# A Mercury Switch for Thermocouples

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During the recent national emergency, when materials for research either were not available or were difficult to obtain within a reasonable period of time, the need arose for a switch which would automatically and alternately close each of two thermocouple circuits connected to a single recording potentiometer. Such a switch must be so constructed that the contact points do not become fouled, thus creating electrical resistance. To meet this need, the mercury switch described below was constructed and found to operate efficiently.

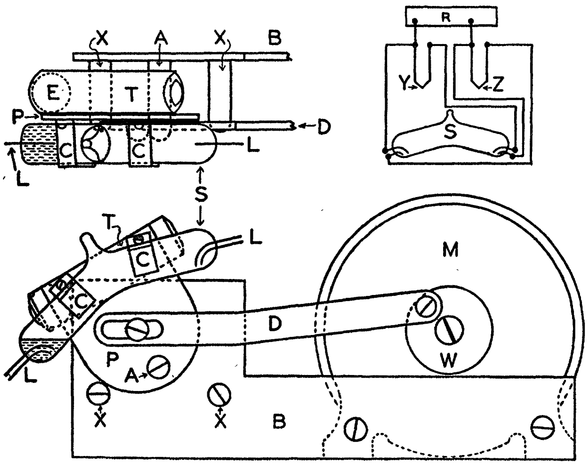

FIG. 1

The switch proper (S) was made from a piece of 12-mm. soda-lime glass tubing, 65 mm. in length and bent to form an angle of about 150°, as shown in the front and top views in **Fig. 1.** Two platinum lead wires (L) were sealed into the ends of the switch as indicated. A minimum quantity of distilled mercury was placed inside the tubing to insure that the two lead wires at one end would be adequately covered and, thus, the circuit through them closed. The glass switch was evacuated and sealed off as shown.

The switch (S) was mounted by means of two small brass strips (C) to a brass plate (P), mounted on a brass base (B) by means of a pivot (A) which was made of a brass collar on a 1-inch, No. 10, 32-thread brass machine screw. The plate (P) and the base (B) were made of $\frac{1}{16}$-inch sheet brass.

In order to change from one thermocouple circuit to another, the driver (D), made from $\frac{1}{16}$-inch sheet brass, was attached to the driving wheel (W) on the shaft of a 1-r.p.m. motor. Obviously, any desired period of time for each circuit may be obtained by using a motor (M) with the desired r.p.m. or suitable reduction gears on an available motor. On this switch a Speedway motor,[2] No. 953-W, for 110-volt, 60-cycle alternating current, having a shaft speed of 1 r.p.m. was used. This afforded a 30-second cycle for each thermocouple circuit.

To insure the quick breaking of one circuit with the simultaneous quick closing of the second circuit, a steel ball (E), $\frac{3}{8}$ inch in diameter, was placed inside a $\frac{1}{2}$-inch brass tube (T), $1\frac{3}{4}$ inches long. The ends were crimped and the tube soldered on the back of the brass plate (P) as shown in Fig. 1. The extent to which the switch may be thrown in either direction is governed by the studs (X) upon which the brass plate (P) rests. These studs were made in the same manner as the pivot (A) previously described.

The wiring diagram for the thermocouple circuit is shown in the upper right-hand corner of Fig. 1. The two thermocouples are indicated by Y and Z; the recording potentiometer by R.

Very satisfactory results were obtained using this switch with one recording potentiometer to determine the temperatures of the heads of two gas fractionating columns operating simultaneously.

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[1] The author is indebted to A. E. Wood for suggested improvements in the original design of this switch.

[2] Manufactured by the Speedway Manufacturing Company, 1834 South 52nd Avenue, Cicero, Illinois.

