RESEARCH ARTICLE | MARCH 01 1955

Erratum: The Theory of the Fixed Frequency Cyclotron FREE

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Rev. Sci. Instrum. 26, 303 (1955)
https://doi.org/10.1063/1.1771284

Letters to the Editor

Prompt publication of brief reports of NEW ideas in measurement and instrumentation or comments on papers appearing in this Journal may be secured by addressing them to this department. No proof will be sent to the authors. Communications should not exceed 500 words in length. The Board of Editors does not hold itself responsible for the opinions expressed by the correspondents.

Cage Zone Refining

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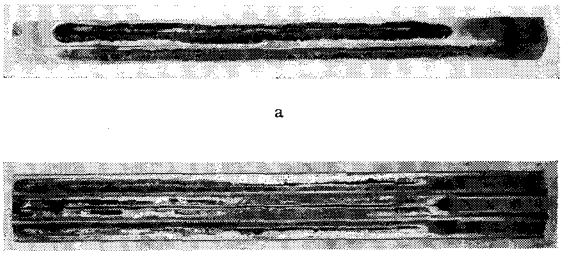
(Received December 13, 1954)

For many substances, crucible contamination stands in the way of applying the zone refining technique. To zone melt without any crucible is therefore something of an object. Keck and Golay achieved it for silicon,[1] and Emeis for silicon and germanium,[2] by maintaining a molten zone between two vertically aligned solid rods. Our method is based on the "cage melting" principle developed here some years ago.[3] This requires that the specimen be prepared in the form of a long prism rather than a long cylinder. The cross section is thus not a circle but a polygon, which may be curvilinear or may be re-entrant. For example, the specimen can be a square bar; or it can be a round bar furnished with longitudinal fins, either integral or attached as by fitting into slots. The specimen is caused to move vertically through a short induction heating coil. The eddy currents spare the fins (or corners, in the case of a square bar—we may refer to the corners as fins), and besides, the fins lose heat to the surroundings readily. It turns out that a short length of the bar can be kept molten throughout its interior and even over portions of the surface between the fins, while the fins themselves remain solid, constituting the bars of a "cage" that confines the liquid. That the liquid does not pour out through the molten portions of the surface, or "windows," is to be attributed in part to surface tension. If the induction coil is suitably shaped and it is contrived that the molten zone is not too low in the coil, another substantial part of the support of the liquid is furnished by the electromagnetic "levitating" force of repulsion between the inducing and the induced currents. The molten zone traversing the length of the bar provides the condition for zone refining. Reducing the current slightly in successive passes would lessen contamination by the fins. The latter would be cut away after the operation, leaving a zone refined core. This method, unlike those of Keck and Golay and of Emeis, does not allow single crystals to be grown. On the other hand it probably can deal with bars of bigger diameter than theirs.

Figure 1 is a photograph of two cage zone melted titanium bars. The square bar was later analyzed for iron, a known impurity. There was distinctly less iron at the initial than at the terminal end.



a

b

FIG. 1. Titanium bars cage zone melted at 10 000 cps in an inert atmosphere. The upper bar is 12 in. long, $\frac{3}{4}$ in. square, and received five passes. The lower bar is $9\frac{1}{4}$ in. long, has eight $\frac{1}{16}$ in. wide by $\frac{1}{8}$ in. high fins integral with a cylindrical body of 1 in. diameter, and received two passes (later increased to four with little change in appearance).

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[1] P. H. Keck and M. J. E. Golay, Phys. Rev. **89**, 1297 (1953); Keck, Van Horn, Soled, and MacDonald, Rev. Sci. Instr. **25**, 331 (1954).

[2] R. Emeis, Z. Naturforsch. **9a**, 67 (1954).

[3] P. H. Brace, U. S. Patent No. 2 664 496, December 29, 1953.

Erratum: Glass Ball Valve

[Rev. Sci. Instr. **25**, 1220, (1954)]
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Figure 1 in this paper was reproduced upside down.

