SCIENCE

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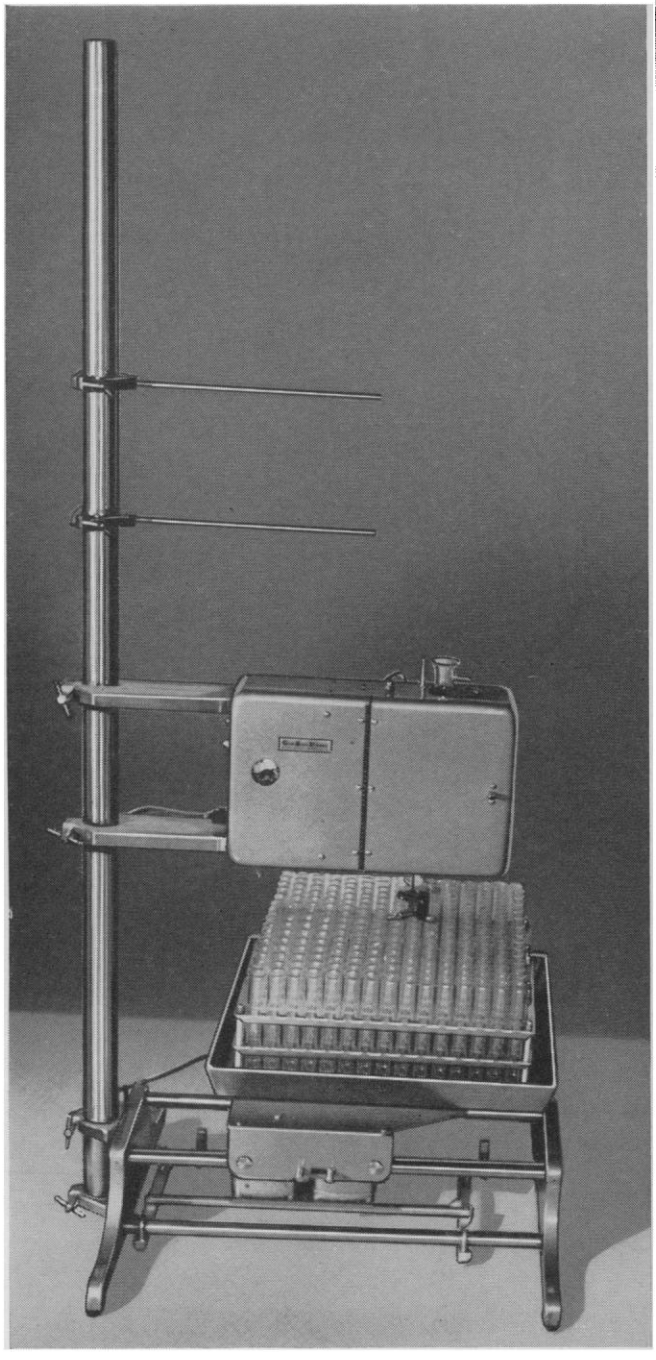
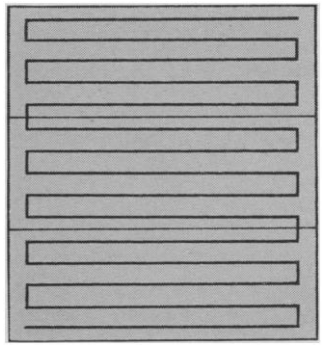
AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

new from **GME**



SQUARE FRACTIONATOR

collects fractions directly
in standard rectangular racks



Model V 15^2 offers new convenience and eliminates possibility of errors in transferring tubes from the fractionator to racks.

The racks themselves, with all the test tubes in the order collected, may be removed from the fractionator for further processing.

The tubes are filled in the order shown in the boustrophedon drawing above.