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# Carbon 14 Production From Ammonium Nitrate Solution in the Chain-reacting Pile[1]

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It may be of interest to describe the method of production of the radioactive $C^{14}$ currently being released by the Manhattan District in its isotope distribution program. $C^{14}$ was discovered several years ago (*4*), and its general characteristics were correctly determined from weak samples resulting from prolonged cyclotron activation. These characteristics may be summarized as follows: (a) a half-life estimated as some thousands of years; (b) no gamma rays; (c) beta particles with a maximum energy of 0.14 Mev. In addition, it had been ascertained that $C^{14}$ results from the reaction of neutrons with nitrogen—$N^{14}(n,p)C^{14}$, and that this reaction takes place under the action of slow neutrons (*1*). The latter property has become a particularly fortunate one since the advent of chain-reacting piles, with their great abundance of slow neutrons. Its significance is twofold: in the first place, samples thousands of times stronger than those which were made with great patience with the best cyclotrons can now be produced with relatively little effort, and, secondly, the $C^{14}$ which results is (at least in theory) isotopically pure, since no other carbon is involved in the manufacturing process. Thus, a high level of specific activity is obtainable—always an important consideration, but particularly so when very long half-lives are involved.

Thus, the problem of manufacture becomes one of irradiating nitrogen in the pile and of subsequently separating the carbon. Although there are many ways of doing this, the choice is narrowed by practical considerations. For example, space economy demands that the nitrogen be in some form of high atomic density, and neutron economy demands that it should not be combined with elements which would contribute high parasitic neutron absorption. Furthermore, the nitrogen must not be in the form of a compound which will decompose

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[1] Work done under the auspices of the Manhattan District.

[2] The assistance of E. P. Meiners, Jr., Miss T. I. Arnette, and F. Schuler is gratefully acknowledged. We consider ourselves honored to have been associated with the late Dr. Louis Slotin in the early phases of the work.

badly under the radiation present in the pile. Also, the material should not contain, in combination or as impurities, elements which would lead to conflicting radioactivities such as would require special decontamination procedures.

In our case, considerations of expedience also were important. At the time of the start of the work the occasion demanded an apparatus on the laboratory scale which would produce significant amounts of $C^{14}$, which would employ only readily available materials, and which would avoid the laborious process of "canning" material in welded aluminum jackets prior to irradiation. With these factors in mind, we chose to take advantage of the high water-solubility of ammonium nitrate and to build a solution "factory" which would work on the principle of continuous extraction. It was to be expected that most of the $C^{14}$ would be evolved from such a solution in the form of gaseous compounds (*4*). Also, it was known that the decomposition of the solution by the radiation in the pile would produce a gentle stream of gaseous products, which might automatically provide a means of carrying the $C^{14}$ out of the solution.

The apparatus diagrammed in Fig. 1 was constructed upon a design intended to make the most of the automatic carrying and automatic purification inherent in these considerations. A glass centrifugal pump circulated the ammonium nitrate solution through a U-tube in the pile and then through a tall, lead-shielded vessel which served two purposes: (1) to provide a venting-off point for the gaseous products, and (2) to act as a heat exchanger so that the $NH_4NO_3$ solution might be cooled. A reservoir (shown at extreme right of figure) was used for occasional replenishing of the liquid or for storing the solution if the factory had to be emptied. The circulating system, constructed of aluminum, stainless steel, and glass, had a total volume of 55 l. The evolved gases which gathered above the liquid in the tall, lead-shielded vessel, were led off through a simple train containing drying agents, oxidizing agents, and, finally, bubblers containing barium hydroxide solution, in which the $C^{14}O_2$ precipitated as $BaC^{14}O_3$.

The factory was operated continuously, requiring only occasional inspection and removal of the $BaCO_3$ precipitate every few days. The gas stream ran at the rate of about 15 cc./minute, and measurements of its radioactivity showed that the extraction train was 99 per cent efficient. W. B. Leslie, of Clinton Laboratories, also analyzed the solution and found small fractions of $C^{14}$ present as HCOOH, $CH_3OH$, and HCHO. From his data we have ascertained that these fractions comprise about 1 per cent of the total $C^{14}$ collected. As might be expected, there is also dissolved in the solution a small residual amount of $C^{14}O_2$ which can be recovered easily by acidification. Tests also showed that practically no $C^{14}$ was present in the form of the cyanide radical either in the gaseous phase or in the solution.