Erratum: The Theory of the Fixed Frequency Cyclotron

[Rev. Sci. Instr. **24**, 589 (1953)]
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Dr. H. P. Yockey[1] has kindly pointed out to the author that the final term in Eq. (3.3) is in error by a factor r/d. Upon further investigation, it was found that the approximation used for the electric field in the derivation of the focusing formula by the numerical method was not sufficiently accurate for the purpose. Based on the alternative derivation—by the modified Rose method—the final focusing formula (3.30) can be considered valid only up to terms of order $(V_0/E)^{\frac{1}{2}}$.

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[1] H. P. Yockey (private communication).

Laboratory and Shop Notes

BRIEF contributions in any field of instrumentation or technique within the field of the Journal can be accorded earlier publication if submitted for this section. Contributions should in general not exceed 500 words, and no proof will be shown to the authors.

High-Vacuum Jet System for Condensation Pumps

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(Received July 8, 1954)

A jet for an oil-diffusion pump is described which has been designed to overcome the back leakage of air molecules once they have been passed forward of the jet. The phenomenon of back leakage is discussed by Hickman as follows[1]: "Langmuir has shown that the air handled by the pump collects as a layer against the walls before being driven down to the exit and expelled. Now it is apparent . . . that the air which is entrained near the jet may be rejected again laterally where the operating vapors curve upwards. The high concentration of air which has been left by vapors condensed at the wall is in especially favorable position to pass back."

In an effort to overcome this return of air to the area being evacuated, a pump has been designed which has a section of the wall removed and an annular jet fitted. (See Fig. 1.)

A three-stage air-cooled oil-diffusion pump, Model G.F. 25A 1659 as supplied by Distillation Products Incorporated, U.S.A.

was chosen for modification. The polymer sink was left off the modified version. The position of the annular jet in the modified pump is such that it forms a composite pumping unit with the last jet. Air molecules which have been passed forward of this composite pumping unit are unable to move back along the wall of the pump into the area being evacuated without passing through a stream of opposing pumping vapors.

The composite pumping unit described here can be incorporated in either vertical or horizontal condensation pumps.

In tests the modified pump gave pressures of 1×10^{-6} mm of Hg using silicone oil DC—703. This oil was used because other workers have commented on its tendencies to backstream.[2] No cold trap was used. Unfortunately this value was the limit of the triode ionization gauge employed and the full characteristics of such a jet system, whether favorable or otherwise have not been investigated.

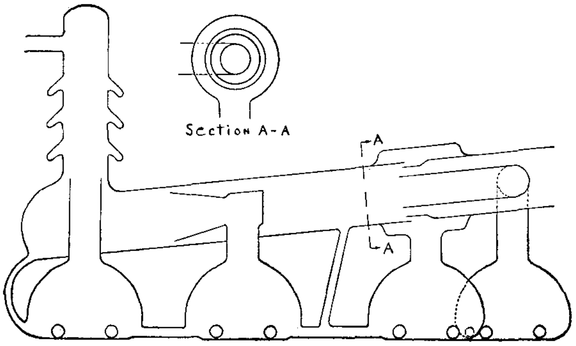

FIG. 1.

It is recognised that the unmodified pump is capable of pressures lower than 1×10^{-6} mm of Hg but when fitted to the system as used above and charged with the same oil, such a pump gave 1×10^{-5} mm.

[1] Saul Dushman, *Scientific Foundations of Vacuum Technique* (John Wiley and Sons, Inc., New York, 1949).
[2] L. G. Parratt and E. L. Jossem, Rev. Sci. Instr. **23**, 188, (1952).

X-Ray Beam Measurement of Distortion in a Magnet Cloud Chamber*

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(Received January 11, 1955)

IN a recent article Carter and Street[1] describe a method of measuring cloud chamber distortions using a collimated beam of soft x-rays. The aggregate of the ionization clumps formed by the secondary electrons ejected from the filling gas by the x-rays forms a visible cloud chamber track which should be straight. Deviations from straightness are a measure of track distortion. A similar x-ray device was constructed by the author and proved valuable in connection with a cloud chamber experiment at the Cosmotron.[2] This apparatus was somewhat different from that used by Carter and Street and the observations were extended to magnet cloud chambers.

