tion of the polarizing current. An analysis of these results, given elsewhere (5), suggests the following possibility: The mechanical stimulus causes the membrane potential across each generator element to drop to a certain fraction of the resting potential. This is equivalent to assuming that the transmembrane resistance across each generator element is shunted by a fixed leak resistor, when excited. This might occur, for example, if the activated generator element became permeable to all kinds of ions, as has been postulated for the end plate membrane of skeletal musculature (6). An increase in resting potential obtained by polarizing the receptor membrane with an inward current would then cause a proportionally increased fractional drop of membrane potential. Hence the generator poten-

Fig. 3. Refractoriness of the receptor membrane unrelated to charge transfer. Two mechanical stimuli (S_1 and S_2) are successively applied so that the generator potential (G_2) in response to the second stimulus falls on the refractory trail of the generator potential (G_1) in response to the first. The ratio G_1/G_2 is determined while the amplitude of G_1—that is, the total amount of charge transferred—is varied in A by varying the stimulus strength (S_1) at constant resting membrane potential, and in B, by varying the resting potential across the receptor membrane at constant stimulus strength. (G_1 in response to three steps of stimulus strength was varied in B over a range of generator potential by polarizing currents.) Values of S_1 are displacements of the crystal stimulator given in relative units. S_2 was constant throughout all experiments. The vertical bars subtend a standard error of mean of approximately 30 generator potentials in each case. Curves in B were drawn by the method of least squaring.

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tial, which is the aggregate result of all excited generator elements, should be directly proportional to the resting potential (2) (and to the polarizing current). It is of interest that the generator potential of a visual receptor has also been reported to increase as a function of the resting membrane potential (7).

It has previously been shown that excitation of a small region of the receptor membrane leaves a refractory condition behind so that a subsequent application of a mechanical stimulus to the same region elicits a response that is considerably smaller than normal. The refractory state, like the excited state, is confined to the mechanically stimulated region but does not spread to adjacent regions (1, 2). If a generator potential is produced by applying a mechanical (conditioning) stimulus to a relatively large area of receptor membrane— that is, to an area containing a relatively large number of generator elements— a subsequent equal (test) stimulus, falling on the refractory trail of the first, elicits a generator potential of an amplitude inversely related to that of the conditioning generator potential (8, 9). The measure of this effect has been called the "size factor of refractoriness" (10).

Since the amplitude of the generator potential increases as a function of the number of excited generator elements (2), and as a function of the electrical gradients across each excited generator element as well, the question arises whether it is the amount of charge transferred in response to the conditioning stimulus or the number of generator elements excited by the conditioning stimulus which determines the size factor of refractoriness. The present set-up gave us the opportunity to explore this question. The conditioning generator potential could be varied either by (i) changing the strength of the stimulus or by (ii) polarizing the receptor membrane at constant stimulus strength. By the first procedure, the number of conditioning-excited generator elements is varied at constant resting membrane potential of generator elements; by the second, the membrane potential of a given excited population of generator elements is varied. The results are shown in Fig. 3. It is seen that with procedure (i) the size factor—namely, the ratio of conditioning (G_1) to test generator potential (G_2)—increases progressively with the amplitude of conditioning generator potential (Fig. 3A), while this ratio remains approximately constant with procedure (ii) (Fig. 3B). It is clear from this result that the size factor of refractoriness does not depend on the amount of charge transferred but on another factor related to the strength of the stimulus.

The following explanation may be offered for this result: The conditioning stimulus excites a number of generator elements out of a statistically fluctuating population of excitable elements. Excitation of a generator element is followed by a refractory period. The first of these assertions has a good experimental basis (9, 11); the second is an assumption. If, then, a test stimulus is applied during the refractory period, the number of nonrefractory generator elements available for excitation at the instant of application of the test stimulus may be expected to decrease with an increase in the number of generator elements excited by the conditioning stimulus. Hence the amplitude of test generator potential, which is a function of the number of excited generator elements (2), will expectedly decrease as a function of conditioning generator potential. A quantitative analysis of this question is given elsewhere (5) (12).

