balances require—though they may not receive—finer equilibrating.

No aspect of the current scene, however, deepens one's concern for the future of freedom more than does the widespread willingness to believe that collectivism can provide a happier national estate and justify all its attendant risks. Evidence of it is found in a growing preference among the rank and file of workers (not alone government employees) for state security and for state guarantees behind their jobs. This frame of mind roots in the vicissitudes exhibited in economic history, and to it our elected officialdom has shown that it is peculiarly responsive. Hence it is, that the power to tax is being used to insure jobs; and when taxes no longer can provide the desired insurance along with the countless other growing obligations of every "liberal" government, it only will remain for the state to take over the erstwhile sources of employment, and taxes.

From the proposition, when so briefly and bluntly stated, many at first may withhold agreement. By way of verification, however, note that just now a seeming majority of American scientists, lovers of freedom par excellence, are demanding government support for their research. It is a disturbing spectacle, yet quite in harmony with the trend of our time. And if scientists quite generally, the intellectually elite, are so eager for government funds, and, at the same time, seemingly indifferent to the reasons why their former sources of support have dwindled dangerously, it betokens that, for the rank and file of citizens, promises of security and abundant employment, when made by the state, exert a great drawing power at the same time that they excite little or no suspicion.

What better epitome of the social and political confusion that technology has wrought?

We are entering upon the hour of decision! The doctrine that, if a nation will but put scientists to work at the taxpayers' expense, there will be "jobs for all, all the time," is certain to bear bitter political fruit. It is deceptively easy to drive ahead in science and its industrial applications, but correspondingly difficult to formulate a free and nonpolitical deontology. As we acquire firmer footing in the first area, we stumble into more ominous quicksands in the latter. In order better to comply with the demands of the machine, we unconsciously are fashioning our political prison. Not machine politics but machine-made politics should be our chief concern. Let us clearly understand the many ways in which technology encroaches upon political liberalism! The pattern of tragedy is being more and more surely defined, and from it no *deus ex machina* is likely to effect our liberation. So let all, even those of us who are engineers and scientists, renew the challenge:

"For what avail the plough and sail,
The land, or life itself,
If Freedom fail."

Electrical Essay

Which Source Feeds Which Load?

Two similar batteries, X_1 and X_2, of the same voltage feed two equal loads, R_1 and R_2, by connecting wires as shown in Figure 1. The wires from A to B, and from B to C are interlaced tightly so that very little magnetic field outside their neighborhood is produced by the interlaced wires. These wires are at nearly the same potential, so that the electric field between them is very feeble.

An electric power engineer and a radio engineer debate as to which battery feeds which load.

The electrical engineer, knowing that the energy flow

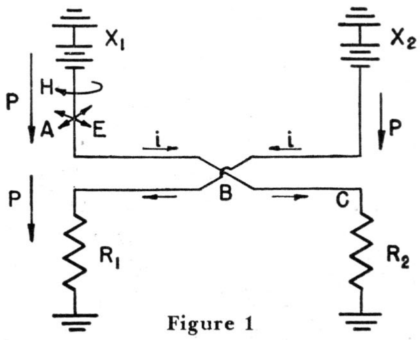

Figure 1

would be indicated by wattmeters, which, wherever they are connected, give the product of potential and current, traces out the wires, and concludes that battery X_1 feeds load R_2, and that battery X_2 feeds load R_1.

The radio engineer, however, just had been making some antenna calculations, and knows that electric energy flow is given by the Poynting vector, $\mathbf{P}=\frac{c}{4\pi}[\mathbf{E}\times\mathbf{H}]$, a vector which stands perpendicular to both the magnetic field intensity and the electric field intensity, and whose magnitude is proportional to the product of the magnetic and electric intensities and the sine of the angle between them.

The radio engineer readily constructs the Poynting vector for the lead coming from X_1. He finds a nearly equal Poynting vector in the same direction for the lead to R_1. However, for the twisted wires from A to B, where the magnetic field **H** is strong, the electric field **E** is weak, and where the electric field **E** is strong, the magnetic field **H** is weak. He then only can construct a very feeble Poynting vector there, only enough to cover the losses in the twisted wires from A to B. He finds entirely similar results for the Poynting vectors at X_2, R_2, and the twisted wires from C to B. He, therefore, concludes that battery X_1 feeds load R_1, and battery X_2 feeds load R_2.

