SCIENCE

18 September 1959

Volume 130, Number 3377

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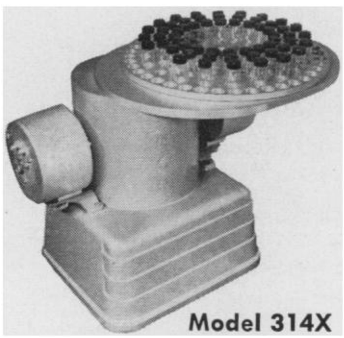

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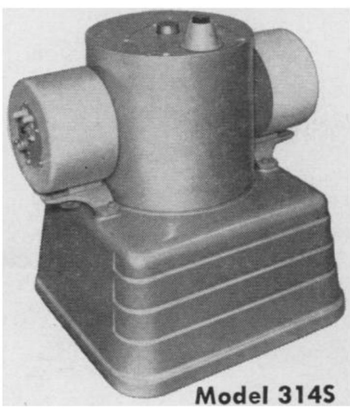

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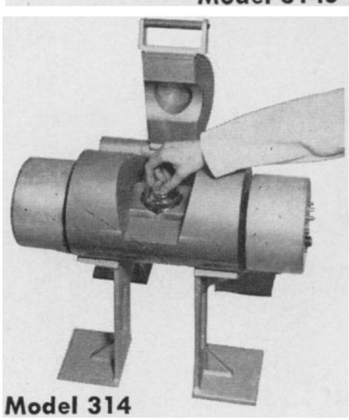

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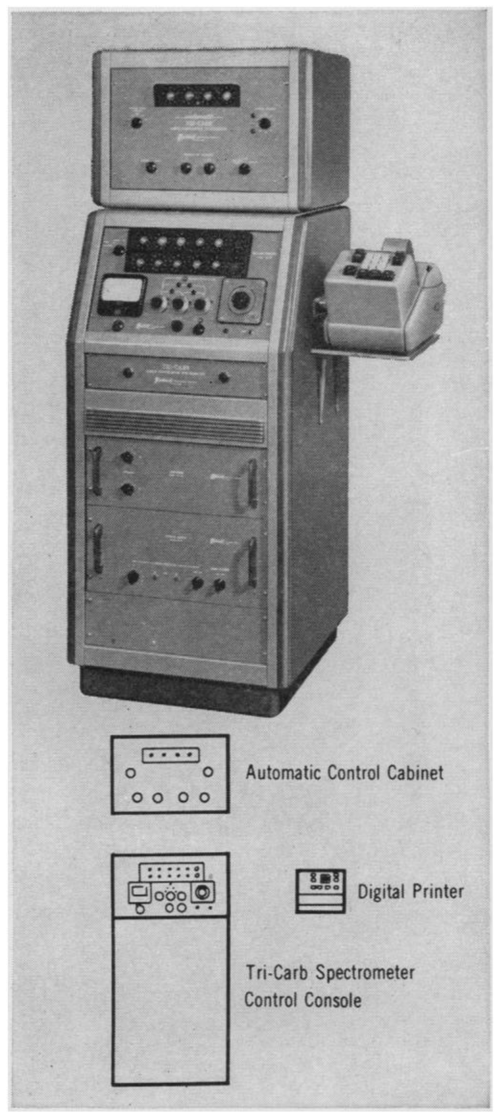

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Ref Dr. Folin's Manual of Biological Chemistry, 5th Edition, Journal Biological Chemistry, Vol. 106, No. 1, Page 311 (1934).

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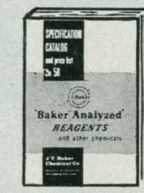

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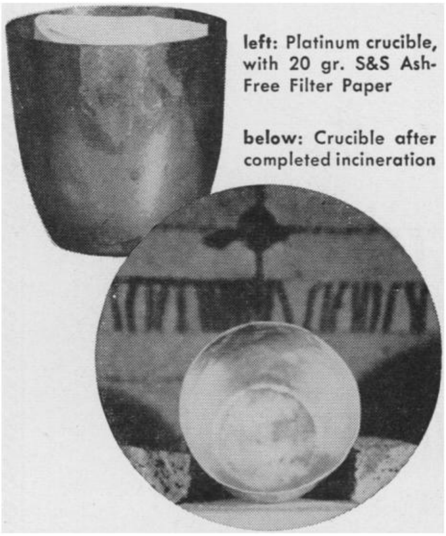

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Letters

Estimates of Radiation Dose from Strontium-90 Due to Fallout

A recent article by Merril Eisenbud, "Deposition of strontium-90 through October 1958," concludes, from consideration of the radiation delivered to bone marrow by the Sr^{90} absorbed by the bone from fallout debris, that "the maximum foreseeable dose [of radiation] from strontium-90 in the New York area is thereby estimated to be about 5 percent of the dose due to natural radioactivity" (*1*).

This conclusion appears to be inaccurate. In what follows it is shown that, instead, on proper calculation, Eisenbud's data lead to the conclusion that Sr^{90}-induced radiation to the bone marrow is, on the average, 15 to 60 percent of the natural background radiation. Some localized areas of bone marrow will receive considerably more intense radiation. Such calculations show also that the bone itself will receive, from Sr^{90}, radiation amounting to from 10 to 400 percent of the background radiation.

Eisenbud estimates that when Sr^{90} deposition due to fallout from past tests is at a maximum (in 1965), milk in the New York area will reach the level of 11 μμc of Sr^{90} per gram of calcium, and that a child using this milk as a source of dietary calcium will develop a skeleton containing about 5.5 μμc of Sr^{90} per gram of calcium (5.5 strontium units). For the purpose of this discussion this estimate is accepted as a first approximation, although, as shown below, it is probably too low. Eisenbud calculates, from the skeletal Sr^{90} level given above, the resultant radiation dose to the bone marrow. This dose is then compared with a value representing the dose from natural radiation, and it is concluded that the fallout radiation amounts to 5 percent of background radiation. Eisenbud's considerations of this matter are contained in the following paragraph from his article: "The United Nations Scientific Committee on the Effects of Atomic Radiation calculated . . . [(*2*)] that 1 micromicrocurie of strontium-90 per gram of calcium is equivalent to a dose of 1 millirem per year to the bone marrow. An individual having 5.5 micromicrocuries of strontium-90 per gram of calcium in his skeleton will therefore receive a dose of 5.5 millirems per year in addition to the dose from natural radiation of cosmic and terrestrial origin. According to the United Nations Scientific Committee, skeletal irradiation from natural sources is 125 millirems per year. The 5.5 micromicrocuries of strontium-90 per gram of calcium will therefore increase the natural dose to

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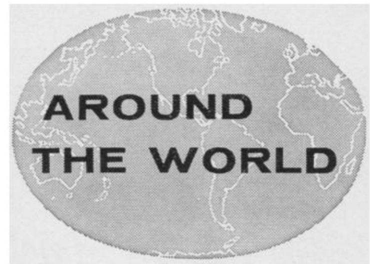

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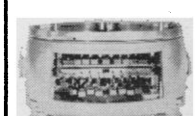
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the bone marrow by about 5 percent."

According to the United Nations report (*2*, p. 9, Table 1, and p. 58, Table 25), the natural radiation to the *bones* is 125 to 130 mrem/yr, while the natural radiation to the *bone marrow* is 95 mrem/yr. Eisenbud's comparison appears to be between an estimated Sr^{90} radiation to the bone marrow and the natural radiation to the bone.

More properly, Sr^{90} and natural radiation ought to be compared relative to the same tissue, either bone or bone marrow. Such comparisons lead to the following results.

1) With regard to bone, according to the U.N. report (*2*, p. 107, par. 63), 1 $\mu\mu c$ of Sr^{90} per gram of calcium delivers to bone tissue 2.5 mrem/yr. Thus, 5.5 $\mu\mu c$ of Sr^{90} per gram of calcium will result in a bone dose of 13.8 mrem/yr, or about 10 percent of the natural dose (125 to 130 mrem/yr). This estimate refers only to an average value and assumes that the Sr^{90} is evenly spread throughout the skeleton. However, it has been shown by Engström *et al.* (*3*) that microscopic regions of the bone may receive a radiation dose about 40 times the average. Hence, these parts of the skeleton will receive from Sr^{90} a radiation dose amounting to about 400 percent of the radiation from natural sources.

2) With regard to bone marrow, a similar situation exists. This problem is considered in paragraphs 64 and 65 on pages 107 and 108 of the U.N. report (*2*). Paragraph 64 states: "In the following it will be assumed that 1 strontium unit [1 $\mu\mu c$ of Sr^{90} per gram of Ca] will cause a mean bone marrow dose rate of 1 mrem/yr. The true value of the mean marrow dose might however, be as low as 0.5 or as high as 2 mrem/year per strontium unit." The problem is further developed in paragraph 65, which states: "It should be emphasized that bone marrow cells which are almost surrounded by bone will receive doses which may be equal to those in compact bone. Taking into account all causes for non-uniformity, i.e. the non-uniform deposition in the mineralized zones, the variation in bone layer widths and geometrical factors [corners], the bone marrow level is probably five times the figures quoted above."

