Technical Papers

A Device for High-Intensity, Vacuum-Irradiation of Small Samples at Controlled Temperatures[1]

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The device illustrated in Fig. 1 represents a simple type of controlled-temperature chamber which permits vacuum-irradiation of small samples at high dose rates. It is adapted to rapid transfer of samples, and has been used extensively by the author for x-irradiation of dried bacteriophage at temperatures as low as – 196° C, as well as for enzyme preparations. The special features of the device are:

1. A high vacuum can be maintained within the chamber. This is made possible by the special beryllium-window x-ray tube (*A*) which features a machined flange (*D*) with gasket as part of the housing surrounding the beryllium window. Between the target and the sample (*E*) only the beryllium window (*C*) intervenes. If desired, filters can be inserted above the plate in the space between the x-ray tube housing and the metal plate which attaches to the housing. These can be inserted when the plate is fastened to the housing. As an alternate, simpler process, circular filters can be inserted in the small aluminum cups and held a given distance above the irradiated sample (*E*). Either method obviously does not interfere with the vacuum.
2. The material to be irradiated (*E*) is placed in small aluminum cups, which can be quickly locked in place by means of a bayonet clamp on the top plate. When locked in place, the material of each sample is in exactly the same position relative to the x-ray beam (*B*). The material in each cup can be dried, chemically treated, frozen, or given other treatments prior to irradiation. The bottom of the cup is molded into proper shape to give the desired sample geometry. Aluminum was used, not only because it is easily molded but because it also assures rapid heat transfer.
3. By means of two outlets (*K*, *L*), connected through the plate which supports the device, a vacuum can be obtained, gases can be introduced into the chamber, or the chamber can be easily sealed off from the outside atmosphere. A manometer for preliminary checking of pressure and a small McLeod gauge (*P*) for checking more accurately the higher vacua are included in the lines.
4. A spring clip (*G*) fastened to the upper plate holds a thermocouple (*H*) firmly against the bottom of the aluminum cup. Copper-constantan thermocouple wires in glass braid are recessed into the upper plate and extend to a portable precision potentiometer (*N*) (Leeds & Northrup, No. 8662) for registering the temperature at the point of irradiation. We have determined experimentally that discrepancies in temperature above and below the bottom of the aluminum cup, with which the thermocouple is in contact, are not greater than 1% once the chamber has reached equilibrium at a given temperature and once the vacuum has been obtained.
5. A metal chamber (*F*), with bayonet clamp at the top, surrounds the aluminum cup. In this chamber is placed about 50 ml of liquid, chosen according to the freezing point of the liquid and the temperature of irradiation desired. For temperatures above 0° C, water serves well; for temperatures below 0° C, various organic solvents. On the inside of this metal chamber is wrapped an insulated resistance wire (*I*) with leads extending outside to a variable voltage transformer (*M*).
6. Outside the whole arrangement is a Dewar flask (*J*), preferably strip-silvered, in order to facilitate checking the level of the medium used for cooling.

Since the x-ray tube is adjustable, the tube and attached device are lowered into the cooling medium in the Dewar flask. With everything ready for irradiation, the temperature can be controlled by simply utilizing the outer medium in the Dewar flask as the cooling agent, and the inner medium in the metal chamber as the warming agent, the heat being provided by resistance wires. The device obviously works most efficiently when the differential in temperature

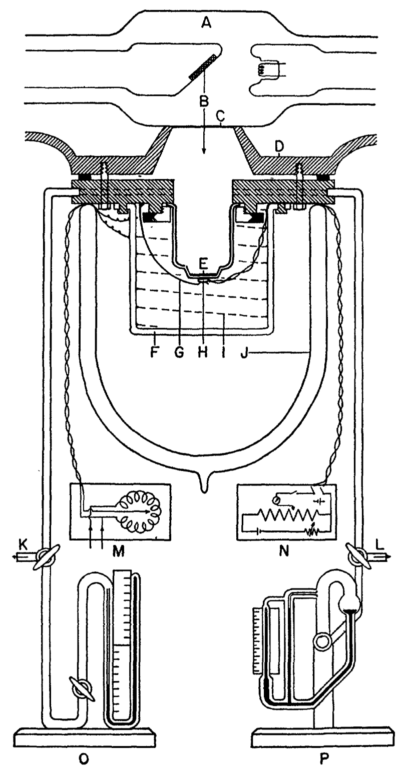

FIG. 1. Diagram of device for controlling temperature during high-intensity irradiation of microorganisms and other small samples *in vacuo*: (*A*) x-ray tube, (*B*) x-ray beam, (*C*) beryllium window, (*D*) x-ray tube housing, (*E*) sample, (*F*) metal chamber containing temperature-controlling liquid, (*G*) spring clip to hold thermocouple (*H*), (*I*) resistance wires, (*J*) Dewar flask, (*K*, *L*) evacuation outlets, (*M*) variable voltage transformer, (*N*) potentiometer, (*O*) manometer, (*P*) McLeod gauge.