Who is right, the electric power engineer, or the radio engineer?

J. SLEPIAN (F '27)
(Associate director of research, research laboratories, Westinghouse Electric Corporation, East Pittsburgh, Pa.)

smaller and smaller, the expense of the firing circuits does not decrease, and finally the cost of this auxiliary is so high in comparison with the rest of the rectifier that the over-all result is not economically sound. At the present time this lower limit for an economical design of sealed pool tube rectifiers is at about 100 amperes per anode. This situation is a problem confronting engineers active in the development of tubes of this general type for wider applications.

Considerable thought and effort, therefore, are being given to the development of ignitors that require much less current than the present ones that take a maximum of about 25 amperes.[36] This is not an easy problem in view of the outstanding performance of present-day ignitors as regards life and reliability. Life of a modern sealed ignitron is measured in years rather than in a few thousand hours and it requires time to develop new devices with the assurance that these long life records will be maintained.

Most large steel envelope sealed ignitrons contain two separate ignitors. In view of the long average life obtained in modern tubes the question has been raised as to whether two ignitors are really necessary or advantageous. The concensus of opinion seems to be that two ignitors will be continued as a design feature. They represent low-cost accident assurance against ignitor breakage or burn-out resulting from trouble in the firing circuit. Designers of these tubes point out, however, that when a tube finally fails after many years of service it is usually from some other cause than ignitor failure and, therefore, it is seldom that the spare ignitor can be used to rejuvenate completely the tube and start it off on a second career of long life.

REFERENCES

1. A 100-Million-Volt Induction Electron Accelerator, **W. F. Westendorp, E. E. Charlton.** *Journal of Applied Physics* (New York, N. Y.), volume 16, October 1945, page 581.

2. A New System of Frequency Modulation (Phasitron), **R. Adler.** *Proceedings,* Institute of Radio Engineers (New York, N. Y.), January 1947, page 25.

3. The Magnetically Focused Radial Beam Vacuum Tube, **A. M. Skellett.** *Bell System Technical Journal* (New York, N. Y.), April 1944, page 190.

4. Cyclophon: A Multipurpose Electronic Commutator Tube, **D. D. Grieg, J. J. Glauber, S. Moskowitz.** *Proceedings,* Institute of Radio Engineers (New York, N. Y.), November 1948, page 1251.

5. Traveling-Wave Tubes, **J. H. Pierce, L. M. Field.** *Proceedings,* Institute of Radio Engineers (New York, N. Y.), February 1947, page 108.

6. The Image Orthicon—A Sensitive Television Pickup Tube, **A. Rose, P. K. Weimer, H. B. Law.** *Proceedings,* Institute of Radio Engineers (New York, N. Y.), volume 34, July 1946, page 424.

7. A Memory Tube, **A. V. Haeff.** *Electronics* (New York, N. Y.), September 1947, page 80.

8. Frequency Modulation and Control by Electron Beams, **L. P. Smith, C. I. Shulman.** *Proceedings,* Institute of Radio Engineers (New York, N. Y.), July 1948, page 644.

9. An Electron-Ray Tuning Indicator for Frequency Modulation, **F. M. Bailey.** *Proceedings,* Institute of Radio Engineers (New York, N. Y.), October 1947, page 1158.

10. Electron Beam Deflection Tube for Pulse Code Modulation, *Bell System Technical Journal* (New York, N. Y.), volume 28, January 1948, page 44.

11. 1947 Engineering Developments. *ELECTRICAL ENGINEERING,* volume 67, January 1948, pages 22–31. The microtube, page 31.

12. Miniature Tubes in War and Peace, **N. H. Green.** *RCA Review* (Princeton, N. J.), June 1947, page 331.

13. The Radio Proximity Fuse, **H. M. Bonner.** *ELECTRICAL ENGINEERING,* volume 66, September 1947, pages 888–93.

14. Tube Failures in ENIAC, **F. R. Michael.** *Electronics* (New York, N. Y.), October 1947, page 116.

15. Regulated Rectifiers in Telephone Offices, **D. E. Truckess.** AIEE *TRANSACTIONS,* volume 61, 1942, August section, pages 613–17.

16. New York–Boston Microwave Television Relay. Electronics (New York, N. Y.), January 1948, page 114.

17. Reflex Oscillators for Radar Systems, **J. O. McNally, W. G. Shepherd.** *Proceedings,* Institute of Radio Engineers (New York, N. Y.), volume 35, December 1948, page 1424.

