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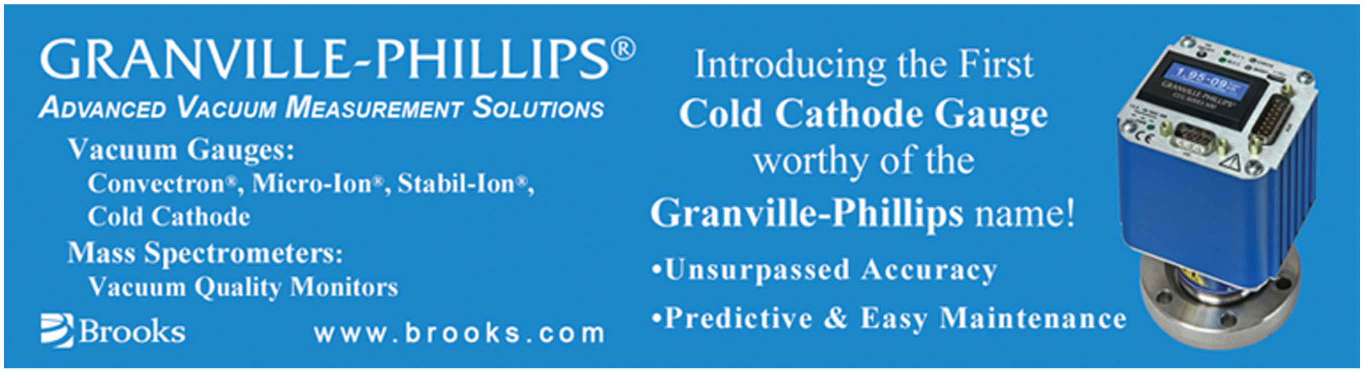

cm^3. The magnetic field varies from zero to about 7 kG over the volume. The microwave source is a 10 mW, 24 GHz klystron coupled through a waveguide to a hole in the cavity wall. The detector is a 1N26 microwave diode in a waveguide coupled through a hole on the opposite side of the toroidal cavity.

The system was calibrated by sweeping the klystron frequency through about 50 MHz and measuring the average mode spacing. The result is about 3.0 MHz/mode which is consistent with the observed Q of about 10^4, but much larger than the theoretical value of 0.012 MHz/mode, indicating that only a small fraction of the modes are observable. The observable mode spacing corresponds to a density increment of 1.8×10^9 cm^{-3}/mode, which we take as the calibration constant for the system.

A plasma was produced by electron cyclotron resonance heating using a high power pulsed magnetron.[6] The decay of the afterglow plasma density was measured using the mode counting technique and a Langmuir probe. Figure 2 shows typical results. The upper trace is the ion saturation current to a long Langmuir probe that line averages the signal across the plasma midplane. This signal, when corrected for the temperature decay, is approximately proportional to the average density. The middle trace shows the analog output of the mode counting circuit which should be proportional to the average density. The scale is about 2×10^{10} cm^{-3} per large division. The lower trace is the output of the microwave diode showing the succession of about a dozen cavity modes excited as the density decays.

In order to test quantitatively the accuracy of the mode counter, the density was varied by varying the power level of the electron cyclotron resonance heating source. The density was measured using a Langmuir probe, properly corrected for changes in temperature, and using the mode counting technique. The result shown in Fig. 3 indicates agreement within about a factor of two from 3×10^9 cm^{-3} to almost 10^{11} cm^{-3}.

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An improved laser-schlieren system for the measurement of shock-wave velocity

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An improved laser-schlieren system for the measurement of shock-wave velocities has been developed which employs a single detector. Calibration of multiple detectors has been obviated. The system has been shown to yield, in addition to the shock-wave velocity, additional information on the arrival time of the contact surface. Shock-tube performance is compared to the predictions of Mirels' theories.

In studies involving the chemical shock tube, the velocity of the incident shock wave is an important parameter since it can be related to the temperature of the shocked gas. In addition, it can be easily measured. The usual method of measuring shock velocity is to time the passage of the shock front past fixed sensors. These sensors must have a response time of less than a microsecond, they must give good space resolution, and they can not interfere with flow in the shock tube. Methods of shock front detection currently used include metal film resistance probes,[1,2] and the Fraunhofer diffraction[3] or Schlieren refraction[4] of a laser beam. This note describes an improvement of the laser-schlieren method.

A laser-schlieren system takes advantage of the change in optical density across a shock front to vary the amount of light falling on a photodetector. Kieffer and Lutz developed this method to study vibrational relaxation in hydrogen[5] and deuterium[6] and it was adapted by Jacobs[7] and D'Amato[8] for velocity measurements. Their system uses a single laser light source split into beams which are transmitted across the shock tube normal to the direction of flow. Each beam has a separate detector. Although there is no theoretical limit to the number of detection stations, the 50% decrease in light intensity at each beam splitting limits the number to three. There is also the difficulty of calibrating each of the multiple detectors to correct for their individual characteristics. This note describes a modification which allows any number of passes with a single light source and a single detector, thus removing this calibration problem.

