# Miniature Glass Heat Exchanger for the Microsecond Range

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The electrical noise generated by the switching of the solenoid proved to be objectionable in this application and we subsequently developed the simple method illustrated in the diagram (Fig. 1).

The Dewar flask $F$ which holds the liquid nitrogen around the cold trap $C$ is placed on the pan of an inexpensive beam balance $B$. Fastened to the beam is a small foam rubber plate $R$ which acts to restrict the air bleed from vent $V$ of the pressurizing line $P$ if the Dewar flask becomes lighter due to evaporation losses and the beam lowers. This pressurizes the supply flask $S$ and forces more liquid nitrogen through insulated line $L$ into the Dewar flask $F$ until the evaporation losses are replenished. The right level is set simply by adjusting the weights on the beam of the balance $B$.

The needle valve $N$ has to admit just enough air as is necessary to raise the liquid nitrogen from the lowest level in the flask $S$. Too much air will cause oscillation of the balance if no damping is applied. This system will regulate without lag or overshoot, continuously replenishing evaporation losses and maintaining the level within a fraction of a millimeter. Liquid nitrogen consumption was one quarter of that with manual filling.

In many applications, of course, the cold trap cannot be weighed. But, if there is enough space to place a float into the flask, one could easily control the level by connecting the float to a sensitive switch or a valved vent.

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[1] Jesse E. Sherwood, Rev. Sci. Instr. **23**, 446 (1952).
[2] Robert D. Goodwin, Rev. Sci. Instr. **26**, 1052 (1955).
[3] George F. Wells, Rev. Sci. Instr. **29**, 893 (1958).

## Microwave Cavities for Magnetic Resonance Spectrometers*

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IN carrying out paramagnetic resonance absorption experiments it is desirable to use as high a frequency as possible for magnetic field modulation as this tends to minimize low-frequency noise effects from the crystal detector or system microphonics. This means that the microwave cavity should have very thin metal walls to avoid cavity vibration, and to allow the modulation to penetrate into the cavity. To accomplish this, glass cavities with thin metal films have been used.[1] In this connection we have used a material which serves a similar purpose but may permit more flexibility in design. The material used is hydrous aluminum silicate.[2] This material is quite soft before firing and can be readily machined. After firing at 1000°C it becomes very hard and can be coated with a thin metal film.

In our case a cavity operating in the $TE_{012}$ mode at 9400 Mc was made with the dimensions of X-band wave guide. The cavity as made was split along the broad face since this does not affect the operation of the cavity. The pieces were then fired and coated. As a coating, silver paint such as Hanovia No. 32A, which is fired at 850°C, is satisfactory. A thin coating of gold evaporated over this, protects the silver coating and improves performance. The two pieces were then held together with Teflon screws, one of the pieces having threaded holes. Alternatively, the cavity can be permanently cemented together with Eastman 910 cement. Such cavities have an unloaded Q of approximately 5000 at room temperature and 20 000 at helium temperature. A short length of wave guide was also made with this material and coated with silver paint. The cavity was attached to this with Teflon screws so that no heavy metal parts were in the modulation field.

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[1] Bennett, Hoell, and Schwenker, Rev. Sci. Instr. **29**, 659 (1958).
[2] This material is available commercially as Grade A Lava from American Lava Corporation, Chattanooga 5, Tennessee.

## Miniature Glass Heat Exchanger for the Microsecond Range

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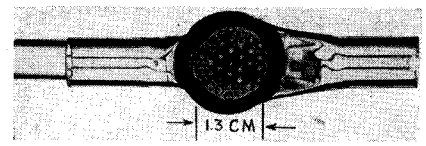
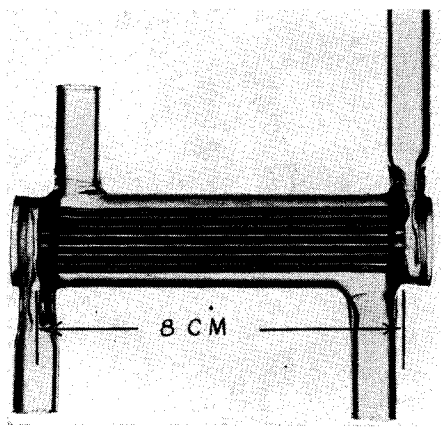
THE heat exchanger herein described is intended for use in rapid trapping of free radicals in high concentration for magnetic resonance studies, and more generally will be used for rapid heating and cooling of gases for kinetic studies to extend the time domain in methods described by Johnston.[1]