18. Designing Thoriated Tungsten Filaments, **H. J. Dailey.** *Electronics* (New York, N. Y.), January 1948, page 107.

19. Metal-Ceramic Brazed Seals, **R. J. Bondley.** *Electronics* (New York, N. Y.), July 1947, page 97.

20. The Magnetron as a Generator of Centimeter Waves, **J. B. Fiske, H. D. Hagstrum, P. L. Hartman.** *Bell System Technical Journal* (New York, N. Y.), April 1946 page 167.

21. Klystron Oscillators, **A. E. Harrison.** *Electronics* (New York, N. Y.), November 1944, page 100.

22. Disk-Seal Tubes, **E. D. McArthur.** *Electronics* (New York, N. Y.), February 1945 page 98.

23. Circuit Cushioning of Gas-Filled Grid-Controlled Rectifiers, **D. V. Edwards, E. K. Smith.** AIEE *TRANSACTIONS,* volume 65, 1946, pages 640–3.

24. A New Line of Thyratrons, **A. W. Coolidge, Jr.** *ELECTRICAL ENGINEERING,* volume 67, May 1948, page 435.

25. Method for the Measurement of the Ionization and Deionization Times of Thyratron Tubes, **Milton Birnbaum.** Scheduled for publication in AIEE *TRANSACTIONS,* volume 67, 1948.

26. Frequency Performance of Thyratrons, **Hubert H. Wittenberg.** AIEE *TRANSACTIONS,* volume 65, 1946, December section, pages 843–7.

27. Grid-Controlled Rectifiers for R-F Heating, **Bruce Boyd.** *Electronics* (New York, N. Y.), October 1946, page 125.

28. Shield-grid Thyratrons, **O. W. Livingston, H. T. Maser.** *Electronics* (New York, N. Y.), April 1934, page 114.

29. Large Electronic Direct-Current Motor Drives, **M. M. Morack.** *Proceedings,* National Electronics Conference (Chicago, Ill.), volume 2, 1946, pages 212–25.

30. A 400-Ampere Sealed Ignitron, **H. C. Steiner, H. H. Price.** AIEE *TRANSACTIONS,* volume 65, 1946, October section, pages 680–5.

31. High Voltage Ignitron Rectifiers and Inverters for Railroad Service, **J. L. Boyer, C. G. Hagensick.** AIEE *TRANSACTIONS,* volume 65, 1946, pages 463–70.

32. Pentode Ignitrons for Electronic Power Converters, **H. C. Steiner, J. L. Zehner, H. E. Zuvers.** AIEE *TRANSACTIONS,* volume 63, 1944, October section, pages 693–7.

33. High-Voltage Mercury Pool Rectifiers, **C. B. Foos, W. Lattemann.** *Proceedings,* Institute of Radio Engineers (New York, N. Y.), July 1936, page 977.

34. Crosley-OWI 200 Kw "Voice of America," **R. J. Rockwell.** *Electronic Industries* (New York, N. Y.), volume 4, 1945, page 594.

35. Sealed Ignitrons for Radio Transmitter Power Supplies, **H. E. Zuvers.** *Proceedings,* National Electronics Conference (Chicago, Ill.), volume 3, 1947, page 309.

36. Characteristics of Resistance Ignitors, **D. E. Marshall, W. W. Rigrod.** *Electronics* (New York, N. Y.), May 1947, page 122.

Electrical Essay

Faraday's Law of Induction

If S is any smooth, continuous surface bounded by a single, smooth, continuous closed curve, then always the integral of the electric field intensity E around this closed bounding curve, $\int E_s . ds$ is equal to the negative rate of change of the integral, over the surface of the normal component of the magnetic flux density B.

$$\int E_s dS = -\frac{\partial}{\partial t}\int\int B_N dS$$

True or false?

Answer to Previous Essay

The author's reply to his previously published electrical essay (*EE, Apr '48, p 337*) is as follows.

Don't ask such questions! See Joseph Slepian's "Energy Flow in Electric Systems—the *Vi* Energy-Flow Postulate," AIEE *TRANSACTIONS,* volume 61, 1942, December section, pages 835–40, as to why such questions are without meaning.

J. SLEPIAN (F '27)
(Associate director, Westinghouse Research Laboratories, East Pittsburgh, Pa.)

ments of the physical sciences and of engineering, will be published jointly by the Harvard University Press and John Wiley and Sons beginning next year.