- **Accurate collection in 225 test tubes**
- **Eliminates 450 tedious test tube transfers**
- **Equipped with 3 racks — each has 5 rows, 15 tubes per row**
- **Improved volumetric unit**
- **Timer or N.I.L. drop counter attachment are available**

MODEL V 15^2 Complete unit with stainless steel test tube pan, three test tube racks for 225 test tubes (18 x 150 mm.), improved volumetric unit, 5-foot supporting column, 2 apparatus clamps with rods, 2 funnel valves, collecting cylinders for fractions to 15 c.c.

MODEL T 15^2 Complete unit with stainless steel test tube pan, three test tube racks for 225 test tubes (18 x 150 mm.), 5-foot supporting column, 2 apparatus clamps with rods, timer for 18-sec. to 120-min. intervals in 6-sec. increments.

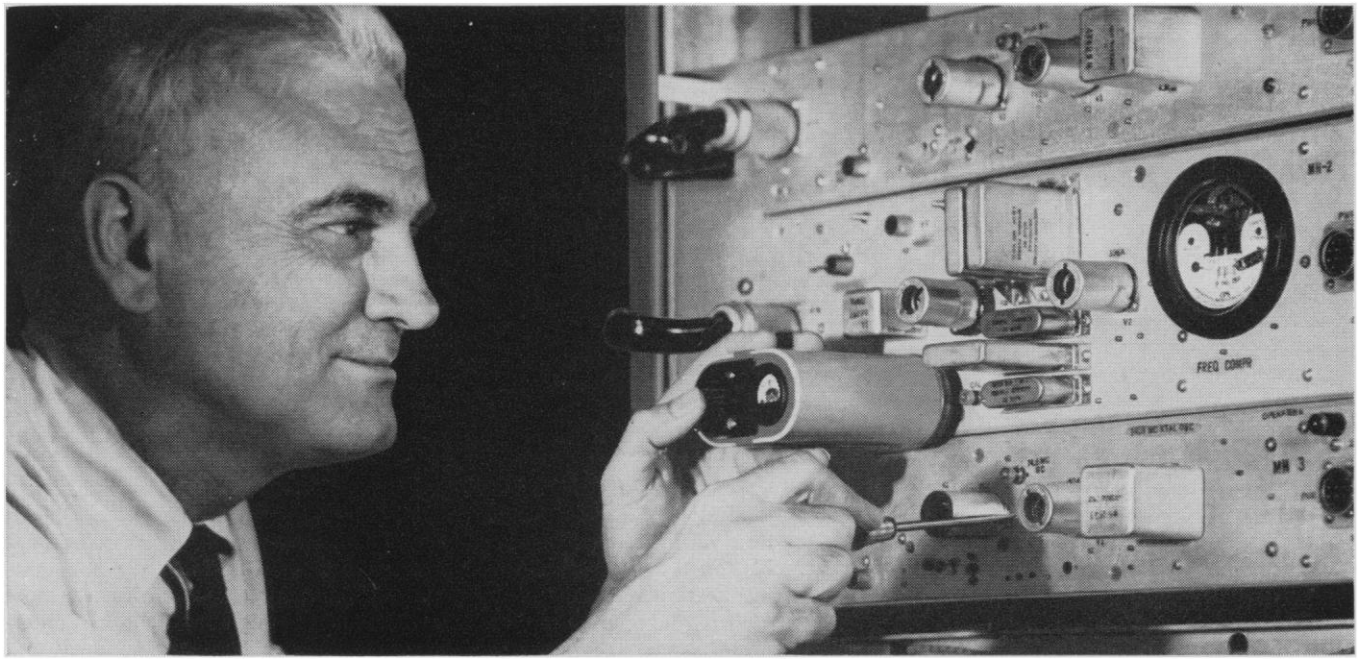
MODEL D 15^2 Complete unit with stainless steel test tube pan, three test tube racks for 225 test tubes (18 x 150 mm.), 5-foot supporting column, 2 apparatus clamps with rods, N.I.L. drop counter.

Extra stainless steel or aluminum test tube racks available.

