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"Theoretical and Experimental Studies
of the Underlying Processes and Techniques
of Low Pressure Measurement"

Under the Direction of

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I. Introduction

Vacuum research continued at a reduced level from the expiration of the previous grant on November 30, 1965 until receipt of the current extension in May, 1966. This extension was retroactive to December 1, 1965, making the first report due at this time. It should be emphasized that although the first half of the formal period has passed, only a much smaller part of the funds have been used.

The principal activity of the vacuum group during the period covered by this report has been related to improving the low pressure characteristics of the Schuemann suppressor gauge, and such vacuum work as will be necessary to the continuation of this aim. Certain surface physics work directed by Professor Propst is also briefly discussed in this report.

II. Further Development of the Schuemann Suppressor Gauge

The Schuemann suppressor gauge in the forms made following the original invention, or in the commercial version as now manufactured by RCA, is not capable of utilizing the full potential of the suppressor concept. The problem of accurate total pressure calibration at pressures below 10^{-10} Torr has not been solved by any generally available gauge. Thus further development of the suppressor gauge has been undertaken to overcome problems associated with the early models.

Specifically, the problems with the gauge have been those of outgassing the electrode structure to make possible operation at pressures as low as 10^{-12} Torr, Barkhausen oscillations, and problems associated with the mechanical structure of the electrodes..

In the past few months, several new forms of the gauge have been built and tested. Special effort has been given to choosing a design and electrode materials such that the metal components could be outgassed. To improve the outgassing properties further, all of the recent gauges have utilized a spherical bulb, which aids in keeping the envelope cool during outgassing. The geometry now used, with attention to grid-filament spacing, has apparently eliminated space charge oscillations. The construction has been simplified by supporting all electrodes other than the ion collector from a single header. This gauge, of which a photograph is shown in Figure 1, has operated effectively at pressures into the mid 10^{-12} Torr range. Lower pressures have not been available to continue the tests further. Figure 2 shows that the operation of the gauge has only a slight effect upon the pressures of the principal gases as measured with a GE 90^{o} spectrometer. The very small CO peak which appears with the gauge on is barely above spectrometer dark current.

III. Efforts to Reach Lower Pressures--Glass Systems

The metal valves used to isolate the trap from the working portion of the system during bakeout are the major source of gas (H_2) in our present glass systems. In the hope of removing this limitation, we have made a glass valve similar to those reported in the literature.[1,2]

The second model is presently being tested for leakage conductance, and all indications are that such a valve will be useful. If the hydrogen from the metal valve is eliminated, the dominant residual gas in the systems will be helium.

Thought has been given to two possible ways of reducing the helium limit. One would be to use a glass with a small permeability for helium, such as an alumino-silicate glass. Another would be to use a large cell ion pump with a significant pumping speed for helium at very low pressures.

IV. Lower Pressures--Metal Systems

Although the outgassing rates per unit area are usually much higher for stainless steel than for glass after equal baking, it should be possible to make metal gasketed stainless steel systems reach pressures as low as 10^{-12} Torr. Larger pumping speeds are possible in steel systems because of greater conductances, and it is more convenient to use large getter areas with large pumping speeds for active gases. Further, special techniques have been developed by Petermann at the Battelle Institute, Geneva (private conversation) which reduce the hydrogen evolution by forming an oxide barrier on the stainless steel surface.

A steel system designed for comparing ionization gauges is in preparation. It is presently being evacuated with an ion pump built in the laboratory, and made for high speed at low pressure. Titanium sublimation is also included. The initial results have been encouraging with pressures reaching as low as 8×10^{-11} Torr. The only significant residual gas is hydrogen. The system is now being outfitted with a well-trapped diffusion pump to maintain low pressures during bakeout, and to thus reduce the saturation of the metal by the gases present during bakeout. The diffusion pump will be valved off from the stainless system during normal operation.

V. The Adsorption of Gases at Metal Surfaces Studied by the Auger Process

The first measurements on this work have been started. The first system to be studied is the adsorption of N_2 on polycrystalline tungsten. These measurements have shown an extremely low sticking probability. This might be due to the recrystallization of the tungsten sample (preferred 110 orientation), or it may be associated with the presence of stable silicon compounds on the surface since the apparatus is pumped by an oil diffusion pump using silicon oil. Tests will be made of both of these possibilities.

References

[1] R. Decker, J. Appl. Phys. 25, 1441 (1954).

[2] A. H. Turnbull, R. S. Barton, and J. C. Riviere, An Introduction to Vacuum Technique (Wiley and Sons, New York, New York, 1962), pp. 126-127.

