicating the formation of an emulsion. Stable emulsions of oils and water are also readily formed. It appears that the emulsifying action is due to cavitation followed by decavitation at the interface between the two liquids. Perhaps the term "cavitation" requires a brief explanation. Whenever liquids under the action of a sound field or otherwise attain velocities which are high enough to reduce the hydrodynamic pressure to the vapor pressure of the liquid, bubbles of the liquid are formed. This process is called cavitation. When these cavities collapse, enormous pressures are produced in the liquid near their boundaries. A theoretical investigation of this phenomenon by Lord

Rayleigh leads to the conclusion that pressures of several thousand atmospheres are not uncommon. The mechanical effect of these pressures is normous and is no doubt responsible for the emulsifying action.

The dispersion of metals and various solids in liquids has also been brought about under the action of supersonics. The process has been applied to the production of fine grained photographic emulsions and promises to reduce materially the time required for their manufacture.

Supersonic waves under certain conditions may produce coagulation instead of dispersion. Boudy and Söllner have described a fascinating experiment which depends upon this action. A shallow "U" is bent in the middle of a heavy-walled capillary, which is filled with an emulsion and the ends are sealed so as to leave a cushion of air between the meniscus and the seal. When the "U" is lowered into an oil bath above a quartz vibrator, standing waves are set up, their existence being indicated by the accumulation of the disperse phase at regular intervals along the capillary. If the disperse phase has a density less than that of the other, as in the case of an emulsion of toluene in water, the first region of accumulation occurs at a distance from the meniscus equal to one-half of the distance between consecutive regions of accumulation. Since the meniscus is a loop of the standing-wave system, this clearly indicates that the toluene collects at the nodes. If, on the other hand, the disperse medium is the denser, as is the case of a suspension of quartz in water, the first zone of accumulation is at the meniscus. Thus quartz is found at the loops of the system. Now if quartz be suspended in an emulsion of toluene, the supersonic wave separates the quartz from the toluene, the former collecting at the loops, and the latter at the nodes. It is not difficult to imagine that this process of separation may be of considerable practical interest.

Of possible industrial importance is the interaction between supersonic waves and smoke particles. It is well known that when smoke particles collide, they adhere and form larger particles, which, after a number of collisions, cannot remain in suspension because of their size, and are precipitated. Supersonic waves encourage this coagulation in at least two different ways. In the first place, particles of different size have different amplitudes of oscillation in a sound field. In the second place, it may be shown hydrodynamically that particles whose centers are on a line perpendicular to the direction of propagation of the wave are attracted and coagulation is assisted. Laboratory apparatus for precipitating smoke by this means has been devised, and experiments are being carried on to determine whether the process is feasible on a commercial scale.

Perhaps it is not inappropriate to mention briefly some of the biological effects of supersonic radiation. Their lethal action on small organisms was early observed. Death in the case of frogs and small fish is probably due to cavitation in the body fluids as well as to internal heating of the vital organs. The viricidal properties of the radiation have been demonstrated by experiments in which the activity of the virus of tobacco mosaic was reduced to zero after a two-hour exposure. Undoubtedly some of the effects may be attributed to the relatively enormous sound intensities which are used. In supersonic investigations intensities of 10 watts per square centimeter have been produced. Compare this with the intensity at a distance of 10 feet from a bass drum, which is of the order of 10^{-8} watts per square centimeter.

Many aspects of the supersonic field must of necessity be omitted in a brief survey. No mention has been made of the investigations of the absorption and dispersion of supersonic waves in gases, which are of considerable theoretical importance. Other interesting properties are the ability of the waves to break up complex molecules and to excite luminescence in liquids containing dissolved gases. Of interest also are the applications to submarine signalling and television.

Under the stimulation of the present world situation it is probable that research in supersonics is expanding at an abnormally rapid rate. The knowledge thus accumulated, however, is not generally available because of its military importance, and there is no way of knowing what progress is being made.

