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Berkeley, California**

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ABSTRACT

The Berkeley 88-inch cyclotron uses metal gaskets in a number of places where rubber would normally be used, because rubber probably would fail due to radiation damage. There are several large openings sealed with metal gaskets. Steel serrations biting into copper make the seal between the magnet pole and the main vacuum tank. One of these seals has failed. Tin-plated iron wire is used extensively as the gasket material. By sanding with 120-grit paper a suitable surface finish for sealing is provided. Metal gaskets work best when used between very rigid components. Care must be taken to place and hold the wire in the desired place while making a seal.

METAL GASKETS FOR THE BERKELEY 88-INCH CYCLOTRON

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Because beam currents may go quite high on the 88-inch cyclotron, there was some concern that rubber gaskets might become damaged due to radiation. The cyclotron, as completed, has some rubber gaskets and some metal gaskets. An attempt was made to use rubber where the radiation was less than maximum, and where rubber could be replaced easily if it became necessary. Metal gaskets were used where the radiation would be high—especially where replacing a gasket would be a difficult operation.

Several types of metal gaskets were used. Figure 1 is an example of the most common variety. Tests were done on both copper and iron wire. Iron wire was eventually used, not because it seals better but because it has more creep resistance. The iron wire used was No. 14 (0.064 in.) thermocouple wire (obtained from Leeds and Northrup Co. in Los Angeles). Thermocouple wire was used because it is high-purity iron, which is quite ductile and welds nicely. Welding was done by resistance welding. The welding outfits commonly installed to weld bandsaw blades worked very well for welding this wire. After welding, the weld is filed and then sanded by hand, to approximate the normal cylindrical shape of the wire. The metal gasket seals more quickly if the iron is tin-plated. The thickness of the plating is not critical: 0.001 in. is suitable. Another advantage of the tin coating is that it prevents corrosion. The tin can also be applied by hot dipping but plating does a neater job.

[†] Work done under the auspices of the U. S. Atomic Energy Commission.

The tabs shown in fig. 1 are 0.010-in. copper, soft-soldered to the two wires. Their purpose is simply to orient and hold the gasket in place while the plate is bolted down. There were many more bolts than those shown in the picture. Typically, $\frac{1}{2}$ -in. bolts were used on $1\frac{1}{2}$ -in. centers. The type of construction shown in fig. 1 was used on both larger and smaller joints. Joints as small as a few inches across were made in this way; others would measure several feet from side to side.

An iron wire, such as we used, seals vacuum-tight at pressures typically from 600 to 1200 pounds per linear inch of wire. In practice we generally used about 6000 pounds per linear inch of wire. In these joints the plates do not come metal to metal. The tension in the bolts is carried only by the wire.

At a loading of 6000 lb/in., iron wire squeezes down from 0.064 in. to a final dimension of 0.040 in.

We used approximately 300 ft of gasket wire in the cyclotron. To the best of my knowledge, all of it sealed immediately, and none of it has developed leaks—with one exception. A gasket was made on the style shown in fig. 1, covering an opening approximately 7 ft high by 10 ft wide. This joint gave trouble. It seemed to seal properly, but after the tank had been evacuated a few times it leaked. It was subsequently resealed by retightening the bolts, but in time it again began to leak. The difficulty in this case was that the large cover plate deflected enough during evacuation of the tank to work the wire. This repeated working would eventually open up a leak. The design was faulty. It should have been made rigid so that evacuation of the tank could not work the wire.

Such gaskets as are shown on fig. 1 work even better when used in conjunction with bolts that are individually sealed vacuum-tight around their heads. This type of construction is shown in fig. 2. The advantage of this

construction is that it makes it possible to check a joint for vacuum-tightness by evacuating the space between the two wires and checking for leaks with a helium leak detector, by applying helium to the outside of both wires. The washers used were made of 20-gage steel (0.036 in.) that were tin-plated 0.001 in. thick. The shoulder of the screw heads must be quite smooth. Stock bolts are sometimes smooth enough and sometimes they are quite poor. They either have to be inspected one at a time or turned or sanded for good smoothness. The residual machining marks should be circular. In general all forms of wire gaskets work best when sealing against a surface with marks running parallel to the wire or sealing member. Approximately 1000 such bolts were used on the cyclotron, and as far as I know all of them ^{sealed} without difficulty and have remained tight.

Surfaces against which the wires sealed were typically prepared by sanding to a finish between 16 and 32 μ in. This sanding was always done by hand, using portable sanders usually. Generally the shop machines surfaces to the usual 62 μ in. finish, and after this it was brought to the necessary smoothness by hand-sanding. If possible the direction of this sanding should be parallel to the direction of the wire. This is not imperative but it does help.

Figure 3 shows another style of metal gasket that was used. This gasket was used in the very important hard-to-get-at joint between the main vacuum tank and the pole of the magnet. This design was thought to be very conservative. Actually, it was quite hard to build, but it did seal nicely when good clean copper was used. The unfortunate fact is that three out of four of these joints at this date have developed leaks. The first leak showed up perhaps six months after assembly and the third one showed up perhaps 18 months after assembly. This is an example of a joint that looked good but is not good. We are not sure why

these joints are leaking. Some of the possible reasons advanced include temperature-expansion difficulties, corrosion, and motion due to magnetic and vacuum forces.

FIGURE CAPTIONS

- Fig. 1. Typical double-wire gasket.
- Fig. 2. Bolt with washer gasket.
- Fig. 3. Copper gasket sealed by metal serrations.

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Fig. 1

2