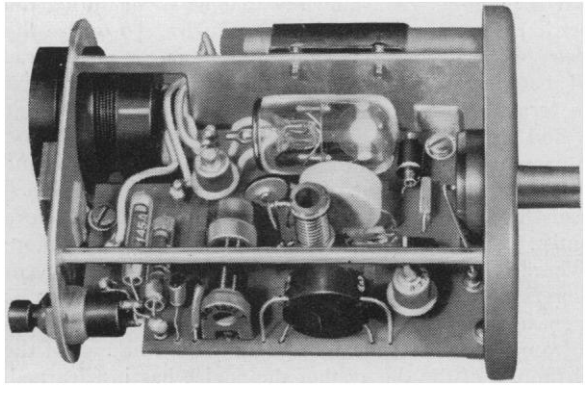
For descriptive brochure, write:

GILSON MEDICAL ELECTRONICS
MIDDLETON, WISCONSIN
on Madison's West Beltline Highway

Bell Laboratories Announces Pocket-Sized Frequency Standard for Microwave Systems



Lawrence Koerner, who developed the portable frequency standard, demonstrates how the device can be plugged in at a radio relay station to supply a checking frequency. Battery-powered, the device maintains precision calibration for several months.



Inside the portable frequency standard. Four Laboratories-developed devices make it possible: (1) transistor, which converts the power from a battery to radio frequency oscillations; (2) voltage reference diode, which maintains constant voltage; (3) piezoelectric crystal unit of superlative stability; (4) thermistor, which corrects for temperature variations.

Microwave radio relay systems depend critically on the accuracy of their "carrier" frequencies. At scores of relay stations along a route, carrier frequency oscillators must be checked periodically against a signal from a precise standard.

In the past, the maintenance man has had to obtain his checking frequency by picking up a standard radio signal from a government station. This operation takes time—and requires elaborate equipment.

With a new *portable* frequency standard developed by Bell Laboratories engineers, the job is much simplified. To check an oscillator, the portable standard is plugged in, and a button is pressed. In seconds, it supplies a checking frequency accurate to one part in a million.

Until now, such precision in a frequency standard has been obtainable only in a laboratory. The new portable standard makes it available for routine use in the Bell System. First use of the standard will be to maintain frequency control in a new microwave system for telephone and TV, now under development at Bell Laboratories.

BELL TELEPHONE LABORATORIES

WORLD CENTER OF COMMUNICATIONS RESEARCH AND DEVELOPMENT

for educational and similar purposes. The study was conducted by the Surveys and Research Corporation of Washington. Expenses up until the end of 1957 amounted to $17,331.51, leaving a balance at the end of the year of $2668.49.

Also during 1957 the Association received a grant of $5100 from the National Science Foundation to help pay the expenses of a conference of representatives of junior academies of science. The grant was totally expended for that conference.

Investment Account

To keep them separated from current funds and from grants for special activities, the Association holds its endowment and investment funds in a separate Investment Account. At the end of 1957 this account included the following:

Cash	$ 14,476.60
U.S. Government bonds	66,206.25
Industrial bonds	145,969.55
Preferred stocks	58,908.59
Common stocks	209,013.94
Total	$494,574.93

The above figures are at cost or book value, rather than at the market value of the securities. The total is $43,206.42 greater than was the book value one year earlier.

During the year the Association received $18,627.82 in dividends and interest on its Investment Account. This income represents a return of 3.8 percent on the book value of the account at the end of the year and slightly better than 4.1 percent on the book value at the beginning of the year.

The income was used as follows:

Investment counsel and cost of servicing securities	$ 1,815.74
Grants to affiliated academies of science	4,089.50
Transferred to operating fund for life and emeritus members	3,933.00
To the Gordon Research Conferences	2,041.33
Award of Newcomb Cleveland Prize	1,005.00
Award of Socio-Psychological Prize	1,008.83
Increase in value of endowment funds	4,734.42
Total	$13,627.82

During the year the Association also gained $18,669.02 from the sale of securities. This amount, plus the $4734.42 shown in the table above, plus the fees of new life members ($7155), plus a small amount received in the form of gifts during the year, and plus an increase of $11,670.05 in funds held for the Gordon Research Conferences, accounts for the total increase in book value of $43,206.42 quoted above.