CIVILIAN PILOT TRAINING AND NATIONAL DEFENSE

The Newark College of Engineering is entering on the third year of its Civilian Pilot Training Program. This program is sponsored by the Department of Commerce under the Civil Aeronautics Administration. It is definitely part of the National Defense Program and is financed by funds from the Army and Navy. It offers an excellent opportunity for young men between the ages of 19 and 25 to train for the Army and Navy Air Corps while still at College or still employed in industry. Graduates of the Civilian Pilot Training Program are given credit for thirty hours of flying in both the Army and Navy and may go directly into advanced Army and Navy flight training from this program.

The program is in three parts. The first part, called elementary flying, consists of 35 hours of flying and 72 hours of ground school work. The flying is done in 60 horsepower piper cubs. By using a light ship of this type, the student has a much better chance of grasping the fundamentals of flying than if he were exposed to the faster ships in the elementary training. The ground school work covers such subjects as meteorology, navigation, rules and regulations and general servicing of aircraft.

Graduates of the elementary phase, on recommendation from their flying instructors, may enter secondary training. This training consists of 40 hours of flying and 108 hours of ground school. The flying is done in 250 horsepower Wacco trainers. It consists mostly of acrobatic flying. The ground school course covers power plants, radio, navigation, air dynamics and instruments. Graduates of these two programs may apply to the Army and Navy for advanced pilot training.

Following these two courses, recommended candidates may continue their flight instructions by taking a program consisting of cross-country flying and training for an instructorship. These instructors may teach in other Civilian Pilot Training Program courses or in the primary Army and Navy training programs. The program is planned to supply candidates for the Army and Navy Air Corps; also to supply flying instructors and possible ferry pilots. Also, due to the shortage of flying personnel for the air lines, many of the graduates of these programs are being accepted for training as co-pilots by the air lines.

To date the Newark College of Engineering has trained some 130 men in the flying program. Of this group about 40 are now in Army and Navy service, an additional 20 are taking the cross-country and advanced flying work. Other students have signified their intention of entering the Army and Navy at the end of the school year.

It is felt that this program is a definite advantage to those men contemplating Army and Navy flying, as it permits the student to learn flying in more easy stages than they experience in military training. Of the men entering the Army and Navy services from this program, less than 5 per cent are disqualified in their military training. This compares to about 30 per cent who are disqualified in Army training without the benefit of Civilian Pilot Training work.

The program at the Newark College of Engineering is under the direction of Dr. Frank D. Carvin, Coördinator of Civilian Pilot Training. Registration for the course to start February 1, 1942, is now under way. Candidates between the ages of 19 and 25 inclusive and with about two years of college credit should apply to the College for further information. Doctor Carvin is available daily from nine to four and on Monday and Thursday evenings from 6 to 8 p. m. Full information on this program can be had by applying directly to the College.

SENATOR ROY V. WRIGHT

By Harold E. Walter

Professor in Mechanical Engineering, Newark College of Engineering

During the past five years Bulletins of The Newark College of Engineering have listed as a special Lecturer of the Faculty, Roy V. Wright, M.E., D.Eng., Lecturer on "The Engineer as a Citizen."

Recent newspaper editions have featured the name of Roy V. Wright, of East Orange, as the newly-elected State Senator from Essex County. That they are one and the same person should be a source of real happiness to the newly-elected Senator and an inspiration to those who are interested in this College. Mr. Wright is to be congratulated on his achievement, which is merely one in a series accomplished by this active man. Perpetual Motion may be impossible in Mechanics, but in the human machine it is exemplified by our new State Senator. Even a cursory glance at his record in "Who's Who in New Jersey" will show that he has been endowed with an unusual ability to work and to achieve.

He was born and reared in Minnesota, and obtained his technical education in the University of Minnesota, from which he received the degree of Mechanical Engineer. Possibly the vigor which he has evidenced throughout his life can be traced to the stamina derived by coping with the rigors of those Minnesota winters. But whatever the cause, he has always possessed an abundance of energy. Upon graduation he entered the railroad shops of the Chicago, Milwaukee and St. Paul Railroad, and he there developed an interest in Railroads and Railroading which has proved to be one of the main influences in his life. He gave his entire attention to this branch of Mechanical Engineering during his young manhood, in fact, until 1904. About that time, however, another interest began to assert itself, namely, human engineering, and from then on this regard for people paralleled his mindfulness of things. Yet the railroad shop seemed to offer insufficient opportunity to develop this two-fold purpose, and accordingly in 1904 he accepted a position as associate editor of the *American Engineer* and *Railroad Journal*, serving in this capacity, and later as editor until 1910. He resigned this position to associate himself with *Railway Age* as Mechanical Department Editor and in 1911 he became editor of *Railway Mechanical Engineer* and has served in this capacity since that date. He has been Vice-President and Secretary of the Simmons-Boardman Publishing Corporation and in addition was Editor of the *Locomotive Cyclopedia*, as well as *The Car Builders Cyclopedia.*