The series has been planned to include monographs on such subjects as ultrasonic generators, the theory of the magnetron, earth waves, meteors and the upper atmosphere, applications of seismology to engineering, and high-power vacuum tubes. The first volume, scheduled for early in 1949, will be P. E. LeCorbeiller's "Modern Network Theory." It is expected that six or eight additional monographs will be published during the two or three years following, with a considerably larger number anticipated over a longer period.

The project is under the supervision of an editorial committee headed by Frederick V. Hunt, chairman of the department of engineering sciences and applied physics, and Professors Hunt, H. W. Emmons, and L. D. Leet each will contribute a monograph in the series. Other Harvard faculty members whose monographs will be published within the next two or three years are E. L. Chaffee, Frederick L. Whipple, and Leon N. Brillouin.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Electrical Essays

To the Editor:

This letter is in answer to the "Electrical Essay" appearing in the February issue (*EE, Feb '48, p 187*). The point raised by Doctor Slepian is a very interesting, and, I believe, very basic one. Of course the God is right, at least in a sense. The matter of whether or not there are magnetic charges would appear at first sight to be an important one, but upon closer examination it appears to be mainly a matter of definition. As Doctor Slepian points out no experiment would reveal the answer. Since this is true, the question of the existence of such charges is of a purely academic nature.

However, even from this point of view, it is possible to justify the field equations as they stand. Following the work of Leigh Page in his "Electrodynamics," we may set up the field equations under the hypothesis that magnetic charges do, in fact, exist. These equations are

$$\text{div}\,\boldsymbol{E} = p_E \qquad \text{div}\,\boldsymbol{H} = a p_E$$

$$\text{curl}\,\boldsymbol{B} = -\frac{1}{c}(\dot{\boldsymbol{H}} + a p \boldsymbol{V}) \qquad \text{curl}\,\boldsymbol{H} = \frac{1}{c}(\dot{\boldsymbol{E}} + p V)$$

$$\boldsymbol{F} = p_E(\boldsymbol{E} + a\boldsymbol{H}) + \frac{1}{c} p_E \boldsymbol{V} \times (\boldsymbol{H} - a\boldsymbol{E})$$

If we then write these equations in terms of two new field quantities defined as

$$\boldsymbol{A} = \frac{\boldsymbol{E} + a\boldsymbol{H}}{\sqrt{1+a^2}} \qquad \boldsymbol{B} = \frac{\boldsymbol{H} - a\boldsymbol{E}}{\sqrt{1+a^2}}$$

$$p = \sqrt{p_E{}^2 + p_H{}^2} = p\sqrt{1+a^2}$$

Then in terms of *A* and *B*, the field equations become

$$\text{div}\,\boldsymbol{A} = p \qquad \text{div}\,\boldsymbol{B} = 0$$

$$\text{curl}\,\boldsymbol{A} = -\frac{1}{c}\,\boldsymbol{B} \qquad \text{curl}\,\boldsymbol{B} = \frac{1}{c}(\dot{\boldsymbol{A}} + p V)$$

$$\boldsymbol{F} = p(A + \frac{1}{c} V \times \boldsymbol{B})$$

These last equations are exactly equivalent to Maxwell's equations and we can see that the form of the equations and the form of the field vectors are mutually arbitrary. Or stated more succinctly, the field equations actually define the field vectors in a self-consistent way.

This should not be too startling as the same factors appear in a critical study of Newton's Laws. That is, the so-called laws are in themselves just sufficient to define in a consistent and convenient way the two quantities they introduce, namely force and mass.

By the way, I recommend highly Page's "Electrodynamics" to anyone interested in the foundations of electromagnetic theory.

JAMES MORAN (M '45)
(Graduate student, Case Institute of Technology, Cleveland, Ohio)

To the Editor:

The electrical essay by Doctor Slepian in *ELECTRICAL ENGINEERING*, April 1948, (*EE, Apr '48, p 337*), regarding the two batteries emphasizes an important difference of viewpoints, and an unhealthy situation in electrical theory. Following Poynting's enunciation of his theorem in 1884, many scientists of note became proponents of the idea that the energy associated with the flow of current in a conductor resides in the medium surrounding the conductor. This idea has much support today, especially in the circles mentioned in the essay. On the other hand the power engineer feels instinctively that there is much going on in the conductor that the Poynting theorem does not take into account. He knows that if the entire system were shielded and biased so that the external fields were nullified, the flow of energy from source to load still would continue as before in a simple circuit such as that of the essay. For an interesting account and searching analysis of the Poynting theorem see O'Rahilly.[1]

The power engineer is handicapped in the support of his beliefs because most of the mathematical physicists have been on the other side, and therefore the theory of simple conduction has been neglected. To be sure, the mechanics of the process has been subjected to study, and we have a fairly good idea of what goes on in the conductor. See, for instance, Houston.[2] But little has been done about what causes the process to take place. The following remarks are intended to assist in that regard.