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12. This work was aided by research grants from the National Institute of Neurological Diseases and Blindness (B-1466) and the National Science Foundation.
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30 June 1959

Molecular Pumping

Abstract. A method is described for producing high vacua. A magnetically suspended molecular pumping rotor is operated inside a sealed glass vacuum system. The system is free of lubricants and can be baked out. The system gives promise of producing pressures below those previously used.

Gaede (1), Holweck (2), Siebahn (3), and others (4, 5) have amply demonstrated the effectiveness of molecular pumping for producing vacua. In some of their experiments the lowest pressure obtained was limited only by the vapor
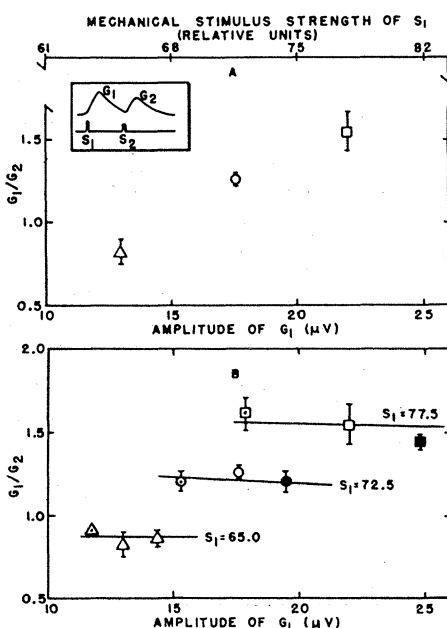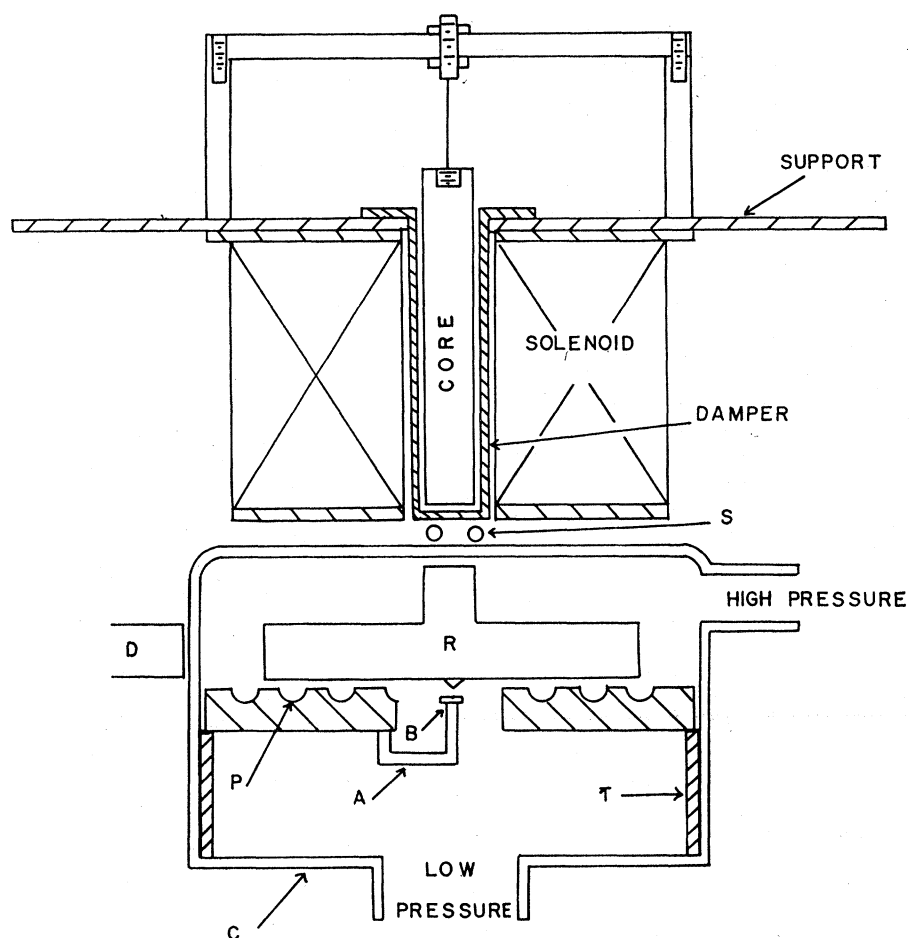
Fig. 1. Molecular pump with magnetically suspended rotor.