In addition to performing those duties he somehow has found time for considerable association and engineering society work; in fact, his contribution has been significant here. He is a Fellow in and Past President of the American Society of Mechanical Engineers. He is a Trustee and Past President of the United Engineering Society; a Trustee of the Newcomen Society of the Franklin Institute; treasurer of Associated Business Papers, Inc., and President of the National Conference of Business Paper Editors. He is a Director in the Ampere (N. J.) Bank and Trust Company, and a member of several Honor Societies.

He was a member of the National Engineers Committee appointed by President Hoover, and a delegate to the First World Power Conference held in London, 1924. He also has served on several European Commissions.

With all of those interests and responsibilities he has found the time and the inclination for public service. He is a trusted church officer and Superintendent of the Sunday School of the Arlington Avenue Presbyterian Church in the town in which he resides, East Orange. He is Vice-President of the Oranges Y. M. C. A. and a member of the National Council of the Y. M. C. A. He has served as Freeholder of Essex County, New Jersey. He is the Author of a "Manual on Citizenship," which was prepared for the American Society of Mechanical Engineers, was a contributor to the publication *Toward Civilization*, and is Co-Author (with his wife) of a book, "How to Be a Responsible Citizen."

Finally, and most important from our standpoint, he lectures to all Newark College of Engineering Students on the topic "The Engineer as a Citizen." This man's history, as briefly outlined here, would indicate a sensitivity to that topic and a competence to discuss it with authority. He has been in close touch with things political in New Jersey for the past twenty years. He understands the responsibilities and opportunities of citizenship in this country as do few men within it. His engineering background would require that he be an incessant seeker after the facts (coupled with an ability to weigh the facts after they have been obtained). I know of no man who has come to high public office with a better background. May he serve the community which has selected him, the State which has acquired him, and the College which has adopted him in the manner in which his qualifications seem to insure beyond a shadow of doubt. His success can serve only as an inspiration to young, budding engineers whose lives he touches at this College.

Senator Roy V. Wright

MISS PREEN, JERSEY ENGINEER, IS READY FOR TASK IN ASSEMBLY

Hunterdon Democrat to Be Only Woman of Party and Youngest at Trenton

Reprinted from the NEW YORK HERALD TRIBUNE *of November 9, 1941*

OLDWICK, N. J., Nov. 8—What New Jersey needs for good government are more engineers and fewer lawyers, according to Miss Mildred Preen, an electrical engineer, who was elected last Tuesday on the Democratic ticket as the first Assemblywoman of Hunterdon County.

Still in her twenties, Miss Preen will go to Trenton next year not only as the youngest member of the State Legislature but as the only Democrat of the five women in the Assembly.

Despite her youth and sex, Miss Preen expects to compensate the handicaps through her experience in the world of men. An aviator, electrical engineer and a student of law and government, she believes that while "some knowledge of law is necessary among legislators, the scientific training received by engineers provides them with facilities to lay a sound foundation for good government."

Miss Preen undoubtedly will inject a new note of energetic and versatile femininity in the Assembly. Born in Newark, she was graduated in 1938 from the Newark College of Engineering as the first woman graduate in electrical engineering at the college. During part of her student years she held a job with the Western Electric Company. After finishing college she pulled on overalls and, as an engineer, bossed road gangs on many Hunterdon County projects for her father, Albert G. Preen, who operates a stone quarry, the Preen Crushed Stone Company, here.

Mildred A. Preen

First Jersey Woman Pilot

Planning a political career, she began studying at Columbia University two years ago, receiving a Master of Arts degree in public law and government. She is now studying for her doctor's degree.