Consolidated Balance Sheet

In order to give a view of the Association's financial position, the figures from the Current Fund and Investment Account have been combined here. At the end of 1957, the consolidated balance sheet showed the following assets:

Cash on deposit:	
Operating account	$ 155,465.01
Investment account	14,476.60
Investments at cost:	
Operating account	411,398.59
Investment account	480,098.33
Land	115,875.00
Building (less depreciation)	746,733.19
Equipment (less depreciation)	51,132.05
Money owed to the Association	59,379.96
Total	$2,034,558.73

These assets were partially offset by the following liabilities:

Prepaid dues and subscriptions for which members and other subscribers had not yet received journals or other services	$358,910.95
Unexpended balance of grants from the Carnegie Corporation, the General Electric Educational and Charitable Fund, the National Science Foundation, and the Ford Foundation	117,878.90

Accounts payable to others	89,170.41
Remainder of mortgage on building, payable in 8½ years	$152,979.56
Held for Gordon Research Conferences	38,172.80
Total	$757,112.62

The difference between the assets and liabilities represents the Association's net worth. As of the end of 1957, the net worth was distributed as follows:

Endowment funds:	
For research	$ 201,292.02
For general purposes (used to pay subscription costs for life and emeritus members)	190,728.90
For the Newcomb Cleveland Prize	27,180.95
For the Socio-Psychological Prize	29,026.65
For creating emeritus life memberships	8,173.61
Value of land	115,875.00
Value of building (less depreciation and mortgage)	593,753.63
Unallocated reserve	115,599.63
Total	$1,277,446.11

This net worth figure is $41,914.20 greater than at the end of 1956.

Auditor's Report

The Association's financial records for 1957 were audited by the firm of G. P. Graham and Company. The tables presented above differ in form from those included in the auditor's report, and the explanations of sources of income and nature of expense are usually given in greater detail. In a few cases, items have been reclassified from the auditor's report to make more meaningful groupings. Except for such rearrangements, there are no differences between the figures presented here and those reported in the audited account, to which was attached a letter reading, in part: "In our opinion the accompanying statements present fairly the financial position of the American Association for the Advancement of Science as at December 31, 1957, and the results of its operations for the year ended on that day, and were prepared in conformity with generally accepted accounting principles. . . . Respectfully submitted, G. P. Graham and Company, by G. R. Bowers."

DAEL WOLFLE
American Association for the Advancement of Science

International Conference on the Peaceful Uses of Atomic Energy

The Second United Nations International Conference on the Peaceful Uses of Atomic Energy at Geneva, Switzerland, began on 1 September and will continue through 13 September. Formal invitations to take part in the 1958 con-

ference were sent by the United Nations to 88 governments and the affiliated specialized agencies. Sixty-one governments are participating.

Plans for the conference were developed by a seven-nation advisory committee, including scientists from Brazil, Canada, France, India, the U.S.S.R., the United Kingdom, and the United States. Sigvard Eklund, Secretary-General of the conference, appointed a 21-member scientific secretariat from 13 countries to assist in the preparation of the agenda. Subjects that are receiving major attention at the conference are basic nuclear physics, including nuclear fusion, nuclear reactors, chemistry, radioisotopes, health and safety problems, raw materials, and metallurgy.

The U.S. delegation, announced by President Eisenhower on 20 August, includes Lewis L. Strauss, chairman, James R. Killian, Jr., Willard F. Libby, Robert McKinney, and I. I. Rabi. Representatives of the Joint Congressional Committee on Atomic Energy are also attending and the U.S. delegation has an advisory scientific group of approximately 200 scientists.