pressure of the lubricant in the bearings or by the fact that it was not possible to bake out the pumping system. For example, von Friesen (4) reported a pressure of 6.7×10^{-7} mm-Hg on the low-pressure side and 0.05 mm-Hg on the high-pressure side of his molecular pump. The pressure ratios usually vary from 10^2 to 10^6. According to theory (6), these pressure ratios should continue to hold at extremely low pressures.

In the course of some measurements of the gaseous friction on a magnetically suspended rotor spinning in a high vacuum, a considerable amount of molecular pumping was encountered. Since this pumping system can be baked out and is free of lubricated bearings, it appears worth while to indicate its possible use in producing very high vacua.

Figure 1 illustrates the principle of the method. The steel rotor R is freely suspended inside a vacuum-tight glass chamber C by the axial magnetic field of the solenoid, which is situated above the chamber. The sensing copper coil S is used to regulate the current through the solenoid in such a way as to maintain the rotor at the desired vertical position in the chamber. The rotor is spun by a rotating magnetic field produced by the drive coils D, located out-

side the glass chamber; that is, the rotor operates as the armature of an induction motor. A detailed description of the magnetic suspension and drive circuits has been published previously (7).

The pumping takes place between the spinning lower surface of the rotor R and the stationary upper surface of the plate P. Grooves are cut in the upper surface of P which spiral out from the axis to the periphery. The plate P is made of nonmagnetic low-vapor-pressure metal. The gas molecules are driven from the axis to the periphery by the spinning rotor. The clearance between the rotor and the plate P can be made 0.05 cm or less, while the depth of the grooves is of the order of 1 cm, the exact depth depending upon the pumping speed and the size of the rotor. The stainless-steel safety stop B is mounted on an arm A in such a way as not to obstruct the inlet to the pump. The plate P is supported on a closely fitting aluminum or copper foil washer which in turn is supported by a carefully ground glass telescoping tubing T. This permits the clearance that is necessary for differential expansion of P and C and at the same time provides a seal between the lower and upper chambers. With the solenoid removed, the entire system may

be baked out for as long as necessary.

The peripheral speed is determined by the strength of the rotor but can easily be made twice the average molecular speed. The diameter of the rotor can be varied over as large a range as desired. If by means of modern pumping procedures the region around the periphery of the rotor is evacuated to a pressure of 10^{-9} or 10^{-10} mm-Hg, then a pumping ratio of 10^4 would give a pressure of 10^{-13} to 10^{-14} mm-Hg near the axis. If two or more such pumps were operated in series or in parallel and the glass chamber C were surrounded by an evacuated glass envelope, the pressure probably could be much further reduced. Another important factor is that the pumping speed can be made quite high. Also, the pump may be refrigerated—say, by liquid nitrogen—after the bake-out process and while it is in operation. This should greatly increase the effectiveness of the pump. With appropriate changes in the drive system, stainless-steel or other nonmagnetic vacuum chambers may be used instead of glass (8).

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31 August 1959

Effect of Ultraviolet Pretreatment on Yield of Mutations by X-rays in Wheat

Abstract. A decrease in the yield of chromosomal aberrations in root meristems of wheat induced by four different doses of x-rays has been found to occur when the seeds are pretreated with ultraviolet radiation. However, in X_2 generation, the mutation rate for combined treatment is lower than for x-rays alone in lower dosages and higher than for x-rays alone in higher dosages.

Pre- or post-treatments combining such radiations as ultraviolet light or infrared with ionizing types have not been tested for their effects on mutation in higher plants. Swanson (1) has demonstrated that pre- or post-treatment with ultraviolet light will reduce the amount of chromosomal damage induced by x-rays in Tradescantia. In Aspergillus, combined ultraviolet and x-ray doses induced more mutations