Pyrex capillary melting point tubing of about 0.8 mm i.d. and 0.25 mm wall thickness is cut to the desired length. The ends of the capillary tubes are turned on a 0.036-in. diam pencil lead with a very bushy flame directed against the end of the tube until the end of the capillary tube is thickened in amount corresponding to about $\frac{3}{16}$ in. diminution in length. The tubes are then assembled in a hexagonal spaced tube bundle by using 0.013-in. thick cardboard spacers and Goodyear Pliofilm cement.

A circular end plate disk of diameter $\frac{1}{2}$ in. greater than the tube bundle and of 0.075-in. thickness is next fused on




(a)




(b)

FIG. 1. (a) End and (b) side views of miniature glass heat exchanger for the microsecond range. There are 37 capillary tubes 7.8 cm long by 0.9 mm i.d. in the tube bundle.

to the end of the tube bundle so that a good seal is effected with each tube and a flat surface maintained on this end plate. The flame is not directed against the capillaries, but rather only against the end plate on the side opposite to the capillaries.

A $\frac{5}{8}$-in. length of 0.036-in. diam extra soft pencil lead is inserted in each capillary tube. A stationary burner is directed at a spot on the end plate just above a capillary tube. The pencil lead is pushed through the end plate with a wire so as to protrude about $\frac{3}{16}$ in. One by one, all of the pencil leads are pushed through with the wire as each corresponding spot is heated.

By using a medium grade of emery paper wet with turpentine, the protruding pencil leads and the glass end plate are ground down to a flat surface. The pencil leads then can be pushed out with a wire.

The second end plate is put on in the same manner as the first. The end plates are next cut down to a diameter of about 1.5 mm greater than that of the tube bundle. The cardboard spacers used to hold the tube bundle in proper shape are then dissolved out with boiling concentrated nitric acid.

The tube assembly and two end disks are fused in a jacket with inlet and outlet sidearms as shown in Fig. 1.

Tests run by passing air through a 0.8-mm-i.d. capillary tube 9.3 cm long with inlet temperature at 20°C and heating medium at 95.2°C gave the following flow rates and corresponding outlet temperatures: 1000, 95.1; 2000, 94.9; 2500, 94.7; 3500, 94.2 ml per minute and °C, respectively. The time spent by the gas in the tube for outlet temperature only 1°C less than that of the thermostat temperature is only 800 μsec. When allowance is made for the space at the end of a tube bundle as well as for the expansion of the gas in the tubes due to both a pressure drop and increase in temperature, this time becomes about 500 μsec. This time may be cut down considerably by using a shorter heat exchanger mounted in line with a second heat exchanger so that orifices impinge gas jets against each other. The second heat exchanger thus can supply a large amount of preheated inert gas which is mixed with the chemically reacting gas of the short heat exchanger. This arrangement plus consideration of the logarithmic dependence of both the temperature gradient along the capillary tubes and the rate of a chemical reaction taking place in the short heat exchanger is estimated to reduce the kinetic time equivalent to that where the gas maintained at the higher temperature in a quenching system to about 100 μsec.

Other applications of the general type of construction described are a high-capacity flowmeter, microcondenser, and with two tube assemblies mounted with orifices in-line, as a mixing device probably as efficient as the type devised by Hartridge and Roughton.[2]

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[1] H. S. Johnston, Discussions Faraday Soc. **17**, 14 (1954).
[2] H. Hartridge and F. J. W. Roughton, Proc. Cambridge Phil. Soc. **3**, 450 (1926).

## Pulsed 200-Kilogauss Magnet for Accelerator Experiments*

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A 200-KILOGAUSS pulsed air-core magnet system designed along principles previously described[1,2] has recently been put to use in experimentation at the Bevatron. The magnet coil (Fig. 1) has a 2-in. bore. The magnetic field exceeds 196 kilogauss over a 1-in. region along the axis, 180 kilogauss over a 2-in. region, and 150 kilogauss