II. MICROWAVE GASEOUS DISCHARGES

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A. MICROWAVE BREAKDOWN IN HYDROGEN AT HIGH PRESSURES

In preparation for extending data on the continuous wave breakdown of hydrogen at high pressure by the use of pulse techniques, a study was made of the effect of various pulse widths and pulse repetition frequencies on the breakdown of hydrogen. This was done to determine what combinations of pulse widths and pulse repetition frequencies would give values of breakdown electric field equal to that obtained for the continuous wave. The heavy lines in Fig. II-1 represent the data taken of breakdown for various values of pulse repetition frequency as a function of pulse width for a given value of pressure of hydrogen. In all instances, as the pulse width increases, the value of breakdown electric field approaches that for continuous wave breakdown. This effect, of course, occurs at smaller values of pulse width for large repetition rates than for small repetition rates.

Because the plate dissipation of the magnetron is limited, the increased peak output of the magnetron must be accompanied by an appropriate change in the duty cycle of the pulse. If the peak power is to be twice the continuous wave power, the duty cycle must not exceed 0.5. On the curves of Fig. II-1 the pulse duty cycle is plotted as a dotted line. From these curves it can be seen that there are values of duty cycles which make it impossible to obtain the combinations of pulse width and pulse repetition frequency which would give an equivalent continuous wave breakdown. However, for duty cycles greater than 0.1 there are combinations of pulse width and repetition frequency which give an equivalent continuous wave breakdown. Data obtained at different pressures indicate that the percentage deviation of pulse breakdown from continuous wave breakdown decreases as the pressure increases; thus it is reasonable to assume that a duty cycle that permits equivalent continuous wave breakdown at the pressure indicated in the figure will continue to do so as the pressure increases.

The trend of these constant duty cycle curves can be understood through the realization that the time required to obtain breakdown in the gas is the time required for the electron density in the gas to reach the ambipolar transition density of approximately 10^7 electrons/cm^3. There are, however, an initial number of electrons left over from the previous breakdown which can influence the time required to obtain the necessary build-up of electron density. An equivalent continuous wave breakdown is obtained when the electron density builds up within the limits of a given pulse width to the ambipolar transition density from an original density determined by the time elapsed since the previous breakdown. The build-up of electron density is determined by the free diffusion of electrons in hydrogen; the decay of electron density after a breakdown is determined by

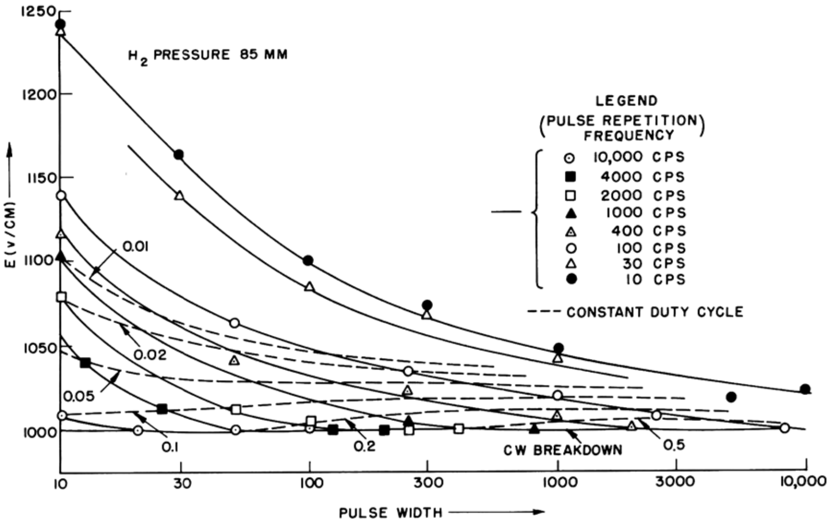

Fig. II-1

The variation of breakdown field as a function of pulse width and pulse repetition frequency showing the effect of the pulse duty cycle.

the ambipolar diffusion of electrons in hydrogen from the breakdown density to the ambipolar transition density. If the pulse repetition frequency is smaller than a critical frequency, practically no influence is felt from the electrons of the previous discharge and the pulse breakdown for a given pulse width should no longer be a function of pulse frequency. The decay of electron density in the ambipolar region is given by

$$n = n_o \exp\left(- \frac{D_a}{\Lambda^2} t\right)$$

where n_o = initial electron density, n = density at time t, D_a = ambipolar diffusion coefficient, Λ = diffusion length of cavity, and t = time. For a pressure of 85 mm of Hg, and values of $(D_a p) = 700$, $\Lambda = 0.4$ cm, $n = 10^7$, and $n_o = 10^{10}$, a diffusion time of 0.13 sec is obtained which corresponds approximately to a repetition frequency of 7 to 8 cycles per second.

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B. PLASMA OSCILLATION

To further the investigations of D. H. Looney (1), a tube has been constructed and put into operation (2); oscillations and a standing-wave pattern have been observed. The plasma-beam interaction region was three times the maximum length used by Looney. The purpose of the new tube is to allow independent measurements of the oscillation frequency, plasma electron density, and standing-wave pattern in the interaction region.

The variation of phase velocity with electron density can now be determined, and the assumption that the plasma electrons behave as a gas which propagates an acoustical pressure wave can be tested using various models of the electron gas.

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References

1. D. H. Looney and S. C. Brown, Phys. Rev. 93, 965 (1954).
2. Quarterly Progress Report, Research Laboratory of Electronics, M.I.T., July 15, 1954, p. 12.

C. MICROWAVE DETERMINATION OF THE PROBABILITY OF COLLISION OF SLOW ELECTRONS IN NEON

The collision probability for momentum transfer of slow electrons in Ne will be measured with the microwave method of Gould and Brown (1). Cataphoresis will be used to purify neon (spectroscopically pure Airco neon) from the other rare gas impurities, and activated uranium to eliminate the impurities that are not rare gases (2).

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References

1. L. Gould and S. C. Brown, Phys. Rev. 95, 897 (1954).
2. R. Riesz and G. H. Dicke, J. Appl. Phys. 25, 196 (1954).