This country is presenting more than 700 papers, of which approximately 200 are being presented orally, while the rest will appear in the printed procedure. The U.S. exhibit covers about 36,000 square feet of space and includes four major sections: Basic Sciences, Life Sciences, Fission Reactors, and Controlled Fusion Research. A total of 44 films on many aspects of atomic energy utilization have been produced by the U.S. for the conference, and a U.S. Technical Information Center is available for the use of delegates from all countries.

More than 40 private American industrial firms are taking part in a commercial exhibit that is being held in Geneva at the same time as the conference. The exhibit displays atomic energy equipment, components, products, and services that are now available on the open market.

Forthcoming Events

October

5–8. American Inst. of Mining, Metallurgical, and Petroleum Engineers, fall, Houston, Tex. (E. O. Kirkendall, AIME, 29 W. 39 St., New York 18.)

6–9. Veterinary Public Health Practice, 1st inst., Ann Arbor, Mich. (H. E. Miller, Continued Education, School of Public Health, Univ. of Michigan, Ann Arbor.)

6–11. Electroencephalographic Study of the Higher Nervous Activity Processes in Animals and Man, colloquium (by invitation), Moscow, U.S.S.R. (Miss Mary A. B. Brazier, Massachusetts Neurophysiological Laboratory, Massachusetts General Hospital, Boston 14.)

7–9. Hypervelocity, 3rd symp., Chicago, Ill., (Air Force Office of Scientific Research, Air Research and Development Command, U.S. Air Force, Washington 25.)

7–9. International Soc. for the History of Pharmacy, cong., Venice, Italy. (A. F. Vitolo, Piazza Carrara 10, Pisa, Italy.)

8–12. Nutrition and Vital Substances, 4th intern. conv., Essen, Germany (Secretary General, Bemeroder Strasse 61, Hannover-Kirchrode, Germany.)

10–11. Association of Midwest Biology Teachers, Western Illinois Univ., Macomb. (R. M. Myers, Western Illinois Univ., Macomb.)

11–15. Salinity Problems in the Arid Zones, UNESCO symp., Tehran, Iran. (UNESCO, 19, avenue Kleber, Paris 16e.)

12–17. American Acad. of Ophthalmology and Otolaryngology, Chicago, Ill. (W. L. Benedict, 100 First Ave. Bldg., Rochester, Minn.)

13–15. Association of American Medical Colleges, 69th annual, Philadelphia, Pa. (W. Darley, AAMC, 2530 Ridge Ave., Evanston, Ill.)

13–15. National Electronics Conf., Chicago, Ill. (L. W. Von Tersch, Michigan State Univ., East Lansing.)

13–16. Society of Exploration Geophysicists, 28th annual intern., San Antonio, Tex. (C. C. Campbell, Box 1536, Tulsa 1, Okla.)

13–17. American Soc. of Civil Engineers, annual conv., New York, N.Y. (W. H. Wisely, ASCE, 33 West 39 St., New York 18.)

15–17. American Ceramics Soc., Glass Div., Bedford, Pa. (C. S. Pearce, 4055 N. High St., Columbus 14, Ohio.)

19–22. Land and Water, Soil Conservation Soc. of America, 13th annual, Asheville, N.C. (H. W. Pritchard, 838 Fifth Ave., Des Moines 14, Iowa.)

19–24. American Soc. of Anesthesiologists, Pittsburgh, Pa. (J. E. Remlinger, 802 Ashland Ave., Wilmette, Ill.)

19–26. Allergology, 3rd intern. cong., Paris, France. (S. M. Feinberg, Medical School, Ward Memorial Building, 303 East Chicago Ave., Chicago, Ill.)

19–26. Medical Hydrology, 21st intern. cong., Madrid, Spain. (Dr. Francon, 55, rue des Mathurins, Paris 8e, France.)

20–21. Rubber and Plastics Instrumentation, natl. symp., Akron, Ohio. (D. R. Davis, General Tire and Rubber Co., Central Research Lab., Akron 9.)

20–22. American Oil Chemists' Soc., fall, Chicago, Ill. (Mrs. L. R. Hawkins, 35 E. Wacker Drive, Chicago 1.)