A source of potential produces a displacement of electric charge. This may be accomplished in a number of ways, such as: magnetically in the dynamo; by atomic excitation (unbalance) in the photoelectric cell; propinquity of different substances as in the thermocouple and other contact (or boundary) devices; and by ionic dissociation and polarization as in the battery. In all these cases the naturally uniform distribution of charge is caused or permitted to become unbalanced. As the negative charge is the more mobile, we can say that the general result is an accumulation of negative charge on one terminal of the device and a rarefaction of negative charge on the other terminal. This proceeds until the forces of unbalance equal the internal generative forces.

So long as there is no external circuit connected across the poles, and disregarding local action and leakage, this displacement of charge is maintained in status quo by the internal forces. However, when an external circuit exists, the displacement can extend beyond the terminals. Having done so to some extent, there exists a condensation of negative charge in that portion of the circuit near the negative terminal and a rarefaction near the positive terminal. These conditions proceed to extend along the circuit, establishing what we call a flow of current. If the source is a d-c source, a uniformly varying density will become established along each portion of the circuit having uniform characteristics, and we say a steady state exists.

These matters were touched upon briefly by the writer in a previous communication[3] which was directed primarily toward a somewhat different subject. However, as stated there, the forces of electrostatics are of tremendous magnitude as compared with the common magnetic forces. It readily can be appreciated, therefore, that a very slight condensation or rarefaction of charge is sufficient to maintain a substantial flow of current. It need cause no concern that this concept requires a nonuniform density of charge along the circuit (contrary to the commonly accepted idea that conduction proceeds with electrostatically neutral conductors) because we know that there is a voltage drop along the circuit. This voltage drop means a difference of potential, and difference of potential is only another way of saying difference of density of charge. Thus current flow is seen to be analogous to hydraulic flow, with an extremely incompressible fluid of exceedingly minute mass. It should be clear that this same analysis applies equally well to alternating currents and transient phenomena, although in these cases there are certain other effects which are not pertinent to the present communication.

It therefore appears that in the essay each battery governs the activities in its own circuit and load, and the power engineer is right. It might be well to point out at this juncture that the ideas of the radio engineer are derived from findings and opinions developed at a time when the understanding of current flow and space phenomena just was emerging from its obscure beginnings, and the entire concept should be given a thorough overhauling. The Poynting vector is only an indicator, a straw in the wind which shows the direction in which the breeze is blowing if all the factors are employed correctly. Like any indicator, it should be used with caution in the role of a determinant.

REFERENCES

1. Electromagnetics (book), **A. O'Rahilly.** Longmans, Green and Company, New York, N. Y., 1938. Page 275.

2. The Theory of Electrical Conductivity, Recent Developments, **W. V. Houston.** AIEE *TRANSACTIONS*, volume 49, January 1930, page 30.

3. An Analysis of Electromagnetic Forces, **W. A. Tripp.** *ELECTRICAL ENGINEERING*, volume 64, October 1945, page 351.

WILLIAM A. TRIPP (M '35)

(Electrical engineer, Ebasco Services Inc., New York 6, N. Y.)

To the Editor:

The interesting electrical essay on page 337 of the April 1948 issue of *ELECTRICAL ENGINEERING* catches my eye. I entirely side with the power engineer as I suspect all radio engineers of witchcraft (pure ignorance, no doubt!), and suggest the following "common sense" attack:

Take the diagram exactly as shown, that is, d-c sources and pure resistance loads; then the loads can be detected by the heat generated in them. No one will deny that removal of source $X2$ from the circuit will cease to keep load $R1$ hot; also removal of source $X1$ will not affect the heating of $R1$.

My view is, therefore, that when both loads and sources are connected, measurements cannot distinguish between which feeds which as sources and loads are identical and interchangeable. But by physical interference such as I have suggested, it is proved that $X1$ feeds $R2$, and $X2$, $R1$.