A series of front-surfaced mirrors (see Fig. 1) reflects the laser beam n times through the shock tube normal to

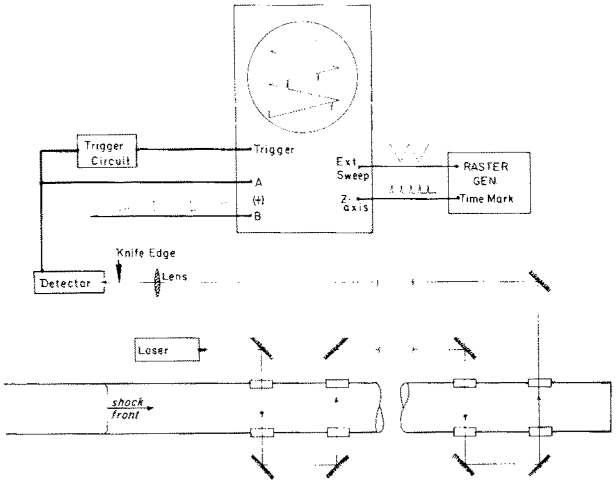

FIG. 1. A laser-schlieren system using one detector.

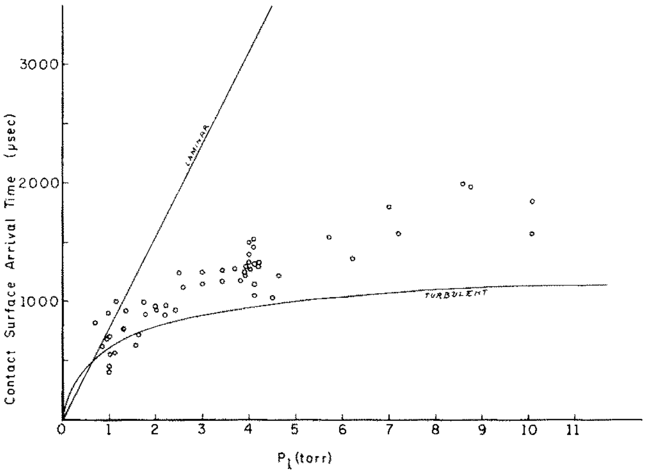

FIG. 3. Contact-surface arrival time as a function of initial pressure.

the direction of travel of the shock front. The undeflected laser beam then passes through a lens and impinges on a knife edge placed across the sensitive region of a photomultiplier. With the passage of the shock front there is an abrupt increase in density and a corresponding change in the optical density of the test gas. The beam is refracted into the denser gas behind the shock front. As the shock front passes the first, third, or any odd window, the beam is deflected on and then off and a positive pulse is generated in the photomultiplier. As the shock front passes the second, fourth, or any even window, the beam is deflected off and then on the knife edge, producing a negative pulse. The train of pulses coming from the photomultiplier is fed to an oscilloscope. If the 'scope lacks a single trigger mode, the first pulse triggers an external single pulse circuit. To increase time resolution a conventional raster generator[9] is used with the horizontal sweep of the 'scope. The single trace is recorded by a camera (see Fig. 2).

This system has been applied to a shock tube made of 7×3 cm aluminum wave guide with a 0.9 m driver and a 3.7 m test section. Six stations are placed 16.7 cm on centers starting 11 cm from the end wall. The distance between the farthest mirror and the detector is made as long as possible since it acts as a lever arm and amplifies the amount of deflection. The light source is a 0.7 mW He–Ne laser with an initial beam diameter of 1.4 mm. The divergence of the beam is 7×10^{-4} rad full angle and the increase in the beam diameter as it passes through the shock tube is negligible. An RCA 931A photomultiplier with an emitter-follower is used as the detector.

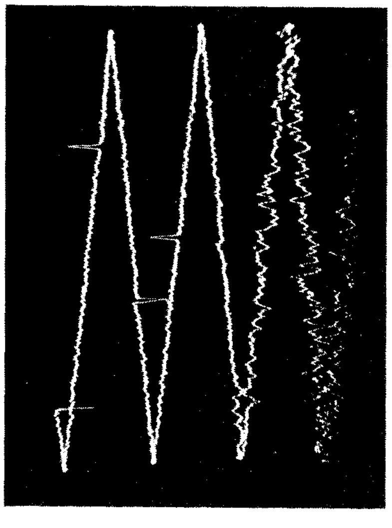

FIG. 2. Record of an experiment with 4 beam passes through the shock tube. The shot was argon into argon with Mach no. 2.34; initial pressure was 2.2 Torr. The raster period was 500 μsec and velocity signals are about one volt high.