20–23. American Acad. of Pediatrics, Chicago, Ill. (E. H. Christopherson, 1801 Hinman Ave., Evanston, Ill.)

20–23. American Psychiatric Assoc., Kansas City, Mo. (1700 18 St., NW, Washington 6.)

21. American Soc. of Safety Engineers, annual, Chicago, Ill. (J. B. Johnson, 425 N. Michigan Ave., Chicago 11.)

22–24. American Assoc. of Petroleum Geologists, southwestern regional, Mineral Wells, Tex. (R. H. Dott, Box 979, Tulsa 1, Okla.)

22–24. Aviation Medicine, 4th annual symp., Santa Monica, Calif. (T. H. Sternberg, UCLA Medical Center, Los Angeles 24, Calif.)

22–26. American Soc. for the Study of Arteriosclerosis, annual, San Francisco, Calif. (O. J. Pollak, P.O. Box 228, Dover, Del.)

23–25. National Soc. of Professional Engineers, San Francisco, Calif. (K. E. Trombley, NSPE, 2029 K St., NE, Washington 6.)

23–25. Rocket Technology and Astronautics, intern., Essen, Germany. (Deutsche Gesellschaft fuer Raketentechnik und Raunfahrt, e.v., Neunsteinerstrasse 19, Stuttgart, Zuffenhausen.)

24–25. International Conference on the Insulin Treatment in Psychiatry, New York, N. Y. (M. Rinkel, 479 Commonwealth Ave., Boston 15, Mass.)

24–25. Taxonomic Consequences of Man's Activities, symp., Mexico, D. F. (H. C. Cutler, Missouri Botanical Garden, St. Louis.)

24–28. American Heart Assoc., San Francisco, Calif. (J. D. Brundage, 44 E. 23 St., New York 10.)

27–28. Child Research in Psychopharmacology, conf., Washington, D.C. (S. Fisher, Psychopharmacology Service Center, Natl. Inst. of Mental Health, Bethesda 14, Md.)

27–28. Plant Physiology, 9th annual research cong., Saskatoon, Saskatchewan, Canada. (D. T. Coupland, Plant Ecology College of Agriculture, Univ. of Saskatchewan, Saskatoon.)

27–29. Radio, Institute of Radio Engineers, fall meeting, Rochester, N.Y. (V. M. Graham, EIA, 11 W. 42 St., N.Y.)

(See issue of 15 August for comprehensive list)

Letters

Machines and the Brain

In the last few years there has been an epidemic of published statements, articles, and books which take for their subject the relationships of machines to brains. Many of these theses have been loosely constructed and have been filled with gross oversimplifications, vague approximations, and unjustified assumptions. Certainly some comparisons and contrasts can be made between known machines and human brains, but the paucity of knowledge of the latter mechanism has given rise to numerous ill-advised speculations. My general concern here is to attempt to attack some of this foggy thinking and, in particular, to respond to the article "Machines and the brain" by F. H. George, published in the 30 May 1958 issue of Science [**127**, 1269 (1958)].

It is asserted in that article that cybernetics has seriously proposed that the brain is a complex two-valued switching device. A more accurate observation is that the switchboard theory of nervous conduction was disappearing at just about the time that cybernetics first came on the scene. Wiener (*1*) himself suggested the possibility of a complex nondigital neural mechanism in addition to the well-known all-or-none transmission. Since then there has been ample evidence for synaptic and humoral

mechanisms which form continuously variable, long time-constant systems. These systems, at least as complex as those using two-valued axonal transmission, mediate the performance of the binary systems. If one must speculate about the nature of the cerebral processes it may be reasonable to say that the flow of information between parts of the brain is essentially "digital" while the logical operations themselves are "analog." The futility of even hoping for adequate mathematical descriptions of the brain is made painfully clear when von Neumann observes (2) that the nervous system operation must differ considerably from what we consciously and explicitly consider to be mathematics.