Eisenbud has chosen to employ, as the parameter relating Sr^{90} concentration to radiation dose, the ratio 1 mrem/yr per strontium unit. However this choice ignores the variability range (0.5 to 2 mrem/yr per strontium unit) given in paragraph 64 of the U.N. report, and the fivefold inhomogeneity factor cited in paragraph 65. If *all* the relevant data in the U.N. report are considered, we reach the conclusion that an average skeletal burden of 5.5 $\mu\mu c$ of Sr^{90} per

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gram of calcium will deliver to localized regions of the bone marrow between 14 (5.5 strontium units × 0.5 mrem/yr per strontium unit × 5) and 55 (5.5 strontium units × 2 mrem/yr per strontium unit × 5) mrem/yr. When these dose rates are compared with the natural rate of 95 mrem/yr, we find that Sr^{90} will contribute to the bone marrow additional radiation amounting to about 15 to 60 percent of the radiation from natural sources.

The foregoing considerations are based only on the sources of data employed by Eisenbud. If other pertinent information is taken into account the above conclusion becomes modified further. As pointed out with reference to a recent estimate of the expected dietary Sr^{90} levels in St. Louis (*4*), data reported by H. P. Straub of the U.S. Public Health Service to the recent hearings on fallout before the Joint Committee on Atomic Energy show that about one-third of dietary Sr^{90} comes from non-milk sources. Since these sources, principally cereals and vegetables, have Sr^{90} concentrations considerably higher than those of milk, the total dietary Sr^{90} level with which bone is in equilibrium is higher than is indicated by estimates based on milk alone. Consideration of this factor would increase the foregoing estimates of Sr^{90} radiation to bone and bone marrow by a factor of about 50 percent. In addition, as Caster (*5*) has pointed out, calculations by Engström *et al.* (*3*) indicate that a heterogeneity factor of 40 to 60 (as against the value of 5 suggested in the U.N. report) may be operative in some conditions. In this case the effect of Sr^{90} relative to natural radiation would be increased proportionately.

In sum, Eisenbud's conclusion appears significantly to underestimate the relative effect of radiation from Sr^{90} resulting from fallout due to nuclear explosions. Since Eisenbud's article is part of the testimony before the recent hearings on fallout before the Joint Committee on Atomic Energy, consideration should be given to appropriate means of correcting the record of these hearings.

Barry Commoner
Washington University,
St. Louis, Missouri

References

1. M. Eisenbud. *Science* 130, 76 (1959).
2. *Report of the United Nations Scientific Committee on the Effects of Atomic Radiation, Suppl. No. 17 (A/3838)* (1958).
3. A. Engström, R. Bjornerstedt, C-J. Clemedson, A. Nelson, *Bone and Radiostrontium* (Wiley, New York, 1958).
4. See *Nuclear Information*, May-June 1959 (Greater St. Louis Committee for Nuclear Information, St. Louis, Mo., 1959), pp. 1-2.
5. W. O. Caster, *Minn. Chemist* 21, 8 (1959).

Commoner's principal criticisms of my article are (i) that my dose estimates did not allow for inhomogeneities in Sr^{90} deposition or for the ranges in the published estimates of dose per strontium unit, and (ii) that I underestimated the dose from Sr^{90} by assuming that the isotope is derived by human beings from dairy sources only.

In addition to these two points, which I will discuss further, Commoner calls attention to my reference to 125 mrem/yr as the natural "skeletal" radiation dose. The dose to the *bone marrow* from natural sources was actually assumed to be 95 mrem, the value I used in concluding that 5.5 mrem/yr is "about 5 percent" of the dose from natural sources. The value of 125 mrem/yr to the *bone* was given redundantly in the text. I am indebted to Commoner for calling this to my attention.

The method I used in estimating the dose to bone marrow was adopted directly from the procedures developed by the United Nations Scientific Committee on the Effects of Atomic Radiation. It is significant that this committee relied on bone marrow dose rather than on osteocyte dose in calculating the biological consequences of Sr^{90} deposition. It is true that, as Commoner says, the

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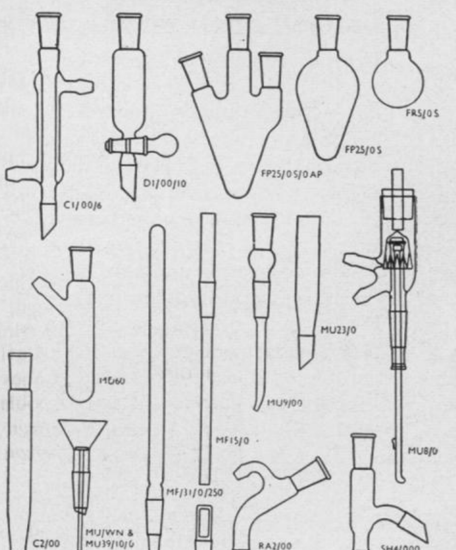

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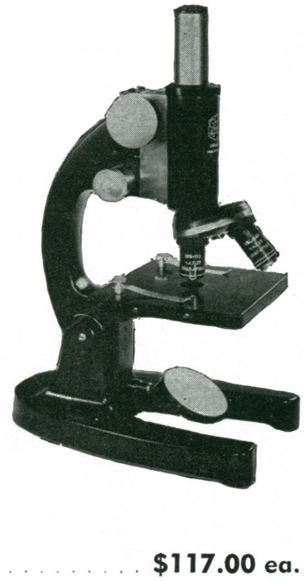

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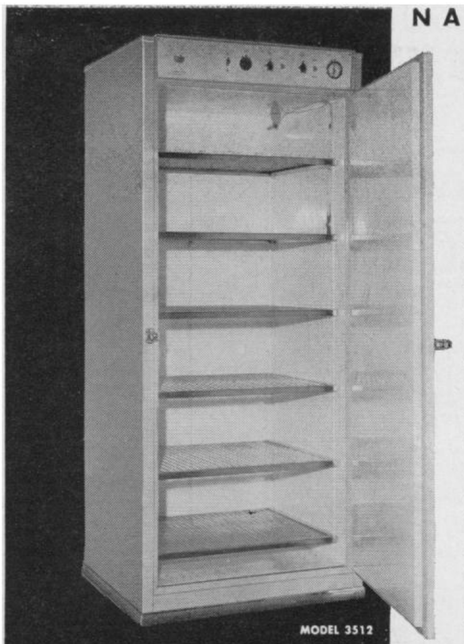

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use of 1 mrem/yr per strontium unit "ignores" the range of estimates given in the United Nations report (0.5 to 2 mrem/yr per strontium unit), but I considered the assumed value to be a satisfactory basis for tissue dose approximation, as indeed did the U.N. Radiation Committee in the calculations for their report. Commoner notes also the fivefold inhomogeneity to which the U.N. report refers, and he states that I should have used this in my computation. Again, the U.N. Committee simply pointed out that this inhomogeneity probably exists, but they did not find it necessary to include this factor in the computations either of dose or of the biological consequences of Sr^{90} deposition.

The doses we are discussing are very much less than the smallest dose required to produce observable effects in the laboratory. Commoner's concern with the significance of these doses derives from the concept that prudence in estimating the possible consequences of the exposure of large populations to small doses of radiation requires one to assume that there is no threshold, and that the biological consequences of radiation doses, however small, can be estimated by a linear extrapolation of existing experimental data. This concept is not applied to all of the biological effects of radiation and is not accepted by many investigations of Sr^{90} toxicity as being applicable to the carcinogenic effects of this isotope.

It is not my purpose to argue for or against this concept but merely to note that it exists and serves as the basis of the concern which Commoner and others have experienced over the possible consequences of small doses of Sr^{90}. This being so, I am puzzled that Commoner continues to emphasize the importance of inhomogeneities in deposition of Sr^{90} at dose levels of the order of a few millirems per year. It is true that the portion of the bone marrow in which more than the average amount of the isotope is deposited receives more than average irradiation. The nonthreshold, proportional theory would suggest that the probability of carcinogenesis would thus be increased correspondingly within that portion of the marrow. However, it is likewise true that the remaining portion of the tissue will have less than the average dose and, for this remaining portion, the probability of carcinogenesis will be lessened. According to the proportional theory, the probability of a carcinogenic response in a given volume of tissue should be a function of the total energy absorbed within the tissue.

Commoner's criticism of my use of milk as the basis for computing potential risk does have merit. Foods other than dairy products have been shown recently to be contributing increasingly large proportions of Sr^{90} to the diet, and this factor should be considered in future computations. Whether or not omission of this factor does in fact imply that I underestimated the dose by a factor of 0.5, as suggested by Commoner, I cannot say at this time.

It is my opinion that "about 5 percent" is a reasonable estimate of the maximum increase in bone marrow dose to be expected. "About 5 percent" could mean that the actual levels would be as much as 10 percent, but in my opinion, it is more likely that the true values will prove to be somewhat lower than 5 percent. This is because the method I used to compute future doses does not allow for the effect of foliar deposition or the possibility that Sr^{90} in soil will become less available to plants over a period of many years.