The modified laser-schlieren system has some advantages over present velocity measurement systems. It avoids the necessity for calibrating multiple detectors. A problem does exist in that alternate detector responses are of opposite sign. However, proper placement of the beam on the knife edge will cause the 'scope to trigger at the same time relative to the passage of the shock front. (Even this may be unnecessary since, for every other window, the detector responds in the same way.) In contrast to a metal-film temperature probe, a laser-schlieren system records events other than the passage of the shock front. For example, the difference between shock-front and contact-surface arrival times reaches a limiting separation.[10] The time between the beginning of the trace and the abrupt change in noise level was shown to correlate with this separation time. In Fig. 3, times for noise-level change are plotted against the initial shock-tube pressure, p_1. Also shown are graphs of theoretical contact-surface arrival times for flows with purely laminar and purely turbulent boundary layers. Theoretical curves were computed according to the theories of Mirels[11,12]; they correspond to a mean Mach number of 2.25. The experimental points correspond to Mach numbers in the range from 1.86 to 3.24.

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Production of a monochromatic, low energy positron beam using the $^{11}B(p,n)^{11}C$ reaction*

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A new technique has been developed to produce an intense positron source by making use of the $^{11}B(p,n)^{11}C$ reaction. Positrons with well-defined low energies have been observed emerging from the irradiated boron target itself without any additional moderating materials. A description of the apparatus used to produce the ^{11}C and to detect the low energy positrons is given.

In view of the current interest in the development of more intense positron beams for studies of low energy positron–atom interactions, and for solid state surface studies, the present technique has been developed to offer an attractive alternative to the use of other currently available positron sources.

Low energy (a few eV) positron beams have recently been generated[1–3] by using commercially available positron sources such as ^{22}Na and ^{58}Co to produce high energy positrons and then letting the high energy positron flux pass through a moderator,[2] backscatter off the inside of a metallic cylinder,[3] or off a system of MgO coated gold vanes.[1]

An earlier technique used to produce low energy positrons[4] made use of a pulsed (1 A peak current), 55 MeV electron linear accelerator. The positrons were created through pair production by the bremsstrahlung generated by the pulsed electron beam when it struck a tantalum target. Various moderators were used to obtain low energy positrons from the high energy positron flux.

In all the experiments mentioned above, the low energy positrons were found to have well-defined energies with the full width at half-maximum of the low energy positron peak on the order of 1 eV. The emission of these low energy positrons is attributed to moderators or backscattering elements external to the source of high energy positrons. The process which gives rise to the low energy positron peak is not well understood.

The present technique is based on the production of ^{11}C by the reaction $^{11}B(p,n)^{11}C$, which has a threshold of 3.0 MeV. More than 99% of the ^{11}C decays by the process.

$$^{11}C \rightarrow {}^{11}B + e^{+} + \text{neutrino}.$$

The ^{11}C has a half-life of 20.3 min. The maximum energy of the positrons produced by this process is 0.97 MeV.

The apparatus for producing and observing the low energy positron beam is shown in Fig. 1. A 4.5–5.0 MeV proton beam from a Van de Graaff accelerator is used to bombard the boron target. The target is biased at some appropriate positive potential and the electrostatic lens system is used to extract and focus the low energy positrons from the boron target into a beam. After passing through vertical and horizontal deflector plates, the positron beam enters the retarding element, which is a "filter lens" type retarding field energy analyzer.[5] In order to extend the retarding potential region, the deflector plates are biased symmetrically about the potential of the retarding element. The positron beam then enters a curved solenoid in which a small axial magnetic field serves as a guiding path for low energy positrons and discriminates against high energy positrons that cannot negotiate the curve defined by the solenoid. The transmitted positrons are detected individually by a Bendix Channeltron electron multiplier (type CEM 4039). A potential of −180 V

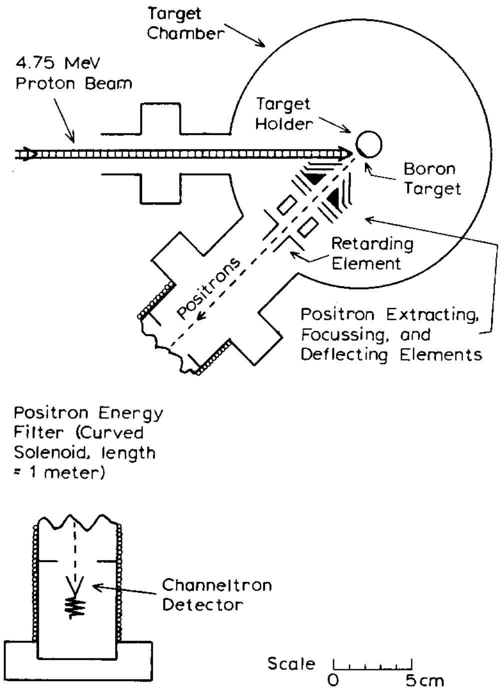

FIG. 1. Schematic of positron beam apparatus.