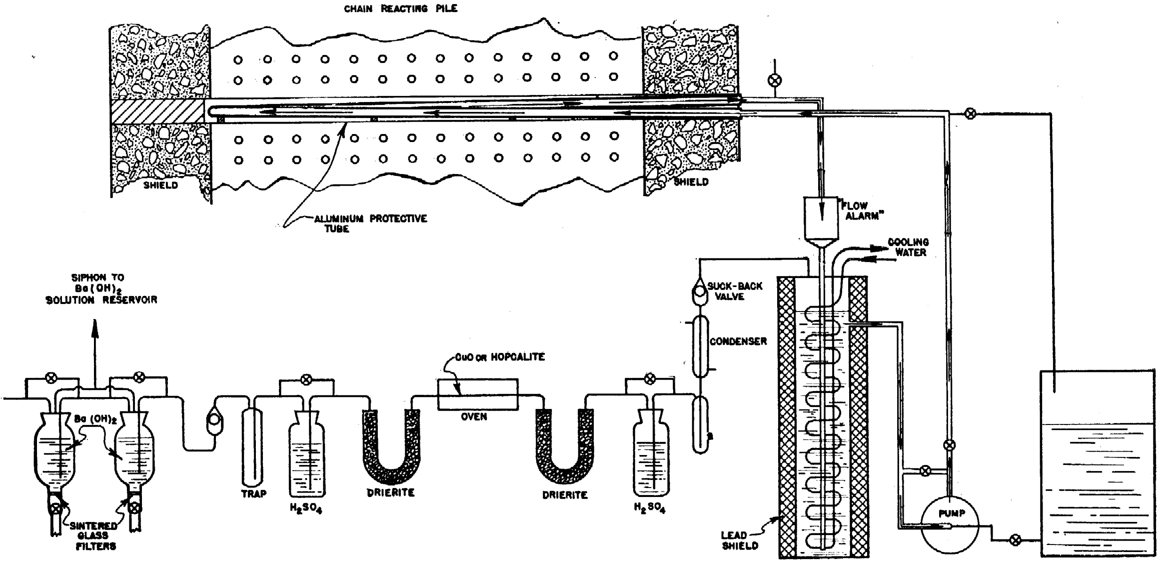

FIG. 1. $C^{14}$ factory using circulating solution of ammonium nitrate.

Mass spectrographic examination of some of the carbon from the factory was carried out by M. G. Inghram, of the Argonne National Laboratories. Dr. Inghram's results are reproduced in Fig. 2. The increase in the intensity of the mass 46 peak in the radioactive sample is quite spectacular. This peak is due mostly to $C^{12}O^{16}O^{18}$ in the normal $CO_2$ and mostly to $C^{14}O_2^{16}$ in the enriched material. Various considerations preclude the possibility that the increase can be due to disturbances in the normal abundances of the oxygen isotopes such as might, for example, lead to too much $C^{12}O^{16}O^{18}$. Quantitatively, Dr. Inghram's results showed that this sample contained $C^{14}$ in an isotopic abundance of 3.3 per cent. When an absolute beta count was obtained on another portion of this sample, a value of about 5,300 years was obtained (*2*) for the half-life of $C^{14}$. This was in good agreement with the value of 4,700 years obtained by Reid, Dunning, Weinhouse, and Grosse (*3*) in an exactly analogous experiment with a different sample of $C^{14}$, which presumably also originated in our factory. For pure

$C^{14}$, this value of the half-life gives a specific activity of about 5 mc./mg.

The richest samples of $C^{14}$ yielded by the factory had isotopic concentrations of 5.0 per cent. We have no satisfactory explanation as to the origin of the inactive carbon. Although some precautions were taken to remove $C^{12}O_2$ from the solution before charging it into the circulating system, we obtained large amounts of precipitate of lower specific activity during the first few days of bombardment. However, after the first week, the isotopic concentration of our product changed very little with long periods of irradiation, which might be interpreted as evidence that carbonate impurities and residual, dissolved $C^{12}O_2$ in the $NH_4NO_3$ solution could not be the only source of the inert carbon. We satisfied ourselves that no inward air leaks were present on the suction side of the pump, but apart from making these observations, we did not attempt to increase the isotopic purity; even 1 per cent is ample for almost all tracer experiments, and we were pleased that the specific activity was as high as it turned out to be.