MERRIL EISENBUD
U.S. Atomic Energy Commission,
New York Operations Office, New York

Teaching and Research

The point that Jesse D. Rising raises [*Science* **130**, 66 (10 July 1959)]—that "many potentially excellent teachers may be doing less than their best teaching in an effort to satisfy the university administration by doing research"—was answered forcefully by an experienced teacher in these words:

"In the life of a university department the interests of research and of teaching are competitors. . . . The activities themselves are in necessary conflict in any department which thus seeks to serve two masters. The activities compete for room space, for the working time of staff members, including mechanicians and secretaries, for funds, and for the control of faculty appointments. . . .

"In my experience the demands of teaching and of research have been in continual conflict for nearly forty years, and I cannot remember that either function ever helped the other. Many a demonstration would have been better prepared and many a student better served if the urgency of some situation in the research laboratory (and the fascination of it) had not pulled in that direction. On the other hand, the continuous concentration that a research dilemma can demand was often broken up by the class bell. I would have done better at either one of these activities if I had kept out of the other, and I suspect that there are hundreds of scientific men who could give the same testimony. This is not a situation that we can take any satisfaction in but is just one of the facts of academic life. . . .

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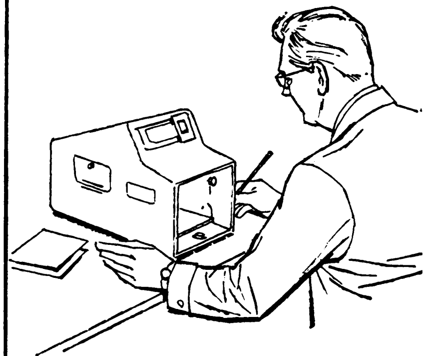

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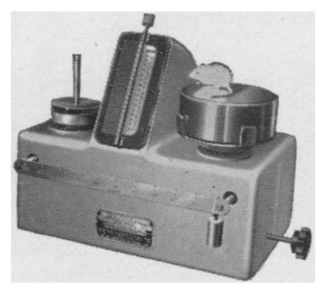

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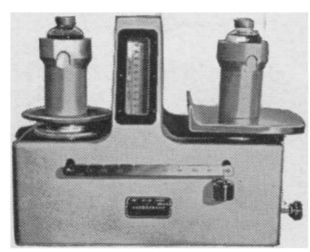

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swing the protective tariff back from the researchers to the teacher as teacher. . . ."

These quotations come from a speech by Paul Kirkpatrick of Stanford University, delivered at a meeting of the American Physical Society in New York last January. They state in better words than many of us can muster the opinion prevailing among many teachers of undergraduate college physics and are worthy of more publicity than they have been given.

URBAN E. SCHNAUS
Department of Physics,
Catholic University, Washington, D.C.

Liesegang Phenomenon

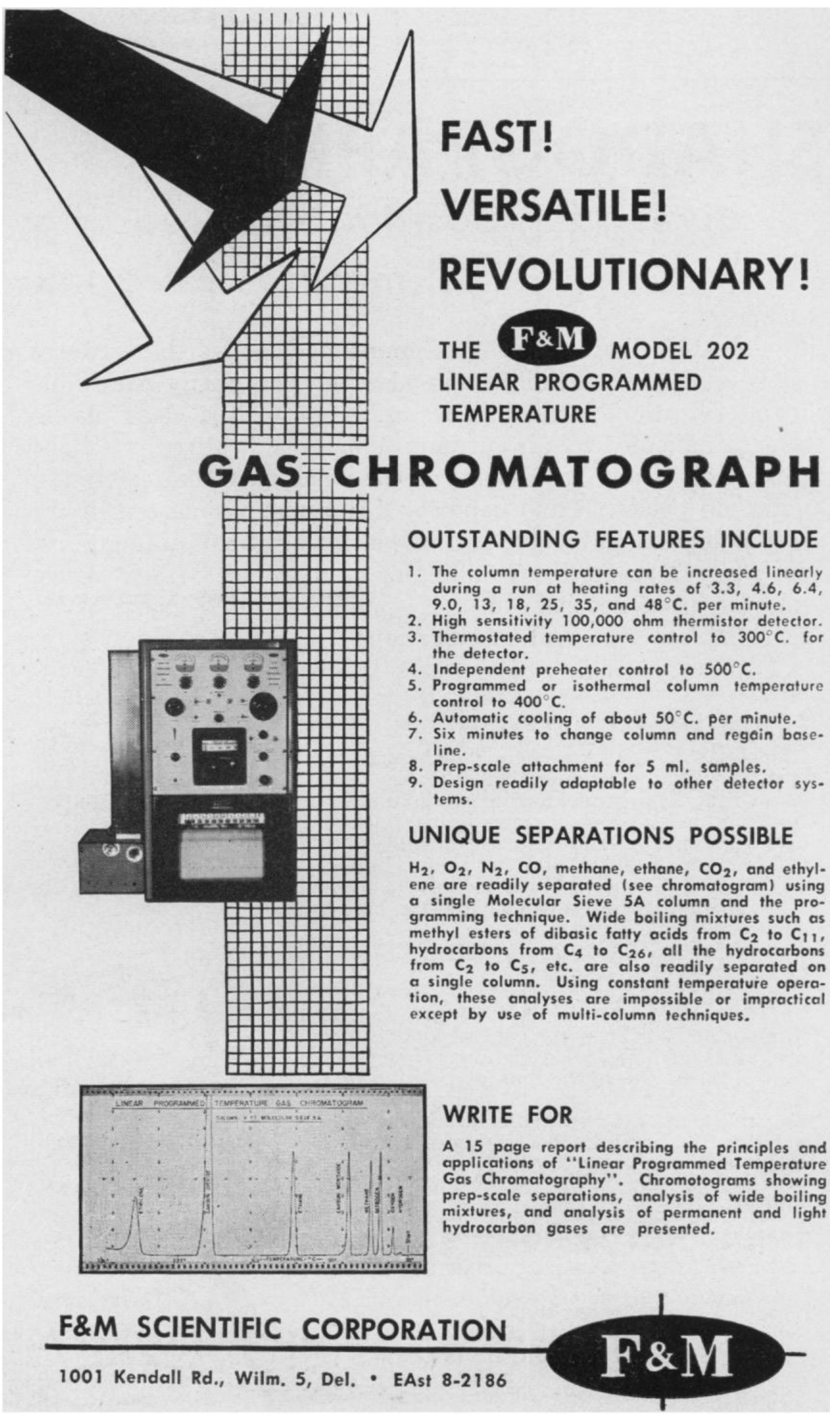
In a recent report [*Science* **129**, 1365 (1959)], Van Oss and Hirsch-Ayalon claim that the Hirsch effect constitutes the proper explanation of the Liesegang phenomenon. This claim is based on the assumption that the Liesegang rings act as membranes which prevent further diffusion of the reacting substances. These authors also cite experimental evidence (see their references 9 and 21) in support of their conclusion that the rings remain impermeable to the diffusing outer (presumably more concentrated) reactant until the other (inner) reactant is exhausted in the vicinity of the ring.

Although it is generally agreed that the medium is exhausted of this reactant in the vicinity of the ring, the evidence for the impermeability of the ring is by no means conclusive. The Liesegang phenomenon is equally well explained [see, for example, Wagner, *J. Colloid Sci.* **5**, 85 (1950)] if a critical ion-product concentration, such as a supersaturation product, is required as a necessary condition for ring formation. In that case the clear spaces between the rings merely result from the lowering of the inner electrolyte concentration by adsorption on the last ring or by counterdiffusion. As a result, the outer electrolyte must then diffuse for some distance until the critical concentration is again reached.

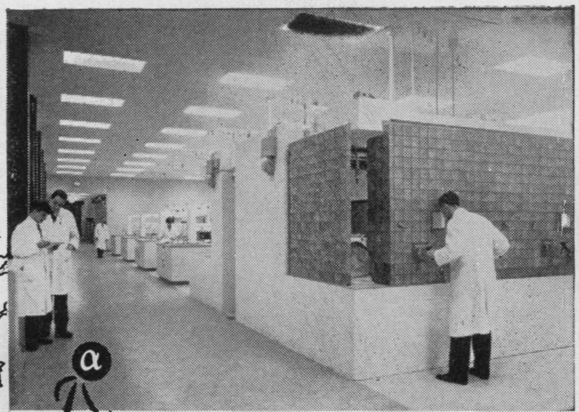
Another argument against accepting the Hirsch effect as the *only* explanation of Liesegang rings under all conditions is found in the experiments by Morse [*J. Phys. Chem.* **34**, 1554 (1930)] in which rings of rather widely spaced crystals were formed in water without any colloidal material present. It seems a little farfetched to suppose that these rings act as membranes.