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between the outer medium and the inner medium is smallest. For example, at temperatures of 0° C and higher, an ice bath for the outer medium is most economical; for temperatures of − 78° C and higher, solid CO_2 in alcohol or acetone works well; for temperatures of − 196° C and higher, liquid nitrogen can be used as the outer medium.

When only a set temperature, such as that of liquid nitrogen or solid CO_2, is desired, the metal chamber (*F*) between the Dewar flask and the aluminum cup can be eliminated from the device, thereby allowing the outer liquid to bathe the aluminum cup directly. This reduces boiling, particularly of the liquid nitrogen, and allows longer periods of irradiation without the necessity of replenishing the nitrogen.

For irradiation problems in which it is impossible to use a vacuum because of the type of material to be irradiated, but in which it is necessary to control contact with the atmosphere, one may simply insert the cup and close all connections, thereby assuring a definite, limited amount of air for all samples. One may flush the chamber with special gases, or one may irradiate with a flow of gas through the chamber.

The problems to which one can adapt this device are, in fact, many.

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An Oscillographic Plethysmograph Using a New Type of Transducer

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In recent years, several devices have been described for studying the circulation in the human digit (*1–5*). In order to detect the small pulsations in the digits of patients with obliterative arterial disease of the extremities, it was found that an instrument of much higher sensitivity than those previously developed was necessary. Since the mechano-optical systems already in use appear to have reached the limits of sensitivity for that type of recording, it was decided to explore the possibility of transducing mechanical into electrical changes and of magnifying such changes by means of vacuum tube amplifier techniques.

The high sensitivity of the RCA transducer tube (No. 5734) looked attractive at first, and it was incorporated into a suitable sensitive bellows. Although such a system had the desired sensitivity, the electric circuits for it required such a high degree of stabilizing as to make the system impractical for clinical use. The available unbonded pressure strain gauges were next explored. Although these possessed high degrees of sensitivity, they lacked necessary ruggedness, and at high amplifications artifacts commonly resulted from minute mechanical vibrations of the freely suspended resistance wire forming the bridge arms.

The principle of the bonded strain gauge was finally adopted in order to avoid the artifacts of the unbonded gauge. Since such a transducer suitable for plethysmography was not available, efforts were directed toward developing one.

A suitable cantilever beam was constructed of 24ST aluminum (selected for its low modulus of elasticity). Four sets of resistance wires were bonded to the cantilever, two sets on each side of the beam, and connected as a Wheatstone bridge.[1] Deflection of the beam in one direction or the other causes pairs on the opposite sides of the bridge to increase or decrease their resistances, thereby unbalancing the bridge. This electrical unbalance was the quantity amplified and measured. Rugged stops in the transducer prevented movement of the diaphragm and cantilever beyond safe limits.

At first the gauge, too, was attached to a sensitive bellows. After clinical testing, the bellows was rejected because it lacked adequate mechanical stability, was too easily excited by vibration, and had a highly undamped low frequency resonance. It became apparent that what was needed was a membrane or diaphragm that would move in only one plane, would have low inertia and low hysteresis, would be flexible linearly over a large range, and would have a low spring constant. Many diaphragms, both metallic and plastic, were studied, until one was finally built which met the requirements. It was made of bakelite-impregnated woven nylon thread shaped according to the general suggestions of the Bureau of Standards for barometer diaphragms. When this diaphragm was connected to the cantilever bearing the bonded strain gauge, a transducer was produced that fulfilled the desirable qualities outlined above (Fig. 1).

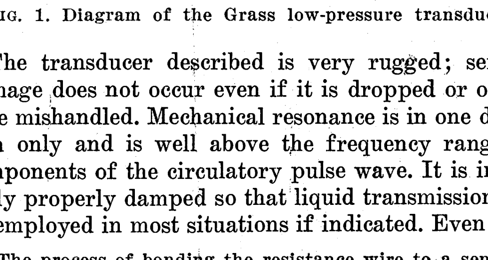

FIG. 1. Diagram of the Grass low-pressure transducer.

The transducer described is very rugged; serious damage does not occur even if it is dropped or otherwise mishandled. Mechanical resonance is in one direction only and is well above the frequency range of components of the circulatory pulse wave. It is inherently properly damped so that liquid transmission can be employed in most situations if indicated. Even with

[1] The process of bonding the resistance wire to a sensitive cantilever beam is intricate and requires long experience to obtain a hysteresis-free linear gauge. A. C. Ruge, who developed the Baldwin S-4 gauge, cooperated in performing this all-important operation.