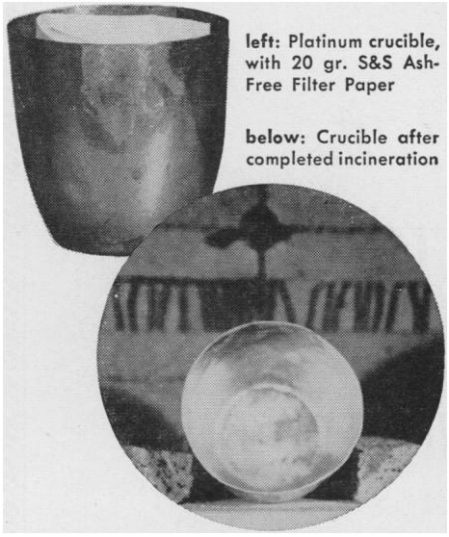
Less than

0.007% Ash—

for Highest Accuracy



left: Platinum crucible, with 20 gr. S&S Ash-Free Filter Paper

below: Crucible after completed incineration

Ask for S&S "Ash-Free" Analytical Filter Papers

For many years S&S Ash-Free Analytical Filter Papers have been known for their extremely low ash content. They have been the choice of chemists who must have the most precise working tools.

To our knowledge, there is no filter paper with lower ash content on the market. In fact, ash content of S&S Quantitative Papers is considerably lower than all other papers we have tested—less than 0.007%.

Ask your laboratory supply house for S&S Analytical Filter Papers—the finest, most precise filter paper you can specify. Yet S&S quality costs no more. If you would like to receive a free S&S Filter Paper Sampler, made up of many grades, just mail the coupon below.

MAIL THIS COUPON FOR FREE SAMPLER

Carl Schleicher & Schuell Co.
Dept. S-99, Keene, New Hampshire

Gentlemen:

Please send me, free, an S&S Analytical Filter Paper Sampler.

Name_____

Company_____

Address_____

City_____ State_____

Letters

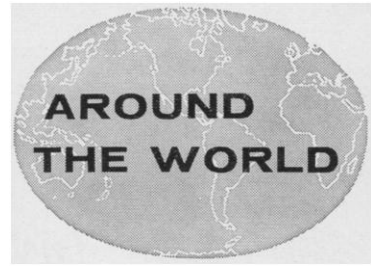
Estimates of Radiation Dose from Strontium-90 Due to Fallout

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 $\mu\mu c$ 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 $\mu\mu c$ 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

FAMOUS FOR ACCURACY



SAUTER ANALYTICAL BALANCES

MONOPAN

A single pan Analytical Balance making most efficient use of the reliable principle of substitution weighing for the determination of mass.
Very precise • Extremely stable • Remarkably simple.
Several exclusive features:
(a) Built in weights housed in bottom compartment. Dust-free . . . away from fumes. Balance life is prolonged. Need for adjustment reduced.
(b) Recessed reading scale in direct line of vision with load pan. Glare free.
(c) Taring weights built in. Easy to add or subtract.
Rugged Construction. Modern Styling. Air damping.
Capacity 200g. sensitivity 0.1 mg. readability 0.05 mg.
Taring up to 26g. in addition to full capacity.
Measurements 7½" x 18" x 18". Net weight 45 pounds.

Exclusive—Weights in bottom, dust-free chamber. Prolongs life of knife. Reduces need for adjustment.

Recessed reading scale eliminates glare. Situated for maximum reading ease in line of vision with load pan.

Write for Illustrated Literature

AUGUST SAUTER OF N.Y., INC.
866 WILLIS AVENUE
ALBERTSON, L. I., N. Y.
Pioneer 6-0254

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 μμc of Sr^{90} per gram of calcium delivers to bone tissue 2.5 mrem/yr. Thus, 5.5 μμc 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 μμc 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 μμc of Sr^{90} per

RADIOACTIVITY AT WORK...#3

Our business is radioactivity—applying it, measuring it, protecting against it.

Applied radioactivity is today's most versatile tool. In this third NSEC report, we focus on a few of the multiplying peacetime uses of radioisotopes and radioactivity.

As you read the brief outlines of our projects and services, you may discover the solution to a specific problem now confronting you—a problem solvable *only* with radioactivity. Or you may see a general application in some area of your work.

We would welcome the opportunity of discussing how radioactivity can assist you—in studying product or process improvements, reducing manufacturing costs, answering complex research questions.