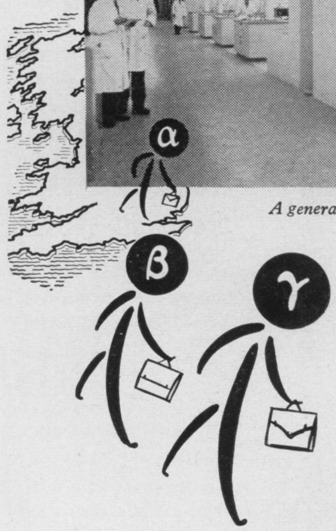
Van Oss and Hirsch also state that Ostwald's supersaturation theory is refuted by Hatchek's experiments. The arguments against this view have already been presented in some detail [K. H. Stern, *Chem. Revs.* **54**, 79 (1953)]. Basically they amount to this: that supersaturation can exist in the presence of crystals, particularly if these are well dispersed; and that under these conditions rings still form because the rate of crystal growth is less than the diffusion velocity of the reactants. When the rings consist of very small crystals, closely spaced, the Hirsch effect may very well operate.

KURT H. STERN
Department of Chemistry,
University of Arkansas, Fayetteville



As the title of our report, "*An* explanation of the Liesegang phenomenon," implies, we did not claim to advance an explanation that excludes all other explanations. It is indeed quite probable that in certain cases diffusion, supersaturation, or even gel-protection effects play their role. Still, as we pointed out, Liesegang bands have been known to occur under circumstances where these effects were lacking. Now, although it remains difficult to ascertain which effect predominates in the formation of any particular set of Liesegang bands, the Hirsch effect can in a general way satisfactorily account for all the circumstances under which Liesegang bands are formed, needing no assumptions on diffusion, supersaturation, or gel protection. The Hirsch effect, an experimentally established and


A general view of one of the isotope laboratories.



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general phenomenon, must give rise to Liesegang bands exactly under those circumstances where these bands actually occur.

The role of the gel or membrane in the Hirsch effect must not be overestimated, the effect itself being independent of the presence of colloid material. Only for the quantitative measurement of the Hirsch effect are carrier membranes, or other porous walls, used to advantage, principally to avoid convection.

The Hirsch precipitates are best considered as barriers to the forming ions rather than as membranes. Actually, by the time Liesegang layers appear and can be inspected, they have already lost their property as barriers (except for the last layer, if one is quick enough). Thus, the occurrence of bands of widely spaced crystals in water does not exclude a Hirsch effect.

C. J. VAN OSS

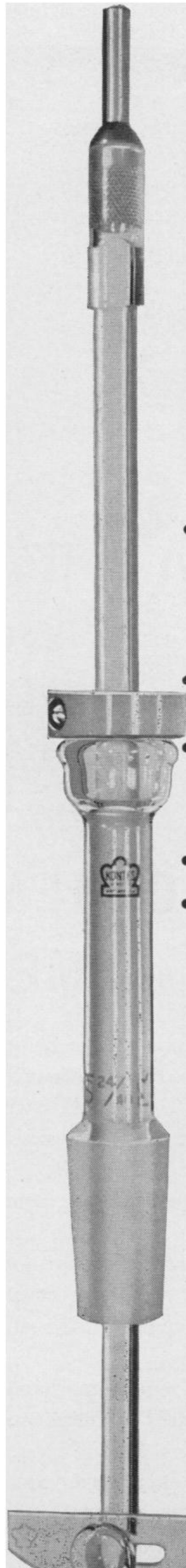
Laboratory of Physical Biochemistry, National Veterinary College, Alfort, France

Radioactive Fallout

Your issue of 22 May [*Science* **129**, 1412 (22 May 1959)] contained an assessment, issued by the General Advisory Committee of the Atomic Energy Commission, of the dangers to the human race of radioactive fallout. Without discussing the obvious impertinence of a collection of physicists, chemists, engineers, and what-have-you who presume to issue a pronouncement on a crucial biological question, I should like to offer comment on certain of the points which they raised.

1) The fact that "the amount of total body external radiation resulting from fallout to date, together with future fallout . . . from previous weapons tests, is: (i) less than 5 percent as much as the average exposure to cosmic rays and other background radiation" is repeated ad nauseam to reassure the public. However, this argument is a red herring designed to deceive. The principal dangers (both physiological and genetic) to the human race from fallout stem from the decay of the radioactive fallout material after it has been taken into the body and incorporated within certain cells and tissues. That the total quantity of radiation reaching the whole body from outside is far greater is largely irrelevant to the question of the potential dangers of fallout from nuclear tests. Throwing rubber balls at a person is not an intelligent way of finding out what would happen were he to swallow one.

2) With respect to the internal effects of strontium-90, they comfort us with the statement that "the amount of strontium-90 which has been found in food and water is less of a hazard than the



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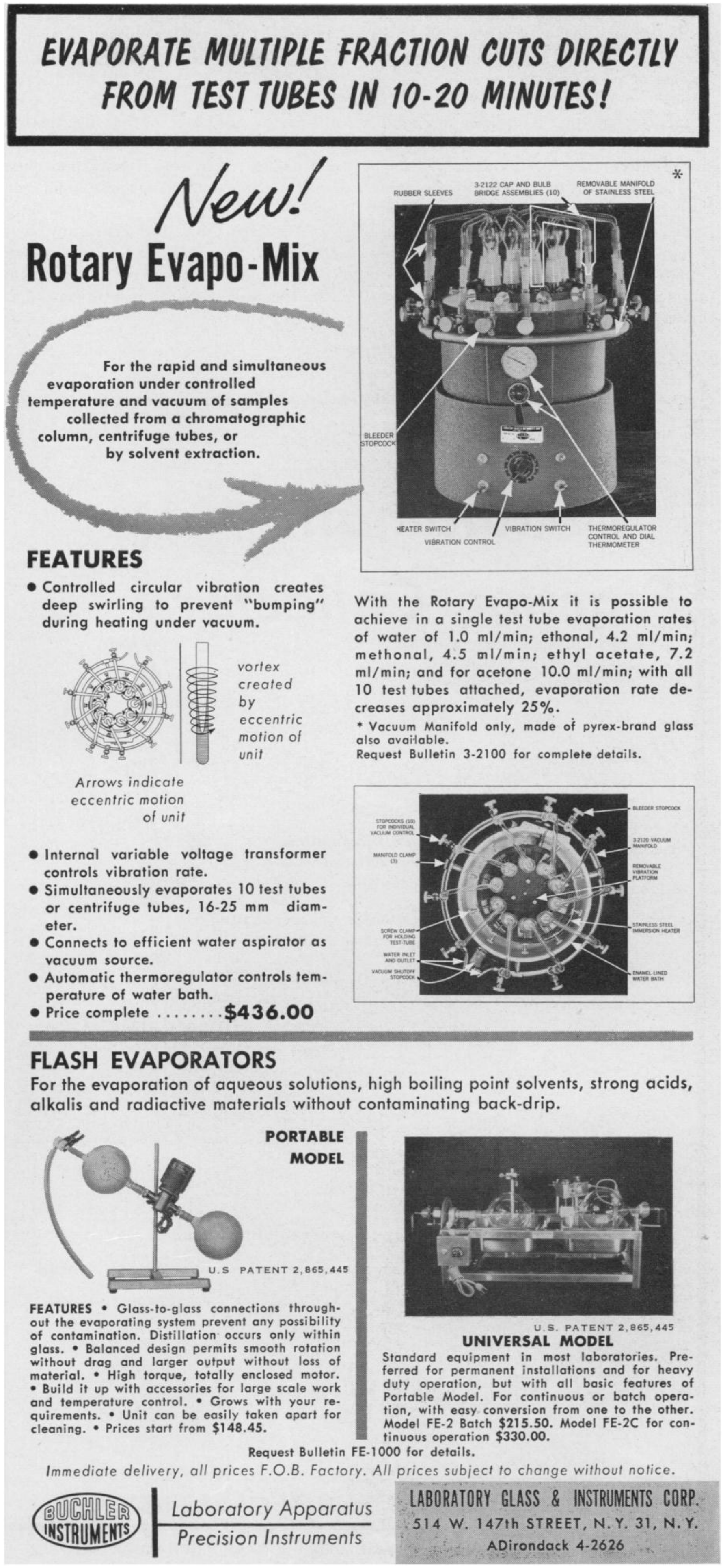
amount of radium normally present in public drinking water supply in certain places in the United States." Since it is impossible to assess as yet the effects in man of ingestion of Sr^{90}, which has been a factor in human ecology only since 1954, one wonders how they can be so sure that it is "less of a hazard" than radium or anything else. Doctors who were prescribing radium for a variety of conditions as recently as the 1920's were also sure that there was no hazard involved, but many people died of it nonetheless. We shall all await publication of the studies on the high-radium drinking water to which the committee refers, but until we have had the opportunity to study them we had better treat this statement with the same suspicion which we have learned to extend to all other reassuring pronouncements emanating from the Atomic Energy Commission and its creatures.

Meanwhile, I should like to offer the following comment on the hazard of Sr^{90}, in order to solicit a refutation by the committee; I suggest only that they consult a biologist first, and if they are not acquainted with any I should be delighted to suggest one or two.