Last year Assemblywoman-elect Preen became interested in aviation. She took the Civil Aeronautics training program for pilots and became the first woman in New Jersey to pass the test and get a pilot's license. Now she flies at every available opportunity—campaigning cut into her time—and has passed more than 100 hours in the air.

Politics first interested Miss Preen when she was a high school student. She began to realize that women deserved a showing in politics and her first taste of big-time politics came last year when she was master of ceremonies at a rally in Clinton, at which the gubernatorial candidate, Charles Edison, spoke. She was Hunterdon County's delegate to the women's division of the National Democratic party in Washington and stumped her home county on behalf of Governor Edison's gubernatorial campaign.

Had No Campaign Manager

Miss Preen was nominated as the Assembly candidate in the Democratic primaries last September without opposition. She campaigned for election, she said, on her own money and without a campaign manager. Many days she passed seventeen hours in campaigning, driving up and down country roads, crossing corn fields and wooded lands to speak her piece for women in politics. She spoke at a dozen rallies and visited at least 5,000 people in their homes.

"The most important thing for a legislator to do is to develop personal contact with the voters, with emphasis on the rural communities where the people rarely see the candidates," she said. "I passed many hours with these people and feel I really understand their problem."

Miss Preen got 6,953 votes, while her Republican opponent, Chester D. Schomp, incumbent, got 6,727. Her plurality of 226 votes was the highest any Democratic candidate in Hunterdon County received.

During her campaign she distributed buttons with this legend: "10-25; PREEN for Assembly." The buttons attracted attention and aroused curiosity. Voters, seeking to intercept the "10-25" inscription, were amused to learn that wearers of the buttons were expected to get from ten to twenty-five votes for their candidate.

Supports Edison's Proposals

Miss Preen is an enthusiastic supporter of Governor Edison's proposals for revision of New Jersey's ninety-seven-year-old constitution and for an end to the patronage problem.

"We need good government in Trenton and we must have people there who are interested in the crusade led by Governor Edison," she said. "The Republican-controlled Legislature certainly held up the works this year because of the patronage problem."

Miss Preen does not favor reduction of legislative representation in rural communities, which may occur if the constitution is amended.

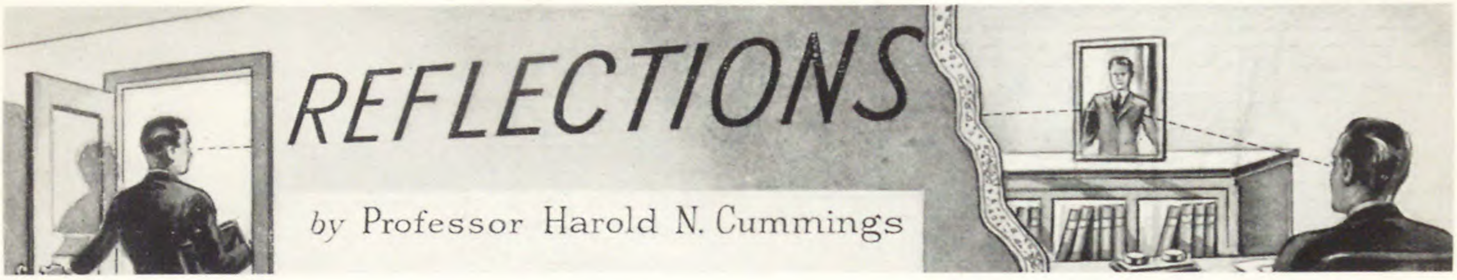
Hunterdon's new Assembly representative is attractive, 5 feet 3 inches tall and weighs 122 pounds. She refuses to acknowledge her correct age, however, preferring that it be known as "just the early twenties." During the campaign her opponent often emphasized and questioned Miss Preen's ability because of her youthfulness.

To this she replied: "If a fellow is old enough to be called to military service between the ages of twenty-one and twenty-eight, he's certainly old enough for the Legislature—and that certainly holds true for women in their twenties."

NOTES ON CONCRETE COURSE TO BE PUBLISHED

(From NEWARK SUNDAY CALL, *November 16, 1941)*

Professor Odd Albert, who teaches a course in reinforced concrete design for Newark College of Engineering and Stevens Institute of Technology, will have a series of articles on that subject in the trade magazine *Concrete* beginning with the January issue. The course is given for both colleges at the Newark school and leads to M.S. degrees.