George has equated simulated nerve nets to biological nervous tissue, implying that the flow of binary signals through explicit logical networks can form a reasonable basis for understanding brain function. One of the most embarrassing pieces of clinical evidence which such notions must explain is that very considerable portions of human brain can be removed without apparently destroying memory or function. In the ablation of a complete cortical hemisphere some five billions of the elements can be removed without much observable effect.

George has the discomfiting habit of implying much while actually saying little and therefore leaving the reader with more flavor than sustenance. The section entitled "Development of nets" illustrates this when the time comes to develop the nets and one finds that the author "leaves the matter for the time," never to return. He agrees throughout this section that certain things should be said, then neatly side-steps with comments that these matters have been discussed elsewhere; unfortunately, references to the "elsewheres" are not given.

George's "summary" of our knowledge of the human visual system is of dubious value. Even a cursory summary of that vast body of information (3), written for an interdisciplinary audience, could easily occupy a small volume. The "summary" which is given is a curious mixture of gross anatomy, psychophysics, and speculation. There is a section of this summary which is truly incredible. It is:

> Perhaps the most interesting feature of the visual pathways is the effect of summation resulting from the fact that information is being passed through a restriction. (Something very similar is seen in the auditory pathways.)
>
> The passing of information through a restriction is something that is characteristic of the central nervous system and makes temporal summation a necessity. It should be mentioned straightway that there is no difficulty in showing how this can be done in logical network terms.

To this I can only observe that the words and sentences are quite clear; it is only the meaning which is baffling.

One of the great puzzles to neurophysiologists, neuroanatomists, and psychologists alike concerns the origin and function of the alpha rhythm. There is not even a good set of speculations extant for explaining this brain-wave phenomenon, yet George confidently describes it as a scanning system to offset blurring due to aftereffects of retinal stimulation.

The impression is given that, after all, the cerebral cortex is a simple structure, only it contains so many variables that its description must be made in probabilistic terms. The author asserts that intercortical and subcortical connections "can be approximated by quite simple mathematical functions." This is extremely misleading in view of the fact that a *single* neuron may have hundreds of dendritic connections and as many, or more, synaptic processes. Even if we completely understood this "simple" unit and its time-varying parametric rules (which must include charge distribution, ionic concentration, membrane and hu-

moral conditions), an adequate description for it would very likely be far from simple. To further construct a mathematical model for a modest volume of these elements (a single cubic centimeter contains roughly ten million of them) is an even more complicated task. We must then include statements about temporal and spatial summation, relative and absolute refractoriness, inhibition, and delay.

Most of those who have done "nerve-net" modelling have been careful to state that their constructs are extremely gross oversimplifications. In his "Probabilistic Logics" (*4*), von Neumann cautions that identifying the real physical or biological world with models constructed to explain it is indeed dangerous and that even plausible explanations should be taken with a very large grain of salt.

LEON D. HARMON
Bell Telephone Laboratories, Inc., Murray Hill, New Jersey

References and Notes

1. N. Wiener, *Cybernetics* (Wiley, New York, 1948), p. 142.
2. J. von Neumann, *The Computer and the Brain* (Yale Univ. Press, New Haven, Conn., 1958), pp. 80–82.
3. See, for example, S. L. Polyak's 600-page volume *The Retina* or the same author's *The Vertebrate Visual System*, containing 1390 pages, 300 of which are devoted to bibliography.
4. J. von Neumann, "Probabilistic Logics," included in *Automata Studies* (Princeton Univ. Press, Princeton, N.J., 1956).

I have been kindly allowed to reply to the criticisms made by L. D. Harmon about my article "Machines and the brain," published in *Science*, 30 May 1958.

It is perhaps most appropriate to start with some admissions. Insofar as I may have created the impression that the cerebral cortex is simple, that machines could easily be built to simulate it in detail, or that everything is now cut-and-dried in digital terms, then I have certainly been guilty of misleading my readers. It may be easy enough in this sort of subject to create a false impression, and many writers have certainly made exaggerated claims.