RADIOACTIVE WASTE TREATMENT AND DISPOSAL

Disposal of the radioactive waste products of a nuclear reactor presents a serious problem. Radioactivity waste differs from ordinary chemical or sanitary refuse in that it cannot be destroyed chemically. Therefore, planning for treatment and storage of wastes must be undertaken in the early stages of reactor design. Under a prime contract with the Atomic Energy Commission, NSEC scientists recently completed a comprehensive survey of all current practices as well as planned techniques for the disposal of highly radioactive waste materials. *NSEC is ready to put its findings to work for those who are planning reactors for power or testing purposes. Ask for our new bulletin which outlines the factors to be considered.*

WATER TRACING WITH HYDROGEN ISOTOPES

Ever been confronted with leakage in a system of underground water pipes? This tracing problem has been solved by NSEC scientists using tritium, the radioactive hydrogen isotope. Both tritium and deuterium, a non-radioactive hydrogen isotope, are used in tracking water flow. Often the path of rainwater, underground streams or reservoirs must be traced. NSEC experts conduct assays of the tritium and deuterium content of the water. They measure tritium with a sensitivity of 10^{-5} microcuries per milliliter. The detuerium content in water is determined using the density-gradient method. Both these hydrogen isotopes are also used to discover the origin of ground water, thus aiding in water conservation. *NSEC assay services assist in other ways, too, including the biological tracing of organic matter for medical and industrial studies.*

TESTING FOR SUSTAINED RELEASE OF DRUGS

A number of pharmaceutical companies are now working to develop a single dosage form of a drug which will be effective over a long period of time: from 12 to 24 hours. The drug, whether capsule, compound or complex, must have a gradual, uniform absorption rate. Its effect must be continuous.

There are many advantages to a prolonged acting drug over a drug which must be taken every few hours. But one of the development problems is *in vivo* testing. How fast is the release rate? Are the peaks and valleys on the absorption curve too pronounced? What is the blood concentration of the drug?

NSEC personnel are now performing such studies for drug firms. Through radioactive tracers, we are able to measure much lower levels and with greater specificity than is possible under conventional colorimetric or fluorimetric methods. *Our specialized procedures are particularly applicable when a very small amount of a drug is to be given.*

NEUTRON DOSIMETRY MEASUREMENT

In the development and operation of nuclear reactors, it is necessary to know the neutron flux at various points in the reactor. NSEC offers a dosimetry service to determine neutron fluxes—to measure thermal, epithermal, and fast neutrons. NSEC provides the dosimeters, the required analytical services, and a report on flux data. Special fission dosimeters are also supplied, for direct measurement of burn-up occurring in fissionable material during irradiation. NSEC designs and develops techniques for difficult or unusual dosimetery problems. *It's possible to measure neutron flux from the highest now available down to 1 neutron per square centimeter per second.*

Want more details about our many projects and services? Just call or write our Marketing Department. The proposals and quotations of our technical staff are yours without obligation.

And to keep informed of the latest advances in this field, read "Radioactivity at Work," our monthly publication. Write us on your letterhead and we'll put you on our mailing list.

Several staff positions are now open for qualified personnel. Resumes should be sent to our Personnel Manager.

Nuclear Science and Engineering Corporation

DEPT. S-10, P. O. BOX 10901, PITTSBURGH 36, PENNSYLVANIA

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

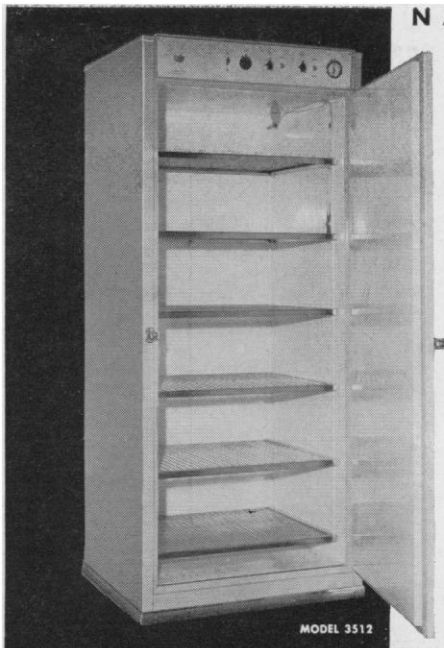
1. M. Eisenbud. *Science* 130, 76 (1959).
2. *Report of the United Nations Scientific Committee on the Effects of Atomic Radiation, Suppl. No. 17 (A/3838)* (1958).
3. A. Engström, R. Bjornerstedt, C-J. Clemedson, A. Nelson, *Bone and Radiostrontium* (Wiley, New York, 1958).
4. See *Nuclear Information*, 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

NATIONAL APPLIANCE



32 CUBIC FOOT INCUBATOR

An economical investment for large volume incubation of tube and plate cultures. Excellent for classroom, incubators can be placed side by side. Will accommodate large containers such as 5-gal. carboys. 30 square feet of adjustable nickel-plated shelves. Additional shelves can be installed any time.

Blower convects air through side wall ducts from bottom heating chamber to top and downward over work area. Fully instrumented. Temperature controlled by hydraulic thermostat and limited by safety thermostat. Temperature—room to 65° C. Max. temp. differential 1° C.

Interior white baked enamel—exterior durable light beige enamel over steel. Outside: 36″ w., 30″ d., 90″ h. Inside: 31″ w., 24½″ d., 74″ h. 2″ fiberglas insulation. 1500 watts, 115, 208, or 230 volts AC.