REFLECTIONS — SPEECH AND DRESS — THREE RING CIRCUS — FOREIGN LANGUAGE PRESIDENTIAL PAPERS — WOMEN IN INDUSTRY — WHAT PRICE FREEDOM

Reflections! Why such a heading for this page? Who, or what, is to do the reflecting? As a matter of fact, both "who" *and* "what" will do a certain amount of reflecting. I expect that now and then things or happenings that come to my attention will cause me to reflect on their causes, or effects, or implications. At other times, my "busy-body" will reflect the passing college world to me and I shall record here what comes to me via the busy-body. By the way, do you know what a busy-body is? I believe the term is a colloquialism for a small mirror so placed that one can sit in his room and by glancing in the mirror see what is going on in the neighborhood outside. Before I discovered this homely name for my office mirror I had thought of it as a horizontal periscope. I prefer "busy-body." It's not at all a war-like mirror, and my purpose in setting it up was entirely peaceful. So, if I may, I shall at times write of things as though they came to me as reflections—as though they had been turned my way by my busy-body.

I attended the general convocation of the student body Wednesday, October twenty-fourth, in the gymnasium. Couldn't help contrasting in my mind the effectiveness of our occasional convocations with that of the daily "chapel" convocations of my college days. I still recall the deadening effect on me and my fellow students of those *daily* doses of good advice, exhortations, and threats of the unpleasant consequences of not walking the straight and narrow path. An occasional calling together of the students and faculty to consider matters of common interest seems psychologically and pedagogically to be much wiser and more likely to be effective — President Cullimore's statement, made during the convocation, that what counts—at first—is what one *says* and the way one *dresses*, rather than what one knows and thinks, seemed strangely at odds with the teachings and the preachings of my college days. A little reflection, however, brought me to the conclusion that anyone who failed to realize the truth in that statement would spend much time wondering why he never seemed to get an opportunity to show what he knows and what he thinks. *First* impressions must depend upon what the other man *hears* and *sees*. Teaching the habit of good speech, good dress and good manners seems, then, to be an important duty of the faculty and instructing staff of any college that professes to prepare students for earning a living.

Mr. Robert L. Vannote's image flits back and forth in my busy-body as he goes about his multitudinous duties. Mr. Vannote runs a three-ring circus now—(1) the field work of the Morris County Mosquito Extermination Commission, (2) the Industrial Relations work of the College as special assistant to President Cullimore, and (3) the actual organization and operation of the Defense Training program of the College under my general supervision. A little reflection on my part raises a question as to whether it's fair to Mr. Vannote, or the Commission, or the College to compare his fields of activity to those of a circus. But a three-ring circus runs more smoothly than many other organizations. There must be a thousand and one matters of detail involved in organizing and operating a large circus—and there are as many details, or more perhaps, in Mr. Vannote's three-ring set-up. The general solution of the problem of responsibility for so much detail seems to involve delegation of duties in large amount. The ability, and the willingness, to do this delegating is, I believe, an absolute necessity. It's easy to say this—it's something else again to practice it, particularly because blame for the mistakes of the delegatee must be taken by the delegator. This assigning of duties requires great confidence in the ability and honest loyalty of those to whom we delegate part of our duties.

"Requirements of Engineers in Foreign Fields," I note, was discussed by Mr. F. X. Lamb, a Newark College of Engineering alumnus, at the meeting October 27 of the Student Chapter of the American Institute of Electrical Engineers. Mr. Lamb has just returned from a long period of service in Japan as an engineer on the foreign staff of the Weston Electrical Instrument Corporation. Young engineers are already beginning to think about the probable opportunities for them in the work or reconstruction that must follow the destruction now taking place in the foreign field. I wonder how many of these young men include in their thinking the need of ability to read and write and speak a foreign language. I never sympathized with—nor even understood—the hysteria that forced courses in German out of the public schools in the United States during the first World War. It would have been so much more logical to intensify and speed up the teaching of the enemy's usual means of communication. We didn't know how long the war would last. We didn't know that large numbers of our high school boys—yes, and girls also—wouldn't be needed in Europe before the war could be won. Why handicap our armed forces or nurses by making them in effect both deaf and dumb in the presence of the enemy? Doesn't a much similar line of reasoning indicate the value of preparing the young engineers that are to go out into the world and help rebuild it by giving at least some of them the opportunity to learn a useful foreign language.