That my writing and thinking may sometimes be foggy, as Harmon suggests, is a fact of which I am all too well aware. More particularly, I agree with the late John von Neumann's warning about *identifying* models with physical or biological systems. Von Neumann had a large influence on my own thinking—especially during a year spent at Princeton (1953–54)—and I would certainly never encourage identification of model and system modelled; nor, indeed, did I ever suggest such a foolish procedure.

I will now turn briefly to the task of justifying myself.

I would certainly claim that the meth-

ods of *finite automata* are of the greatest use in building models of the human brain. This is not to imply that the human brain can be wholly modelled as a digital system (Turing guessed that it was part digital and part analog, and with this most of us would agree). If, however, we were able to mirror many aspects of the brain in such digital terms, it would then be relatively easy to replace digital by analog parts. The procedure is essentially an *effective* one. It also has (and for this reason of its *effectiveness*) a clarifying effect on the concepts we use in neurophysiology.

The example Harmon quotes of brain destruction is an interesting one. This work is associated, primarily, with the name of Lashley. He certainly found that an alarming number of cortical areas could be destroyed, at least in rats, and there is much evidence from frontal lobotomy and other operations in human beings that show the same sort of thing. But why, one wonders, does Harmon imply that this is a special difficulty? The work of D. O. Hebb has already suggested a method for dealing with these results, and von Neumann's principle of multiplexing could certainly be used to account for them. Clearly, any model that claims to be sufficient for brain-model purposes will not depend on precise element-by-element efficiency. Since a large number of elements must be kept in reserve for the mediation of "new ideas," destruction of elements may well have the effect of destroying "creative" capacity.

Unfortunately, limitations of space forbid that I should treat the remainder of Harmon's remarks in detail. But I will summarize further comments in the form of a brief list. (i) Restriction and temporal summation are characteristics of central nervous tissue (see J. T. Culbertson); Harmon's example of my prose is not so convincing, although I would now write it rather differently. (ii) The switchboard theory of the nervous system is by no means out of fashion, and research is increasingly being done on it, perhaps especially in Britain. (iii) I believe it is possible that the cerebral cortex is indeed constructed on relatively simple principles, although, like the digital computer, it gains its great complexity from the enormous number of its elements. (iv) Although, unfortunately, no work has yet been published on the logical interpretation of the alpha rhythm, a great deal of work has been done in this field in Britain (*1*) and will soon, it is hoped, be published.

There is a great deal more to be said on this vast topic of brain models, and I would take this opportunity to emphasize the enormity of the problem of modelling the brain. I believe that the functional aspects are indeed more easily approachable than the anatomical. Nevertheless, there seems to be some reason for optimism about the future of the very powerful methods of cybernetics.

I would also like to take the opportunity to give a few of the many references (*2*) for the work referred to here and previously. I do not repeat the references (all of great importance) in Harmon's note.

F. H. George

University of Bristol, Bristol, England

References

1. D. J. Stewart, "A notation for logical networks" and other unpublished notes.
2. J. T. Culbertson, *Consciousness and Behavior* (Brown, Dubuque, Iowa, 1950); F. H. George, "Logical networks and behavior," *Bull. Math. Biophys.* 18, 337 (1956); ———, "Logical networks and probability," *Bull. Math. Biophys.* 19, 187 (1957); D. O. Hebb, *The Organization of Behavior* (Wiley, New York, 1949); S. C. Kleene, "Representation of Events in Nerve Nets and Finite Automata," *Rand Research Mem. No. RM704*; W. S. McCulloch and W. Pitts, "A logical calculus of the ideas imminent in nervous activity," *Bull. Math. Biophys.* 5, 115 (1943); A. M. Turing, "On computable numbers," *Proc. London Math. Soc. (1936–37)*, ser. 2, vol. 42, pp. 230–65; A. M. Uttley, "The classification of signals in the nervous system," *Electroencephalog. and Clin. Neurophysiol.* 6, 479 (1954); ———, "The Conditional Probability of Signals in the Nervous System," *Rand Research Mem. No. 1109.*