Write for bulletin or catalog of complete N. A. line.

na
NATIONAL APPLIANCE COMPANY
CONTROLLED ENVIRONMENT

National Appliance Co.
7634 S.W. Capitol Hy. • Portland 19, Ore.

Eastern Sales:
H. Reeve Angel & Co., Inc.
9 Bride Well Pl. • Clifton, N. J.

NATIONAL APPLIANCE

A NEW USSR ACADEMY OF SCIENCES JOURNAL

OPTIKA I SPEKTROSKOPIYA

now available in translation as

OPTICS AND SPECTROSCOPY

beginning with January 1959 issue at new low rates

Publishing results of experimental and theoretical investigations by leading Soviet Scientists. Articles in all branches of optics and spectroscopy, including X-ray, ultraviolet, visible, infrared and microwave, thin layer optics, filters, detectors, diffraction gratings, electro-luminescence, thermal radiation backgrounds, infrared polarizers and many applications to other branches of science and to industry.

Translated and published by the OPTICAL SOCIETY OF AMERICA, this branch of Soviet Science is now made available to all interested individuals and organizations *along with the Journal of the Optical Society of America* at the *rate of a single journal alone.* This was made possible by a grant-in-aid from the NATIONAL SCIENCE FOUNDATION to the OPTICAL SOCIETY OF AMERICA. Comments on the Soviet articles will appear in the Letters to the Editor column of the Journal of the Optical Society of America.

	U.S. & Canada (both journals)	Elsewhere (both journals)
Associate membership dues Optical Society of America	$13.00	$13.00
Non-member subscription	$25.00	$28.00

For membership in the OPTICAL SOCIETY OF AMERICA please write to Dr. K. S. Gibson, Secretary, Optical Society of America, National Bureau of Standards, Washington 25, D. C. Qualification for membership consists of "an interest in optics."

For non-member subscriptions write to the AMERICAN INSTITUTE OF PHYSICS, 335 E. 45th Street, New York 17, New York.

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:

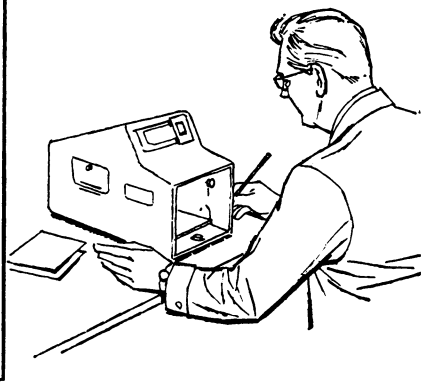
"In the life of a university department the interests of research and of teaching are competitors. . . . The activities themselves are in necessary conflict in any department which thus seeks to serve two masters. The activities compete for room space, for the working time of staff members, including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

"It does seem that it is high time to

High-speed precision balance saves time in research

MODEL 4142

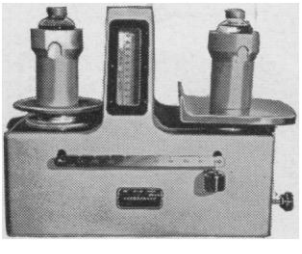


SHADOGRAPH®

gives fast, positive stop reading ...eliminates parallax

Model 4142 Shadograph is recommended for weighing cancer tissue and tumors. Fully-enclosed weigh pan, easily removable for sterilization, is readily accessible through a clear plastic door. Unaffected by air currents. Weight indication by a light projection system gives fast, precise reading. Operates on 110 volts, 60 cycles. Rated capacity 15 grams; visible sensitivity to 5 milligrams. Movable dial viewer for 5 rows of graduations, each row 3 grams by 5 milligram graduations. Weight range selector has 5-notch beam corresponding to dial chart. Write for complete data and specifications.

SMALL ANIMAL BALANCE
Model 4203B-TC-SA recommended for fast, precise weighing of mice, chicks, frogs and small rats. Dial graduated in two columns: 0—30 grams and 15—45 grams in increments of 0.5 gram. Dial shutter with outside control to close off dial column not in use. Beam 100 grams by 1 gram. Other models up to 3 kilos, 350 milligram sensitivity for rats, hamsters and guinea pigs.



CENTRIFUGE BALANCE
Model 4206B-TC also for general laboratory use and small-animal weighing. Has tare control knob to zero the dial, or position for over-and-under reading. Capacity 3 kilos; sensitivity to 350 milligrams. Dial is graduated 0-100 grams in increments of 1 gram. Beam 500 grams by 5 grams.

THE EXACT WEIGHT SCALE CO.
901 W. FIFTH AVE., COLUMBUS 8, OHIO
In Canada: 5 Six Points Road, Toronto 18, Ont.

Sales and Service Coast to Coast

Find us in your local 'Yellow Pages'

Exact Weight SCALES