I enjoy this feature very much. More, please!

FRANK WOODWARD ROBERTS (M '45)

(Ashdown, Western Road, Billericay, Essex, England)

To the Editor:

I have heard from a number of AIEE members protesting my answer in *ELECTRICAL ENGINEERING*, January 1948, page 58, to my quiz problem published as an "Electrical Essay," in *ELECTRICAL ENGINEERING*, September 1947. In my answer I gave a simple example showing an electrostatic line of force making an angle not 90 degrees with the smooth surface of a perfect conductor.

In particular, W. H. Gamble, K. W. Miller, and W. Richter maintain that at the point A at the surface of the conductor in my figure, the electric field intensity E is zero and, therefore, has no determinate direction there. Therefore, say Messrs. Miller and Richter, the line of force at A can have no direction there. Professor Gamble goes farther, and says that there is no line of force which reaches A.

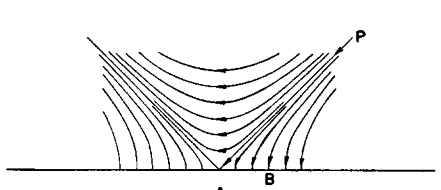

Figure 1

I believe these remarks indicate a confusion between the notion of a line of force, and the electric force or electric intensity itself. They imply that my statement that a line of force makes an angle of 45 degrees with a conducting surface at one of its points, is entirely equivalent to the statement that the electric force or field intensity also makes an angle of 45 degrees with the surface there. This is not at all the case.

Although it is defined by means of the electric force, the line of force itself is not a vector, but a geometric curve. Like any other geometric curve, it has direction, but its direction is determined at a point by the disposition of the *other points on the curve* which lie in the neighborhood of the given point. If only a single point of a curve is given, then it is not possible to determine its direction. We must know also the positions of neighboring points.

Figure 1 of this letter shows the various lines of force in the vicinity of the point A in question on the conducting surface. All along its length the line of force PA in question has its neighboring points so disposed that the direction they determine is 45 degrees from the normal to the surface. This is true, no matter how closely we approach the point A on the curve. As the curve approaches A, there is no wobble or wavering. The neighboring points of A, on PA, continue to determine a direction at 45 degrees to the normal.

It is true that all the *other* nearby lines of force either meet the surface at right angles or fail to meet the surface. However, the direction which PA has, is its own business and is a property of the disposition of its own points, and not of those of the neighboring other curves. And PA insists on keeping itself at 45 degrees to the surface.

If Messrs. Gamble, Miller, and Richter were asked to draw a line at A at 45 degrees to the surface, would they draw a curve which would differ in any way from the line of force PA?

On the other hand, the electric force or field intensity is a vector, defined, in principle at least, at any individual point in free space without reference to its values at neighboring points. It is the force (mechanical or otherwise) per unit charge, required to hold a very small charge at rest at the point under consideration. Unlike the direction of a curve, we may speak of, and in principle observe or measure, the electric force at an isolated point. Being a vector, the electric force has a direction, unless its magnitude is zero, in which case it has no direction.

Professor Gamble raises the question whether the point A should be regarded as being on the line of force PA or not. Apparently, he would prefer that the line of force have no end, than have it *meet* the surface at 45 degrees. This question is somewhat delicate. As its answer depends on the definitions we adopt for quantities at the conductor surface, it is largely a matter of taste.

For example, what is the electric force at a point of the conductor surface? We cannot use the definition for free space given in the foregoing, for how can we determine the force (mechancial or otherwise) needed to hold a small enough charge at rest there? The charge at the surface itself is apparently in equilibrium, so the net force per unit charge for it is zero there. Shall we therefore make the electric force zero there? On the other hand, we correctly may calculate the forces (mechanical or otherwise) required to keep the conductor itself at rest if we ascribe to each unit area a normal force equal to $\sigma^2/8\pi$ where σ is the charge density. This would make the electric force or electric intensity at the surface, normal, and equal in magnitude to $E=\sigma/8\pi$. On the other hand just outside the surface the electric force is normal, but equal in magnitude to $E=\sigma/4\pi$.

Evidently, although frequently not explicitly stated, we arbitrarily define the field at a point of the surface of the conductor as equal to that just outside the conductor there, or more exactly as the limit which the electric field at a point outside the conductor approaches as that point approaches the given point of the conductor surface.