The source of x-rays was a Machlett Laboratories, Inc., A-2 diffraction tube with a tungsten target and a 1 mm thick beryllium window. The pulsing apparatus is shown in Fig. 1 and was designed to operate from the output of a multivibrator variable delay circuit which delayed the beam injection time up to 0.5 sec from a zero time signal. The high voltage was supplied by a Condensor Products, Inc., PS 10 supply which was operated as high as 14 000 v with no apparent adverse effects. Most of the remaining parts were obtained from a surplus radar set. The x-ray tube was located about 40 cm from the chamber and was covered by an iron magnetic shield. The beam was collimated into a narrow ribbon with a slit 5 mm by 0.2 mm and introduced into the chamber through a 0.002 in. thick Du Pont Mylar foil. The expansion cloud chamber was a 16 in. diameter 4 in. high cylinder with a floating back piston and was mounted in a magnetic field of approximately 8000 gauss.

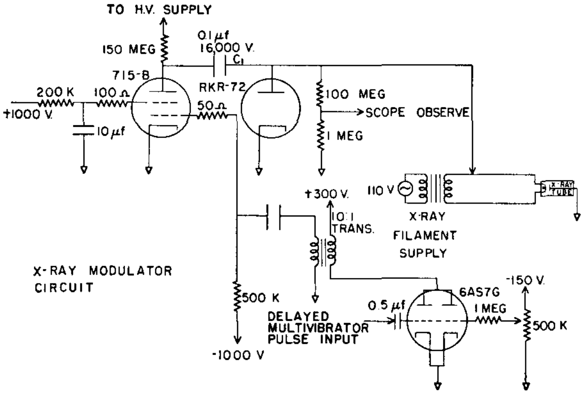

FIG. 1. Circuit used to pulse x-ray tube.

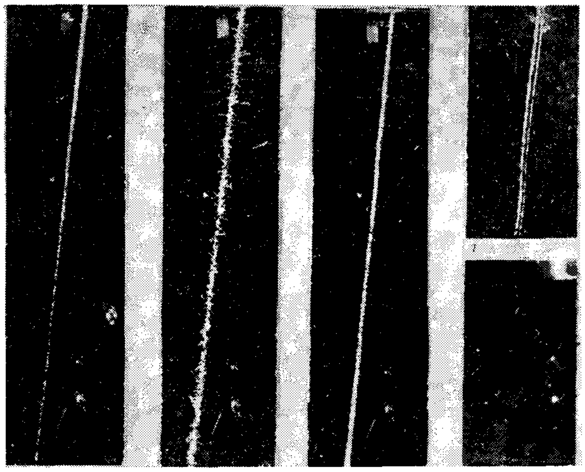
(a) (b) (c) (d)

FIG. 2. X-ray beam under various operating conditions. The faint track next to the main track is simply a reflection in the glass bottom of the cloud chamber. (a) Normal operating conditions in argon. (b) No magnetic field in helium. (c) A magnetic field of 8200 gauss in helium. (d) Severe distortion observed with plate in center of chamber. The reflected track is particularly noticeable in this picture.

With a pulse length of one millisecond at 13 000 v it was possible to determine the center of a track in argon at 5 lb gauge pressure to ±0.003 cm with a usable range of about 15 cm. Little difference was noted in the appearance of the track with or without the magnetic field. A typical argon track is shown in Fig. 2 (a).

The behavior of the beam was quite different in helium where the attenuation of a one millisecond 14 000 v pulse was negligible. No change in intensity could be noted along a 20 cm track. Without a magnetic field the track had the characteristic uneven appearance shown in Fig. 2 (b) and its center could be determined to only ±0.012 cm. With a magnetic field of approximately 8000