Contact Surfaces in Supersonic Flow in Gas Discharges

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During research on the luminosity emitted by electrically excited gases, it was noted that the luminosity extended past the electrodes. Photographs of this phenomenon made with a rotating mirror showed that the luminosity was in the form of a front which moved down the constraining tube with a velocity depending upon the pressure, type of gas, and electrical energy used to excite the gas. It was assumed that this luminous front represented a contact surface between expanding gas excited between the electrodes and gas originally filling the remainder of the tube. To verify this assumption, it was proposed to conduct experiments in which that portion of the tube between the electrodes was filled with one gas, and the expansion chamber filled with a different gas. A spectrographic study of the luminosity would reveal whether it came from gas excited between the electrodes, or from the gas originally filling the expansion chamber, or from both gases. If the luminosity were found to come only from gas originally between the electrodes, the "contact surface" assumption would be supported.

The difficulty in conducting the experiment lay in finding a method of separating the two gases which would not interfere with the gas discharges, but which would separate the two gases until the time at which the tube was discharged. The use of a very thin film seemed to be the best method of separating the two gases.

Unsuccessful attempts were made in which soap films and thin metal foils were employed. The vapor pressure of the soap solution limited the vacuum of the system and presented far too many impurities. Metal foils proved to be poor separators and when vaporized in the discharge of the tube, formed a gas cloud of mass many times greater than the mass of gas in the tube before the discharge.

The first workable film was obtained by the following method: A drop of commercial flexible collodion, diluted with ether, was released on a water surface. It spread, forming a thin film which became even thinner as the ether evaporated, leaving a tough, transparent cellulose film which could be picked up on a wire loop.

The film which finally proved to be the thinnest and strongest was obtained in a similar manner, the only difference being the use of Parlodian dissolved in amyl acetate. Parlodian films only 5×10^{-6} cm thick, which would withstand a pressure difference of 10 mm. Hg when stretched across a 1.5 cm tube, were obtained in this manner.

The experimental procedure was to mount a thin film between two flanges secured to ends of two glass tubes. The flanges were clamped together to vacuum tightness. One flange was machined from nickel and served as an electrode, the other electrode being a cylindrical piece of nickel sealed in the opposite end of the tube from the nickel flange. The other flange was machined from resin-impregnated fiber, a non-conductor. When the flanges were clamped together, the discharge tube was a continuous, straight tube, the portion containing the two electrodes being separated from the expansion chamber portion by the thin film which had been clamped between the flanges.

A forepump and a mercury diffusion pump were used to evacuate the system. Cold traps cooled with liquid nitrogen were used to prevent the entrance of mercury vapor into the discharge tube. It was necessary to exercise extreme caution in evacuating the system. A rapid pumping rate invariably resulted in a broken film, since a pressure difference of only 1 cm Hg across a film caused it to break. For this reason, the stopcock leading to the forepump was opened just enough to allow the system to be evacuated in no less than 30 minutes.

After the discharge tube had been evacuated, it was isolated from the remainder of the vacuum system. The two portions of the discharge tube, separated only by the thin film, were filled with different gases. The procedure used in admitting the gases was to fill one portion of the tube to a pressure of from 2 mm. to 6 mm. Hg. A pressure reading was taken in the other portion of the tube with a McLeod gauge. If the pressure was still of the order of 10^{-4} mm Hg in this side, the film was considered to be intact; whereupon, this side of the tube was filled with a different gas than was used to fill the other side.

The electrical energy used in discharging the tube was supplied by a 15 microfarad condenser rated at 5,000 volts. The potential used was usually 4,800 volts. That 10 cm portion of the expansion chamber tube adjacent to the non-conducting flange was focused on the slit of a spectrograph. The expansion chamber tube was made of vycor, selected, for its wide range of transmission of light waves.

The photographic plates of the spectrograph revealed that the gas originally filling the expansion chamber had not radiated, but that the gas from between the electrodes formed the major portion of the illumination. This would lead to the assumption that the gas between the electrodes had been excited and had expanded, radiating as it traveled and pushing the gas in the expansion chamber ahead of it. It would seem that the contact surface assumption made earlier has been verified.

The first experiments were conducted using hydrogen between the electrodes and helium in the expansion chamber. Helium lines did not appear on the spectrographic plates unless helium was purposely allowed between the electrodes. In later experiments, helium was used to fill the tube between the electrodes, while argon was used in the expansion chamber. In these cases helium lines but no argon lines appeared on the spectrographic plates when examination was made of light from the expansion chamber. At the present time, it would seem that the luminosity traveling along the expansion chamber represents a contact surface between gas from the electrode region and gas from the expansion chamber.