Since 1955, the maximum permissible body burden for Sr^{90} has been set at 1 μc (I cannot find publishable words with which to comment on the fantastic action of the U.S. National Committee on Radiological Protection, which recently doubled this, to 2 μc). In their book *Bone and Radiostrontium* (Wiley, New York, 1957), Engstrom *et al.* state that a total body concentration of 1 μc of Sr^{90} would be expected to deliver, in approximately 10 years, roughly 1000 r to certain microscopic hot spots located in the spongious bone, close to the marrow, where the blood-forming tissues are located. (One thousand roentgens was about the whole-body dose absorbed by the Austrian miners of Joachimsthal over a 17-year period, the mean time required for the development of the fatal lung cancers which used to kill three-quarters of them). In view of this calculation, Engstrom *et al.* recommended that the maximum permissible body burden be reduced to 0.1 μc, a recommendation which, I understand from *Science* [**129**, 1473 (29 May 1959)], has been adopted by the International Commission on Radiological Protection.

If the maximum permissible body burden for workers known to be subjected to radiation hazards is 0.1 μc, that for the population at large should be reduced, according to the International Commission, by one order of magnitude—that is, to 0.01 μc.

In the recent article by Kulp *et al.* [*Science* **129**, 1249 (8 May 1959)], we learn that children seem to have on the average about three times the concentration of Sr^{90} in their bones that adults



have; 1-year-old infants have some eight to ten times the adult concentration. In view of this, and since the biological effects of radiation are more serious on rapidly growing and metabolizing cells, it seems to me that a separate maximum permissible body burden should be set for children, at approximately 0.003 μc.

That this figure is not unreasonably low is apparent in studying data from some Russian studies (cited by Engstrom *et al.*) on the effects of injecting small amounts of Sr^{90} into dogs; these animals developed bone cancers approximately 3 years after injection of 0.0001 μc of Sr^{90} per gram. Engstrom *et al.* calculate that the retained dose in a 10-kg dog would be of the order of 0.01 to 0.1 μc. Now, a 1-year-old child weighs approximately 10 kg, and it seems evident, to me at least, that its maximal skeletal concentration must not be permitted to reach the order of concentration of Sr^{90} known to cause fatal bone cancers in dogs.

We learn from the article by Kulp *et al.* that in 1966, when the highest skeletal concentration of Sr^{90} in young children will occur, some 1 percent of the world's children are expected to have a skeletal concentration of 20 μμc per gram of calcium. Since the average 1-year-old infant, weighing 10.6 kg, has roughly 100 g of calcium in his body, it follows that in 1966 1 percent of these children will have a total Sr^{90} skeletal level of 0.002 μc, and beyond doubt a significant fraction of 1 percent (hundreds of thousands, millions ?) will have exceeded our suggested limit of 0.003 μc, and some may have skeletal concentrations of the order of those known to cause cancer in dogs.

This happy picture is based on the optimistic assumption that no further testing of nuclear weapons will occur (and neglects to consider the effect of other radioactive fallout elements). But what if nuclear tests continue?

J. Gordin Kaplan
Department of Physiology, Dalhousie University, Halifax, Nova Scotia

Imprinting

Eckhard Hess, in his stimulating survey of recent progress in studies of imprinting [*Science* **130**, 133 (1959)] referred briefly to his inability to attain auditory imprinting with mallard ducks, *Anas platyrhyncus.* He did not mention, however, that it has been possible to attain auditory imprinting with other species—for example, *Aix sponsa,* the wood duck [P. H. Klopfer, *Ecology,* **40**, 90 (1959)].

This point would not ordinarily be of great significance except that it illustrates the importance of attending to interspecific differences in the survival value of particular kinds of behavior. Hess' paper shows the wild mallard to be an excellent imprinter, while the wood duck is considered to be poor. But, if auditory rather than visual stimuli are used, quite the reverse situation obtains. To a zoologist this seems reasonable: mallards nest in comparatively open situations, wood ducks in holes recessed in trees. Mallard young can see their mother when she first leaves the nest, the wood duck young cannot. Thus, the seeming importance of visual patterns for imprinting may be a reflection of the dominant sensory modality of the subjects rather than a characteristic of a particular type of behavior. In fact, one of the earliest reports on this subject dealt with olfactory imprinting [W. H. Thorpe and F. G. W. Jones, *Proc. Roy. Soc.* (*London*) **B124**, 56 (1937)]. The importance of olfaction to most mammals should suggest that it would be a mistake to confine further work in this area to the otherwise ingenious apparatus devised by Hess.

Peter H. Klopfer
Duke University,
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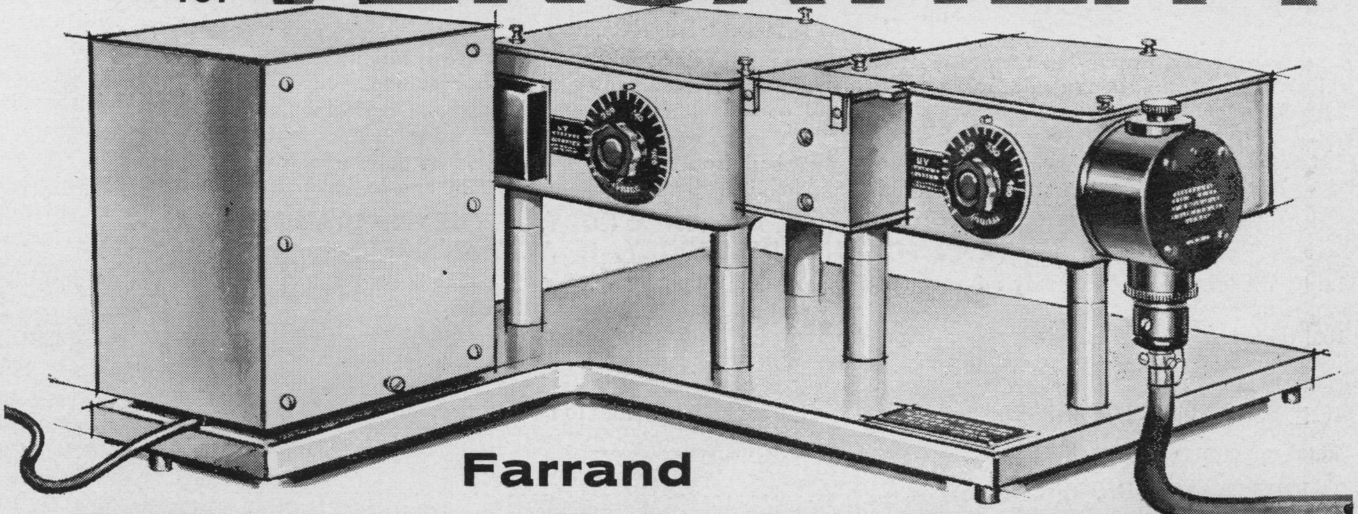

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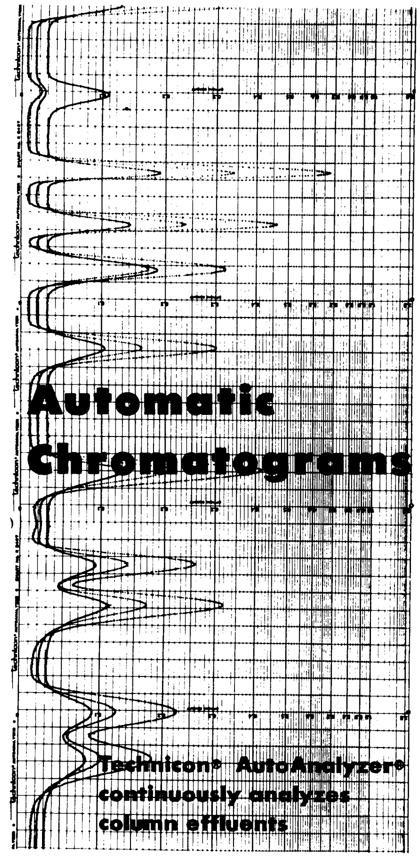

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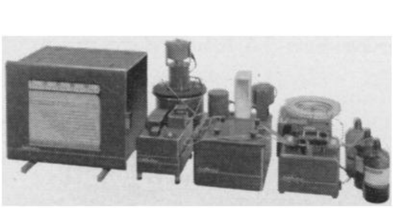

Peter Klopfer's comments concerning my article are worth noting but do not precisely relate to my findings. Certainly we obtained auditory imprinting in the mallards, as well as in other species, since sound is used in our presentation along with the visual object. What we were not able to demonstrate for the mallard was *auditory imprinting in the egg.*

ECKHARD H. HESS
University of Chicago, Chicago, Illinois

Strontium-90 Levels and Wheat

In "Strontium-90 in man III" by Kulp, Schulert, and Hodges [*Science* **129**, 1249 (1959)], "the widespread flow of wheat and powdered milk from the Northern to the Southern Hemisphere" is suggested as a possible explanation for the smaller difference in the strontium-90 levels in bone than in recorded fallout between the two hemispheres.