As we pass through the conductor surface, in general there is necessarily a discontinuity. Just outside the surface, the electric field is generally not zero. Inside the surface, by definition of a conductor, the electrostatic field is always zero. Just outside the surface, lines of force generally are approaching the surface normally. Inside the surface, there are no lines of force.

What we do at the surface itself is a matter of definition or taste. We may match all the quantities at the surface on to the quantities outside, thus throwing the discontinuity on the inner side of the surface. We may match equally well, however, the quantities at the surface on to the quantities inside, or, if we please, we may give the surface quantities values intermediate between those inside or outside.

It is customary to adopt the first of these alternatives. The electric field at the surface generally is taken to have the magnitude $E=\sigma/4\pi$, matching on to the points outside. Points at the surface are said to lie on lines of force, even though points just inside the surface do not lie on lines of force.

Apparently, Professor Gamble follows the usual convention, generally, since at points other than A he is quite willing to have a line of force *meet* the surface. That is, he makes a surface point such as B match on to the *exterior* of the surface. However, the point A, he prefers to match on to the inside of the surface, and lie on no line of force.

There is no purely logical objection to Professor Gamble's choice. It is merely a matter of taste. With his choice, I grant that the line of force PA does not *meet* the conducting surface. However, I am rather sure that he will say that it makes an angle of 45 degrees with the surface there, even if according to his choice it does not meet it there.

J. SLEPIAN (F '27)

(Associate director, research laboratories, Westinghouse Electric Corporation, East Pittsburgh, Pa.)

To the Editor:

In his letter Doctor Slepian states: "I believe these remarks (made by Messrs. Gamble, Miller, and Richter) indicate the

English Teachers for Engineers

To the Editor:

Professor Muir (*EE, Jul '48, pp 724–5*) has attacked an article, written by informed men, on the teaching of English to engineering students. The professor is right about "communications"; the primary need is to change the attitude of the teachers, not the name of the course. Yet his major contentions are contrary to experience.

Over the years I have heard various criticisms of the editors of technical writings who have been trained only academically. An example is: "If it sounds right, he's satisfied. He doesn't care what it means." Professor Muir cannot evaluate the justice of this criticism, because he has not the necessary knowledge of engineering. For the same reason his own sampling of published engineering articles will not tell him why those writings are acceptable to engineers.

Some of us object to the substitution of form for substance. Twenty centuries ago a great teacher expressed the same objection.

A sentence from Professor Muir's letter reads: "This aim is to give instruction in the writing of clear, accurate, logical expository English prose." This sentence demands that the vehicle be clear and accurate, but does not give a syllable to clarity and accuracy of thought. When the truck is spic and span, why bother with its load?

If the professor intended his sentence to mean something else, where is its clearness?

The sentence does not mention conciseness.

Most engineers write for themselves alone, without a thought of the audience. Professor Muir's letter ignores this vital error.

Courses in journalism, for instance, stress simple words and sentences. The instructors do not even mention any other style, as far as I know. An engineering author should have at least two styles, one for a technical audience and a different one for a nontechnical audience. These two are the minimum; he should also be able, for example, to write both for high-school students and for well educated but nontechnical adults, such as the directors of the company.

Professor Muir evidently is teaching essentially as he was taught. That product of inbreeding is the basic fault in the usual attempts to teach English to engineers.

A certain young instructor, in handling an advanced course in English, teaches principles and their application. His method is like teaching the principles of alternating currents, and then solving by those principles whatever problems turn up in the day's work.

The tradition-following colleagues of this young man require their students to memorize certain definitions, and then to memorize selected examples. That method is like memorizing a few definitions in alternating currents and then memorizing specified problems. It develops memory. The younger man's method, which accords with good engineering practice, develops reason.

The first requirement for clear and accurate writing is clear and accurate thinking. Another requisite is a knowledge of the subject. Experience long has shown that minor variations in the traditional method of teaching English are not enough for engineers (*EE, Jul '47, p 740*).

HENRY HENDRICKS KETCHAM (M '23)

(Box 221, Piqua, Ohio)

Electrical Essays

To the Editor:

A number of letters to the editor concerning electrical essays which I have written, have appeared, and call for some comment from me.

Orientation of Diamagnetic Bar, January 1948, page 58. I want to thank B. Litman for the valuable contribution in his interesting letter in the May 1948 issue (*p 509*). It is remarkable that most American textbooks give the incorrect answer to this question. A correspondent writes me that this is not the case for European textbooks.

