The Electrically Driven Ultracentrifuge
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Source: *Science*, New Series, Vol. 85, No. 2198 (Feb. 12, 1937), pp. 185-186
Published by: American Association for the Advancement of Science
Stable URL: https://www.jstor.org/stable/1661542
Accessed: 27-11-2018 15:33 UTC

SCIENTIFIC APPARATUS AND LABORATORY METHODS

THE ELECTRICALLY DRIVEN ULTRACENTRIFUGE

The air-driven "vacuum" type of ultracentrifuge originally developed in this laboratory[1] has already found sufficient application in the different sciences[2,3,4] to warrant an examination of certain possible variations and improvements. Briefly, in the "vacuum" type of air-driven ultracentrifuge the large rotor (centrifuge) is both supported and spun inside a vacuum tight chamber by a small flexible shaft or tube which extends out of the vacuum chamber through an oil gland. The rotating parts consist of the large rotor (centrifuge) inside the vacuum chamber, a much smaller turbine above the vacuum chamber, which is both supported and spun by air, and the flexible shaft that connects the turbine to the centrifuge through the vacuum tight oil gland and lies in their vertical axis of rotation. Although the amount of air required to drive the air turbine is not large (2 to 3 cu. ft. per min., 15 to 20 lbs/in^2 gauge pressure in our latest design), the amount of air required to support the rotating parts is in comparison almost negligible and need only be supplied at from 5 to 15 lbs/in^2 gauge pressure. In many laboratories air compressors of sufficient capacity are not available, so that, in order to run the air-driven centrifuge, an auxiliary compressor must be installed. However, if it were possible to spin the turbine by some other means, the amount of air required to support the rotating parts could then be supplied by a small "blower" or compressor, which is available commercially at the cost of only a few dollars. In view of this and other reasons that will be given later, a study of the available ways of both supporting and driving the turbine has been undertaken, and the present note gives some of our results with an electrical type of drive.

Fig. 1 shows a schematic diagram of the type of apparatus used. A is the large rotor or centrifuge which is surrounded by the vacuum tight chamber V. S is the flexible shaft (1/16 in. rod or tube in the apparatus used), and T is the driving rotor. The vacuum tight gland or bearing G is mounted in round Duprene rings R and vacuum pump oil is forced into the hollow space between the two bushings B. The bushings are usually made of brass, bronze, babbit metal, etc., depending upon the material of the small shaft. Their construction has been previously described. The driving rotor T is supported on an air cushion between the bakelite collar C and T. Many

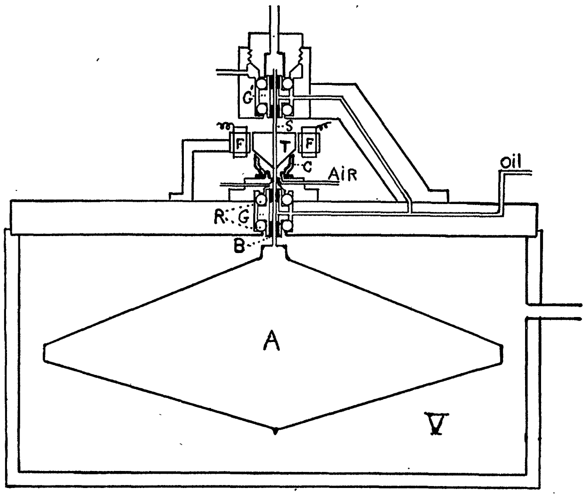

Fig. 1

variations in this air cushion support may be used[1] which are satisfactory. The upper bearing or gland G^1 is made similar to G so that when a tubular shaft S is used the rotor A itself may be evacuated. The driving rotor T is the familiar squirrel cage type of armature so that an alternating current in the field coils F causes it to spin. The principle of the induction motor is thus used to spin T, while a small amount of air at a pressure of a few lbs/in^2 is used to support it. The advantage of this type of electrical drive is that, if properly constructed, the centrifuge will start from rest and gradually accelerate until a rotational frequency is attained practically equal to that of the alternating current in the field coils F. The fact that in practice the rotor T reaches this speed results from the almost negligible friction except for that of the air on the small rotor itself. It is possible to construct electrical circuits and field coil magnets to give fields of considerable magnitude at the desired frequency so that the maximum rotational speed is set by the breaking strength of T or the centrifuge A. In most biological, chemical or medical experiments A is 8 to 10 inches in diameter and usually will explode if driven much above 1000 r.p.s. Hence in practice it is not difficult to construct T to stand this speed.