As related to wheat, at least, this is highly questionable. Argentina and Australia are two of the world's principal wheat exporters. A cursory review of the FAO *World Grain Trade Statistics* indicates that in 1956–57, the latest crop year for which full data are available, movement of wheat (including the wheat equivalent of flour) from the Northern to the Southern Hemisphere was on the order of 1220 thousand metric tons, as compared with a movement of 4300 thousand metric tons of Southern Hemisphere wheat into the Northern Hemisphere. Another 2500 thousand metric tons moved between Southern Hemisphere countries, the largest share of this local trade being represented by Argentine exports to Brazil (1040 thousand metric tons) and Australian exports to New Zealand (340 thousand metric tons). Indonesia, Singapore-Malaya, Ecuador, and the Belgian Congo as well as Brazil are here considered Southern Hemisphere countries, although part of each is in the Northern Hemisphere.

If strontium-90 is moving across the equator in wheat, it would appear probable that the net movement is northward rather than southward.

JAMES J. PARSONS
Department of Geography,
University of California, Berkeley

We appreciate the correction of Parsons showing that the net flow of wheat, if not of powdered milk, is from the Southern to the Northern Hemisphere. Flow in either direction is, of course, equally effective in bringing the strontium-90 content of human bone toward a mean, so that the North-South ratio of strontium-90 concentration in human

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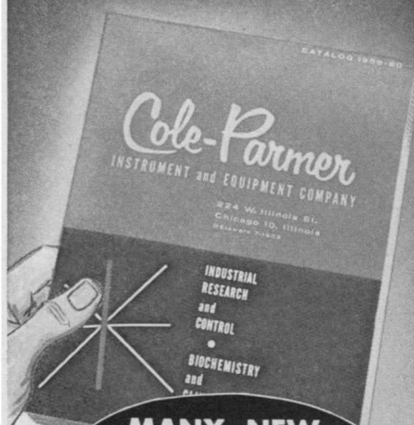

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bone is less than the North-South ratio of cumulative fallout.

The case of Australia is puzzling since the Australians subsist almost entirely on their own foodstuffs yet the average bone level in 1957–58 (0.20 $\mu\mu c$ of Sr^{90} per gram of calcium) was equal to that in the United States. Other climatic and agricultural factors must play a more dominant role here if the bone sampling is representative (*1*).

J. Laurence Kulp
Arthur R. Schulert
Elizabeth J. Hodges
Lamont Geological Observatory, Torrey Cliff, Palisades, New York

Note

1. This is Lamont contribution No. 372.

Church-Affiliated Colleges

Donald L. Thistlethwaite [*Science* **130**, 71 (1959)] has reported that religious affiliation on the part of a college is negatively related to encouraging Ph.D. scholars in the natural sciences.

It has occurred to me that this factor may have an important bearing on his ranking of institutions by geographical region, especially since his sampling is so extensive and since some of these regions have a much higher proportion of church-supported institutions than do others.

An illuminating extension of this study would be a subclassification of geographical ranking according to whether or not the institutions included in the sample have religious affiliation.

James R. Kuppers
Grifton, North Carolina

To test the hypothesis suggested by Kuppers I have done a two-way analysis of variance. In order to avoid cells with missing entries, it was necessary to combine the New England and Middle Atlantic regions. Thus we have a 2 by 4 classification: presence versus absence of religious affiliation and separation by four regions. The results indicate significant differences in the production of graduates who attain the Ph.D. in the natural sciences ($p < .01$) between geographical religious-affiliation groups, but no significant interaction. The nonsignificant interaction indicates that the geographical differences have not been found to vary according to whether or not the colleges have religious affiliations.

Donald L. Thistlethwaite
National Merit Scholarship Corporation, Evanston, Illinois

Meetings

Forthcoming Events

October

14–16. Parenteral Drug Assoc., annual conv., New York, N.Y. (H. E. Boyden, Parenteral Drug Assoc., 130 E. 59 St., New York 22.)

14–17. American College of Chest Physicians, 25th, Albuquerque, N.M. (M. Kornfeld, 112 E. Chestnut St., Chicago 11, Ill.)

15–16. American Ceramic Soc., Glass Div., Wernersville, Pa. (F. P. Reid, ACS, 4055 N. High St., Columbus 14, Ohio.)

15–17. Academy of Psychosomatic Medicine, Cleveland, Ohio. (B. B. Moss, Suite 1035, 55 E. Washington St., Chicago 2, Ill.)

15–17. National Soc. of Professional Engineers, fall meeting, Seattle, Wash. (P. H. Robbins, NSPE, 309 Bancroft Bldg., Univ. of Nebraska, Lincoln.)

16–17. Association of Midwest College Biology Teachers, conf., Notre Dame, Ind. (G. R. Bernard, Dept. of Biology, Univ. of Notre Dame, Notre Dame, Ind.)

17–18. American Acad. of Psychotherapists, 4th annual conf., New York, N.Y. (AAP, 30 Fifth Ave., New York 11.)

17–25. Plastics Industry, intern. fair, Düsseldorf, Germany. (Nordwestdeutsche Ausstellungs Gesellschaft (NOWEA), Ehrenhof 4, Düsseldorf.)

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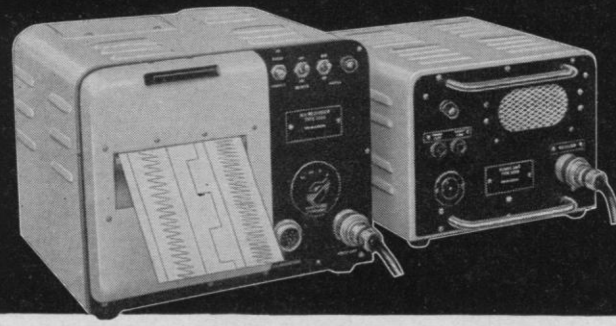

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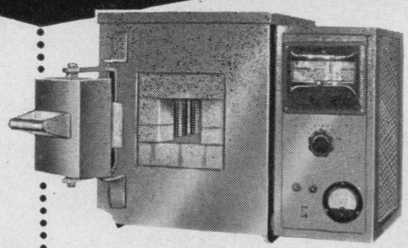

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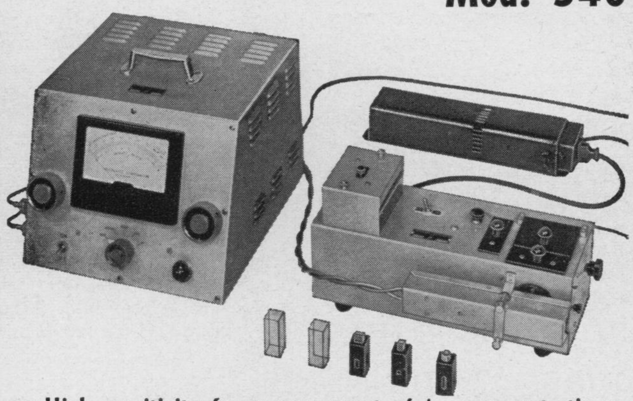

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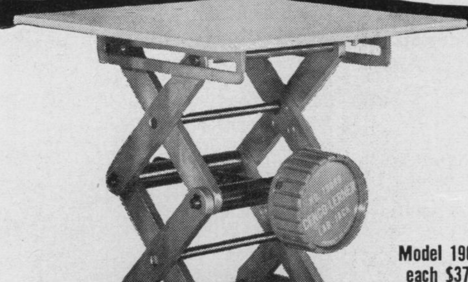

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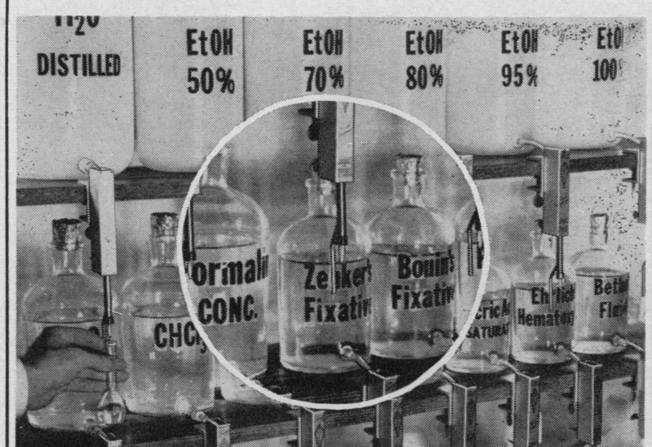

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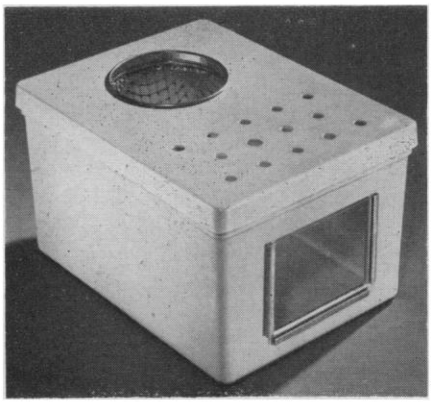

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18–22. Electrochemical Soc., Columbus, Ohio. (R. K. Shannon, ES Inc., 216 W. 102 St., New York 25.)

18–23. American School Health Assoc., Atlantic City, N.J. (A. O. DeWeese, 515 E. Main St., Kent, Ohio.)

18–23. American Soc. of Plastic and Reconstructive Surgery, Miami Beach, Fla. (T. R. Broadbent, 508 E. South Temple, Salt Lake City, Utah.)