The origin of this widespread error is undoubtedly, as Litman points out, the report of Faraday that in his experiments he found a bismuth bar setting itself perpendicularly to the magnetic field. Faraday's field was not uniform.

I have suspected that an iron bar might also set itself transversely in a magnetic field if it had the appropriate kind of nonuniformity. I am glad to have Mr. Litman confirm this expectation.

Electrostatic Line of Force, January 1948, page 58 (reply). This essay, which indicated that a line of electric force in an electrostatic field may meet the smooth surface of a conductor other than perpendicularly, aroused a rather large number of somewhat violent protests. I have already replied to some of them in the August 1948 issue (*p 829*).

In the May 1948 issue (*pp 509–10*), T. W. Mouat and Martin Graham join the distinguished throng who say that I am wrong in my contention. However, I still obstinately insist that in my Figure 1, *ELECTRICAL ENGINEERING*, August 1948, page 829, the line *PA* is a line of force, and it is obvious that it is not perpendicular to the conducting surface.

Incidentally, I have no idea of how a massless charged particle will move if placed in an electric field, and so Mr. Graham's definition of a line of force as the path of such a particle is not of much use to me.

A God Has Fun, February 1948, page 187. James Moran, in the August issue, page 818 gives a very excellent mathematical proof that the God was right in expecting that man would not be able, by any experiment, to detect the adulteration of electric charge by a fixed proportion of magnetic charge. I want to thank him for this. I agree with him that, therefore, the question as to whether the electron is or is not magnetically adulterated in fixed proportion, is meaningless.

Which Source Feeds Which Load, April 1948, page 337. I cannot agree with William A. Tripp, August 1948 issue, page 828, that because the Poynting vector of the radio engineer, and the VI formula of the power engineer give opposite answers to the question asked in the essay, there is an "unhealthy situation in electrical theory." I think the diversity in the answers to the question asked in the essay is only a natural consequence of the lack of uniqueness in the concept of energy flow. All that it is possible for us to observe is the transformations of electric energy, into other forms, and these transformations are only the divergence of the vector electric energy flow. Since a vector field is not uniquely determined by its divergence, it follows that electric energy flow cannot be uniquely determined by any observed phenomena. It also follows that there is an infinity of possible postulated electric energy flows, all equally valid and "true" in the sense that they all have the same divergence, and therefore all correspond equally well to observable phenomena. The radio engineer and the power engineer happen to each respectively use a different, but equally valid energy flow postulate.

The question asked in the essay is a meaningless one. Although it also satisfies a conservation law, energy, unlike matter, does not have a continuing identity in space-time. Therefore, the question asked in the essay, which implies for energy such a continuing identity in space-time, has no absolute meaning. It has a meaning only relative to some postulated electric energy flow. The radio engineer of the essay would deny that the test described by Mr. Roberts (*EE, Aug 48, p 829*) proves that the source X_1 feeds the load R_2 before Mr. Roberts removes the source X_2 from the circuit. His Poynting vector tells him otherwise. After X_2 is removed, then the Poynting vector will say that X_1 feeds R_2, but before the removal of X_2 the Poynting vector says that X_1 feeds R_1. The fact that a switching operation on a system changes the distribution of power consumed in loads does not permit the proof that one proper energy flow postulate is more valid than another.

Suppose in the diagram of the essay, at the point B, a switch is introduced, connecting two points of the adjacent conductors which are at precisely the same potential, so that when closed, the switch carries no current. Then such a switch, either closed or open, will not change the conclusions of either the radio engineer or the power engineer as to the flow of energy to the loads when both sources are connected. However, if Mr. Roberts will make his test of removing the source X_2 with the switch closed, he will find the load R_1 continuing to be warm.

J. SLEPIAN (F '27)

(Associate director, Westinghouse Research Laboratories, East Pittsburgh, Pa.)

The Engineer's Part

To the Editor:

From time to time some very excellent articles concerning the status of the engineer have appeared in *ELECTRICAL ENGINEERING*. In the August issue, the article, "The Engineer's Part," by Harvey N. Davis (*pp 727–33*), does a particularly fine job of pointing out the value of engineering. It seems to me a pity that these articles must appear in a technical publication the majority of whose readers are engineers and of course already convinced of the value of the engineering profession.