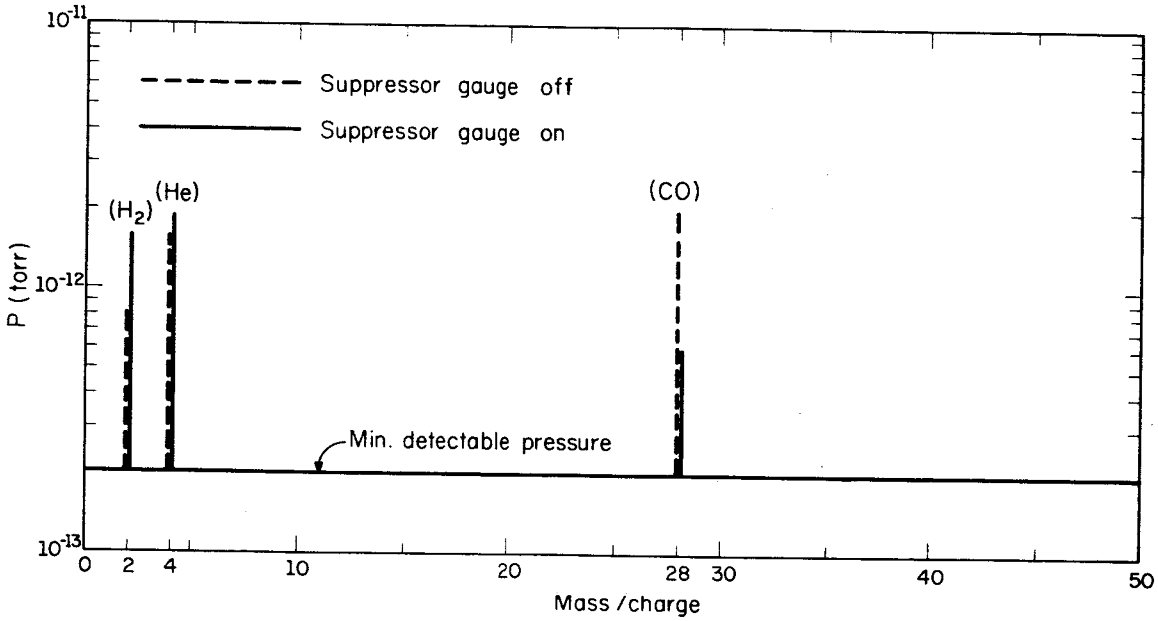

Figure 2. Mass Spectrum of Residual Gas with Suppressor Gauge On and Off.

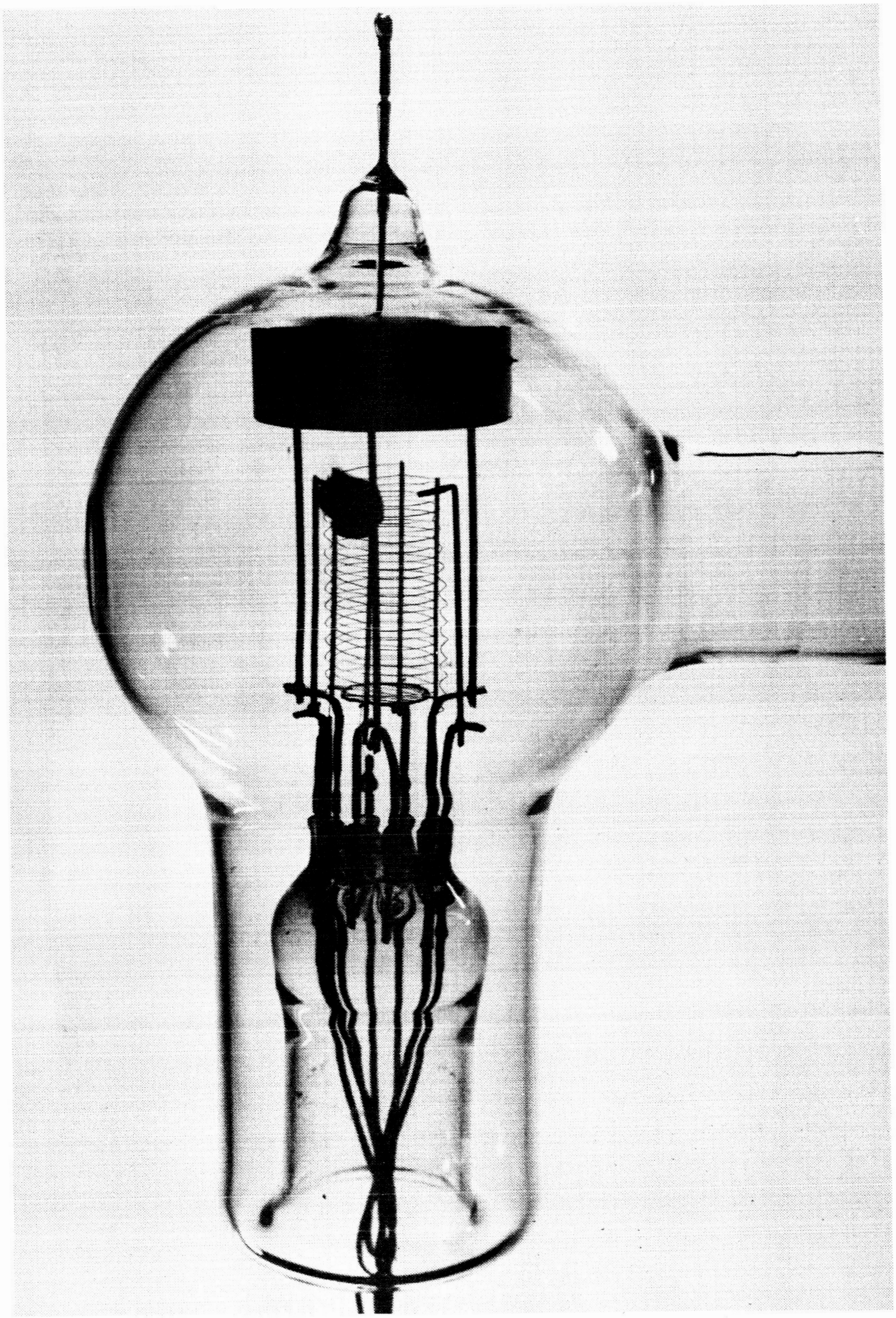

Figure 1. Photograph of Recent Suppressor Ionization Gauge.