Recently I had the privilege of reading the paper that Dr. Cullimore presented before the American Institute of Consulting Engineers on October 1. Of course I realize that such papers are usually held to be a sort of joint property of the writer and the Society. However, I hope that our editorial board can arrange to print either this particular paper, which seemed to me well worth a much wider audience, or some other of the papers Dr. Cullimore has presented along the same general line.

Just as I glanced up at my busy-body, I caught a glimpse of one of the college co-eds passing by. Which one it was and where she was going, I don't know. But it occurred to me that perhaps I should be seeing more and more young women in our corridors and class-rooms if the present emergency stretches out much longer. Certainly ability to grasp and utilize the principles of engineering is not the unique possession of us men. The career of Dr. Lillian Gilbreth, now Professor of Personnel Relations on our Faculty, in the broad field of Management is an inspiration for young women. (As a matter of fact, her career is something for mere men to envy.) The field of politics—fruitful soil for cultivating the principles of management—was entered this fall by Miss Mildred Preen, B.S. in E.E. from Newark College of Engineering in the class of 1938. I suppose that a very moderate amount of reflection while Miss Preen was a co-ed, managing class affairs, and managing them well, would have brought one to the thought that she would be heard from soon after graduation. Now we find her Assemblywoman-elect from Hunterdon County. Her successors as co-eds in the college are apparently keeping up the good work—active in extra-curricular interests, and maintaining high standing in their classes. The adaptability of these women to organization and management work suggests a source of supply in supervisory positions in industry. It is not at all improbable that we shall need more personnel, trained and capable of taking responsible part in management, than can be found without using women. Already a few women have enrolled in E. S. M. D. T. classes. (Those letters stand for the United States Office of Education's short intensive courses known as Engineering, Science, and Management Defense Training.) Those of us who are charged with organizing these courses and obtaining students willing to aid defense by giving their time to the courses have already discussed seriously various plans to bring some of them to the special attention of young women.

My work in the E. S. M. D. T. program of the College brings me into many studies and discussions about expansion of industry. Expansion now involves both increase of space and increase of people's working hours. I must confess that I am puzzled at the attitude of many thinking people on the matter of working hours and overtime. Someone said recently that the forty-hour week, soon to be replaced by a thirty-six, and eventually by a thirty-hour week, was not put into effect because human beings couldn't stand working any longer. It was installed in our social system to give people more leisure, and also to spread employment. Now that we have practically all "employables" working, and industry is yelling for more workers, and we have an emergency that may cost us all of our leisure if we fail in meeting it, I can't help wondering why there is so much fuss about overtime. Why do we have to pay "time and a half," and even "double-time" for any extra effort? It seems to me that those high rates were put into wage regulations to force employers to "spread the work." But now there is plenty of work—too much work. Where is the logic in forcing the public to pay wages designed as penalties, in order to get work done under conditions that no longer require penalty wage rates? Ten hours a day, six days a week, is a punishing program. I know, for I have worked in a mill sixty hours a week. It's no fun, and there's nothing in such a life but working, eating and sleeping. I gather from what little information seems at all reliable that life in the Nazi subject-nations is even harder than that, and if the Nazis have their way it will *never* be any easier. It seems as though a few months —or even a few years—of voluntary hard labor is a very attractive price to pay for ultimate freedom for ourselves and our children so that later we may enjoy a leisurely thirty-hour-week kind of life. Suppose *everyone* that had been working eight hours a day should say, "I'll contribute to defense work two hours of my leisure time each day without extra pay"? Roughly speaking, that would serve as well as paying a twenty-five per cent income-tax levy. What effect would such a step have in controlling inflation? Could there be any inflation? Wouldn't labor and John Q. Public be in a powerful position to root out and eliminate profiteers, both in labor circles and among capitalists? Just reflect on this idea for a while.