19–21. High Polymer, 9th Canadian, Toronto, Ontario, Canada. (K. E. Russell, Dept. of Chemistry, Queen's Univ., Kingston, Ontario.)

19–22. Semiconductor Symp. (Electrochemical Soc.), Columbus, Ohio. (A. C. Beer, Battelle Memorial Inst., 505 King Ave., Columbus 1, Ohio.)

19–23. American Public Health Assoc., 87th annual, Atlantic City, N.J. (B. F. Mattison, 1790 Broadway, New York 19.)

19–23. American Soc. of Civil Engineers, annual conv., Washington, D.C. (W. H. Wisley, ASCE, 33 W. 39 St., New York 18.)

19–23. Radioisotopes in the Biosphere, symp., Minneapolis, Minn. (R. B. Caldecott, Center for Continuation Study, Univ. of Minnesota, Minneapolis 14.)

19–31. International Cong. of Therapeutics, Strasbourg, France. (Prof. Fontaine, Doyen de la Faculte de Starsbourg, France.)

19–31. Pan American Medical Assoc., 10th conf., Mexico, D.F., Mexico. (J. Eller, PAMCA, 745 Fifth Ave., New York 22.)

20–21. Reprocessing of Nuclear Fuels, AEC symp., Richland, Wash. (J. T. Christy, Hanford Operations Office, U.S. Atomic Energy Commission, Richland, Wash.)

20–22. Standards, 10th natl. conf., Detroit, Mich. (K. G. Ellsworth, American Standards Assoc., 70 E. 45 St., New York 17.)

20–23. Clean Air, intern. conf., London, England. (National Soc. for Clean Air, Palace Chambers, Bridge St. London, S.W.1, England.)

22–24. Acoustical Soc. of America, fall meeting, Cleveland, Ohio. (W. Waterfall, ASA, 335 E. 45 St., New York 17.)

22–24. American Documentation Inst., annual, Bethlehem, Pa. (C. G. LaHood, Jr., Library of Congress, Washington 25.)

22–25. British Medical Assoc., annual clinical, Norwich, England. (W. Hedgcock, BMA House, Tavistock Sq., London, W.C.1, England.)

23–24. Canadian Soc. for the Study of Fertility, Montreal, Canada. (J. F. Campbell, 238 Queen's Ave., London, Ont., Canada.)

23–25. American College of Cardiology, 8th annual, Philadelphia, Pa. (P. Reichert, ACC, Empire State Bldg., New York 1.)

23–27. American Heart Assoc., annual, Philadelphia, Pa. (W. F. McGlone, AHA, 44 E. 23 St., New York 10.)

24–29. Darwin Centennial, intern. celebration, Chicago, Ill. (Office of Public Relations, Univ. of Chicago, Ill.)

24–29. First All-India Cong. of Zoology, Jabalpur. (B. S. Chauhan, Zoological Survey of India, 34 Chittaranjan Ave., Calcutta 12.)

26–27. American Cancer Soc., New

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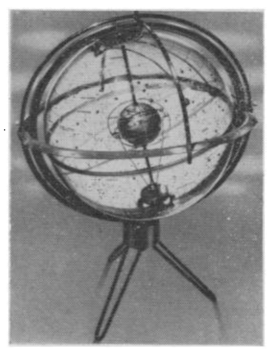

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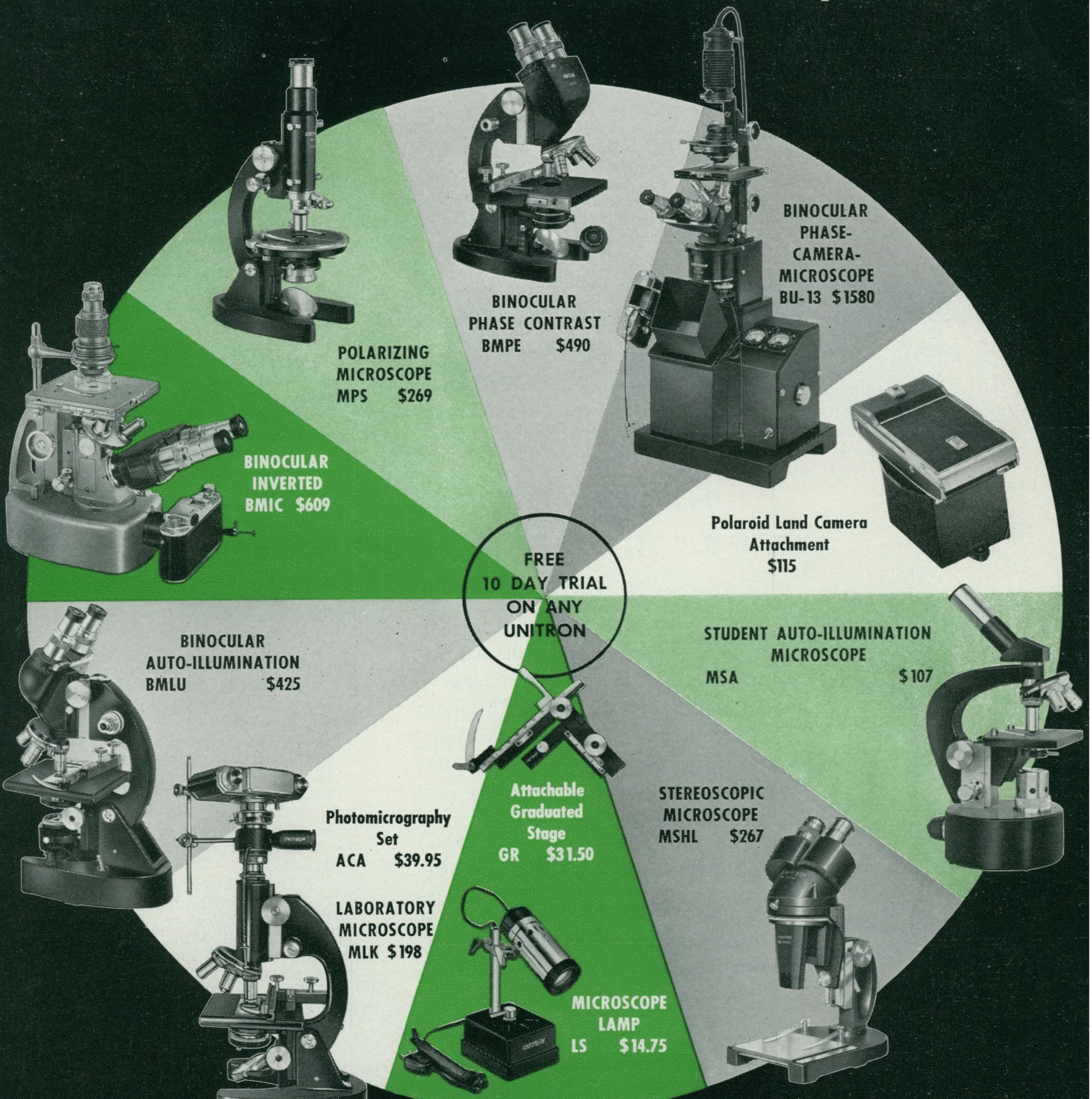

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26–28. Aeronautical and Navigation Electronics, IRE conf., Baltimore, Md. (L. G. Cumming, IRE, 1 E. 79 St., New York 21.)

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26–28. National Rehabilitation Assoc., Boston, Mass. (E. D. Callahan, 14 Court Square, Boston 8.)

26–28. Society of Automotive Engineers, natl. transportation meeting, Chicago, Ill. (R. W. Crory, SAE, 485 Lexington Ave., New York 17.)

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28–29. Computer Conf., Chicago, Ill. (F. A. Judd, Armour Research Foundation, Technology Center, 10 W. 35 St., Chicago 16, Ill.)

28–30. Aircraft Electrical Soc., Los Angeles, Calif. (E. I. Niles, AES, 920 South Robertson Blvd., Los Angeles 35.)

28–31. American Soc. of Tropical Medicine and Hygiene, Indianapolis, Ind. (R. B. Hill, 3575 St. Gaudens Rd., Miami 33, Fla.)

29–31. Animal Care Panel, 10th annual, Washington, D.C. (Animal Care Panel (ILAR), NAS-NRC, 2101 Constitution Ave., NW, Washington 25.)

30–31. Society for the Scientific Study of Religion, New Haven, Conn. (J. E. Dittes, 409 Prospect St., New Haven 11, Conn.)

30–31. West Central States Biochemical Soc., Columbia, Mo. (D. F. Millikan, WCSBS, Dept. of Horticulture, College of Agriculture, Univ. of Missouri, Columbia.)

November

1–4. Society of Economic Geologists, Pittsburgh, Pa. (H. M. Bannerman, U.S. Geological Survey, Washington 25.)

2–4. Atomic Industrial Forum, annual conf., Washington, D.C. (Atomic Industrial Forum, Inc., 260 Madison Ave., New York 16.)

2–4. Geochemical Soc., Pittsburgh, Pa. (K. B. Krauskopf, Geology Dept., Stanford Univ., Stanford, Calif.)

2–4. Geological Soc. of America, Pittsburgh, Pa. (H. R. Aldrich, 419 W. 117 St., New York 27.)