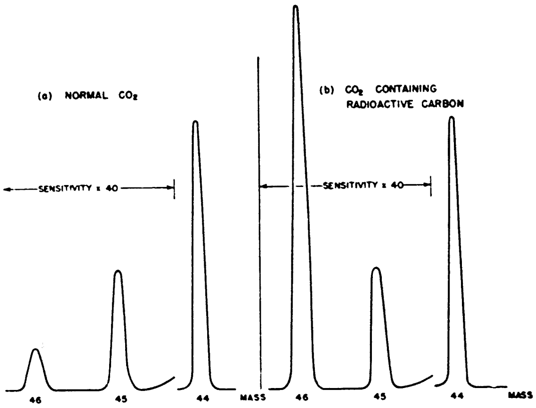

FIG. 2. Mass spectrograms of relevant peaks of normal and enriched $CO_2$ showing the great increase in the intensity of the mass 46 peak due to the presence of $C^{14}O_2^{16}$ in the enriched sample. The mass 44 ($C^{12}O_2^{16}$) peak is given on a scale equally reduced for the two samples. (Courtesy of M. G. Inghram.)

Some 50 mc. of the $C^{14}$ made in this factory have been distributed in lots of 1 mc. or less to research institutions in the United States. The factory has now fulfilled its rather temporary function, and operation is being discontinued in favor of larger-scale production methods. There is a stock pile sufficient to carry over until the new methods come into quantity production. It is to be expected that in a year or so $C^{14}$ will be so cheap and abundant that it will be more in the class of a commodity than that of a novel and treasured substance.

## References

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# A New Method of Recording Arterial Blood Pressure

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A simple, accurate, and linear method of measuring intra-arterial blood pressure has been developed. Preliminary work indicates that this apparatus may prove to be of value in the measurement of other intraluminal pressures, such as those within the veins and in the subarachnoid space.

The apparatus consists of a Statham Pressure Transmitter[1] fitted with a short metal coupling which carries any gage needle. The transmitter operates on the strain gage principle and is enclosed in a metal housing measuring 1 x 1 x 3 inches. The input circuit is supplied by a dry cell; the output circuit is connected to the electrodes of any lead of a string-type electrocardiograph.

Before use the transmitter is calibrated against a mercury manometer, and a desirable range of excursion established by adjusting the string of the galvanometer or the input of the transmitter.

The coupling and needle are then sterilized by boiling, the transmitter filled with heparin (10 mg./cc.), and the coupling screwed into place. Enough heparin is displaced by this maneuver to fill the needle. All adjustments having been made, the vessel to be studied is punctured directly, and a photographic record of the movements of the galvanometer string is taken. The photograph in Fig. 1 illustrates a simultaneous recording by this instrument (A) and by the Hamilton manometer (B). The wide horizontal white lines represent millimeters of mercury as marked; the heavy vertical lines, intervals of 1/10 second.

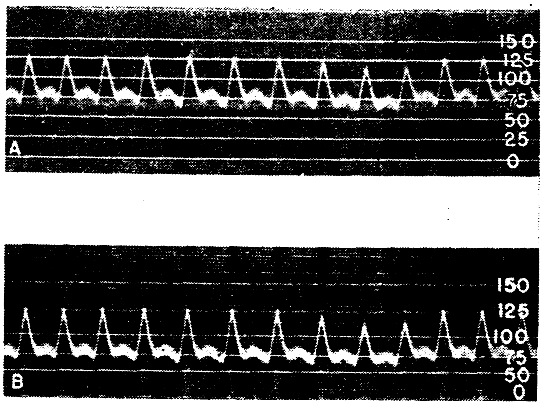

FIG. 1

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[1] Model P6-6g-250, manufactured by the Statham Laboratories, 8222 Beverly Boulevard, Los Angeles 36, California.