The A. C. supply for the motor was obtained from the inverter shown in Fig. 2. This is known as the double capacity single phase polycyclic type of inverter. For a detailed description of its characteristics and its mode of operation a paper by Sabbah[5] should be consulted.

The circuit was constructed from transformers, capacities, etc., which can usually be found in any

[1] Beams and Pickels, *Rev. Sci. Inst.*, 6: 299, 1935.
[2] Bauer and Pickels, *Jour. Exp. Med.*, 64: 503, 1936.
[3] Wyckoff and Corey, Science, 84: 513, 1936.
[4] Beams and Haynes, *Phys. Rev.*, 49: 644, 1936.

[5] C. A. Sabbah, *G. E. Review*, 34: 288, 1931.

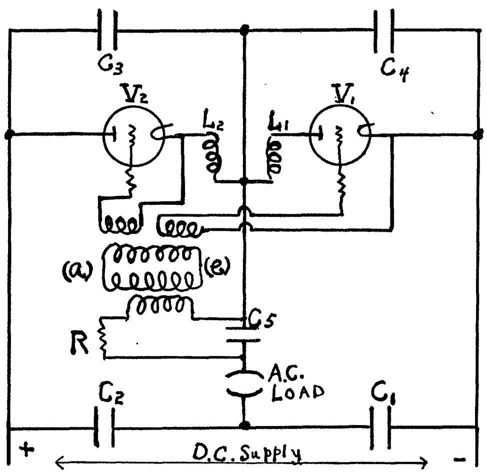

Fig. 2

laboratory or obtained at small cost. For the reactors L_1 and L_2 two windings of a one to one insulating transformer were used. Thyratrons FG-67 were used for V_1 and V_2. The grid excitation was obtained as shown. The frequency of the circuit could be changed by an alteration of R or by a change in any of the capacities C_1 to C_5. The circuit has good stability at any frequency under that at which the tubes V_1 and V_2 fail. This upper limit is well above 1,000 cycles with these thyratrons.

At times the circuit fails to start when the D. C. supply (about 250 volts) is connected. It may be started without producing failure by connecting the 60 cycle lighting supply through a resistance to the points (a) and (b). It is well to protect the tubes in case of failure by a fast circuit breaker or fuse of suitable capacity in the D. C. line.

This type of circuit is capable of furnishing considerable power at frequencies which can be changed gradually or abruptly by a variation in circuit constants. This is of advantage in the initial acceleration of the centrifuge as the frequency may be set initially at some low value and increased as the centrifuge speeds up.

Our experience shows that the induction motor type of drive gives a speed practically as constant as the frequency of the circuit and therefore better than usually required in most work. The heating of the rotor T gives no fundamental trouble because where accurate temperature control is required it is standard practice to maintain the vacuum chamber V at constant temperature by the usual thermostatic controls. If the air surrounding the rotor T is troublesome, T can easily be sealed in a vacuum chamber by a change in design. It should be pointed out that several other types of electrical circuits and drives may be used besides that described above. The synchronous motor drive has been used in this laboratory by Davis[6] to produce 1,400 r.p.s., while methods of driving high-speed electrical motors have also been devised, especially by Colwell and Hall.[7]

Although at present the air turbine drive must be used to obtain the very highest rotational speeds, the electrical drive serves equally well for many purposes and has the advantage, after once being set up, that it is automatic and requires no attention from the operator to keep the speed constant. This work will be continued, and we hope that a more detailed description can be published later.

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[6] T. Davis, *Rev. Sci. Inst.*, 7: 96, 1936.
[7] Colwell and Hall, *Jour. Franklin Inst.*, 221: 797, 1936.

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