2–4. Mineralogical Soc. of America, Pittsburgh, Pa. (C. S. Hurlbut, Jr., 12 Geological Museum, Harvard Univ., Oxford St., Cambridge 38, Mass.)

2–4. National Assoc. of Geology Teachers, Pittsburgh, Pa. (F. Foote, Dept. of Geology, Williams College, Williamstown, Mass.)

2–4. Paleontological Soc., Pittsburgh, Pa. (H. B. Whittington, Museum of Comparative Zoology, Harvard Univ., Cambridge 38, Mass.)

2–5. Physical and Extractive Metallurgy, symp., Chicago, Ill. (Metallurgical Soc. of AIME, 29 W. 39 St., New York 18.)

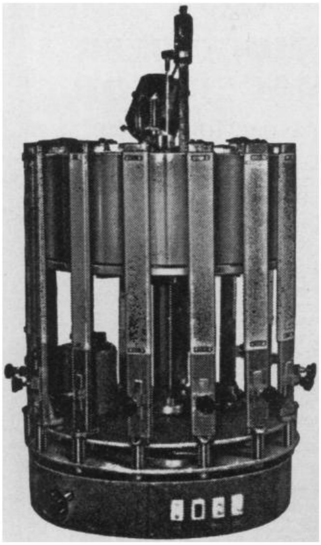
2–6. American Inst. of Mining, Metallurgical, and Petroleum Engineers and Inst. of Metals, fall, Chicago, Ill. (E. O. Kirkendall, AIME, 29 W. 39 St., New York 18.)

2–6. Collegium Internationale Allegalogicum, 4th symp., Rome, Italy. (A. Cerletti, Pharmacological Laboratories, Sandoz, Ltd., Basel, Switzerland.)

4–5. Diffraction, 17th annual conf., Pittsburgh, Pa. (P. K. Koh, Allegheny Ludlum Steel Corp., Research and Development Laboratories, Brackenridge, Pa.)

4–6. American Nuclear Soc., conf., Washington, D.C. (American Nuclear Soc., John Crerar Library, 86 E. Randolph St., Chicago 1, Ill.)

4–6. Antibiotics, 7th annual symp.,



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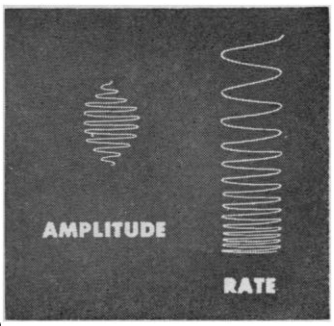

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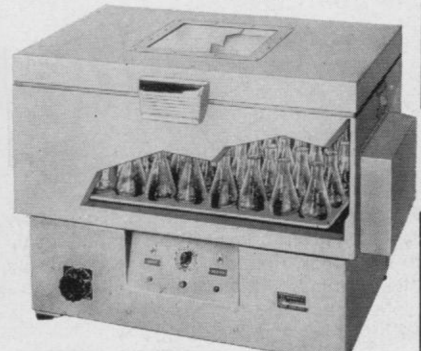

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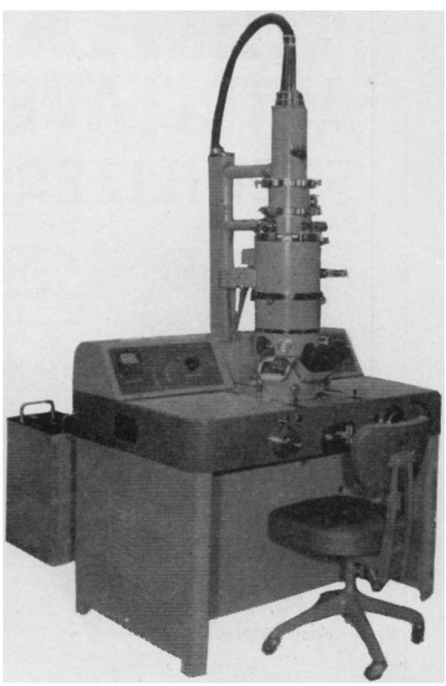

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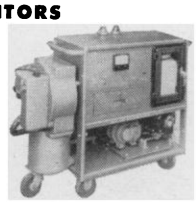

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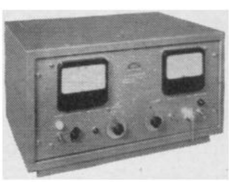

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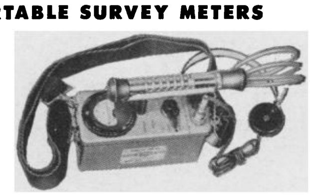

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Washington, D.C. (H. Welch, Div. of Antibiotics, Food and Drug Administration, Dept. of Health, Education, and Welfare, Washington 25.)

4–6. Design of Experiments in Army Research, 5th conf. (by invitation only), Fort Detrick, Frederick, Md. (F. G. Dressel, Office of Ordnance Research, Box CM, Duke Station, Durham, N.C.)

4–6. Eastern Analytical Symp., New York, N.Y. (P. Lublin, Publicity Chairman, Sylvania Research Laboratories, Bayside, N.Y.)

4–6. Industrial Management Soc., Chicago, Ill. (R. J. Mayer, IMS, 330 S. Wells St., Chicago 6.)

4–6. National Automatic Control Conf., Dallas, Tex. (G. L. Turin, Hughes Research Laboratories, Culver City, Calif.)

4–6. Society of Rheology, 30th anniversary, Bethlehem, Pa. (J. T. Bergen, Armstrong Cork Co., Lancaster, Pa.)

4–6. Technical Assoc. of the Pulp and Paper Industry, 13th alkaline pulping conf., Jacksonville, Fla. (TAPPI, 155 E. 44 St., New York 17.)

5–8. Group for the Advancement of Psychiatry, New York, N.Y. (American Psychiatric Assoc., 1700 18 St., NW, Washington 9.)

6. Gastroenterology Research Group, 9th semi-annual, Chicago, Ill. (E. Clinton Texter, Jr., Ward Memorial Bldg., Medical School, Northwestern Univ., 303 E. Chicago Ave., Chicago 11.)

8–13. International Rubber Conf., Washington, D.C. (B. S. Garvey, Jr., Pennsalt Chemical Corp., Industrial Chemicals Div., 813 Lancaster Pike, Wayne, Pa.)

9–11. American Petroleum Inst., 39th annual, Chicago, Ill. (API, 50 W. 50 St., New York 20.)

9–11. Association of Military Surgeons, 66th annual conv., Washington, D.C. (R. E. Bitner, AMS, Suite 718, 1726 Eye St., NW, Washington 6.)

9–11. Chemical Engineering, symp., Hamilton, Ontario, Canada. (Chemical Inst., 18 Rideau St., Ottawa 2, Ontario.)

9–11. Institute of Radio Engineers—Electronics Industries Assoc., fall, Syracuse, N.Y. (L. G. Cumming, IRE, 1 E. 79 St., New York 21.)

9–11. Instrumentation Conf., 4th, Atlanta, Ga. (W. B. Jones, Jr., School of Electrical Engineering, Georgia Inst. of Technology, Atlanta 13.)

9–12. Society of Exploration Geophysicists, 29th annual intern., Los Angeles, Calif. (B. Roberts, SEG, 1544 N. Highland Ave., Los Angeles 28.)

10–12. Electrical Techniques in Medicine and Biology, 12th annual conf., Philadelphia, Pa. (D. A. Holaday, College of Physicians and Surgeons, Columbia Univ., New York, 32.)

10–15. Laboratory Measurement and Automation Techniques in Chemistry, intern. cong., Basel, Switzerland. (ILMAC, 61 Clarastrasse, Basel, Switzerland.)

11–12. Clinical Anticancer Drug Research, Washington, D.C. (B. H. Morrison, III, Cancer Chemotherapy National Service Center, National Cancer Inst., Bethesda 14, Md.)

11–13. Gerontological Soc., Detroit, Mich. (R. W. Kleemeier, Dept. of Psychology, Washington Univ., St. Louis 5, Mo.)

MSE

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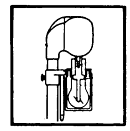
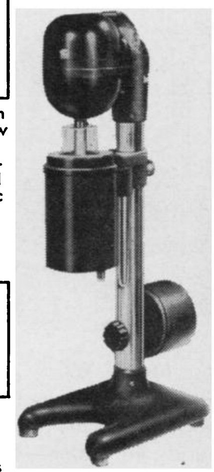
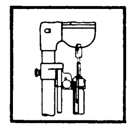
for 1 c.c. to 100 c.c. with provision for cooling



Cross-section showing how the 100 c.c. beaker is accommodated in the plastic container, providing space for coolant





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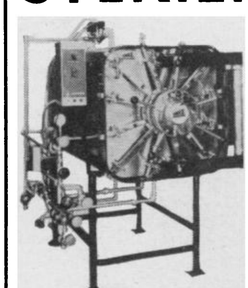

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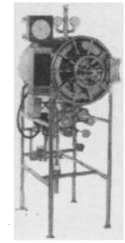

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