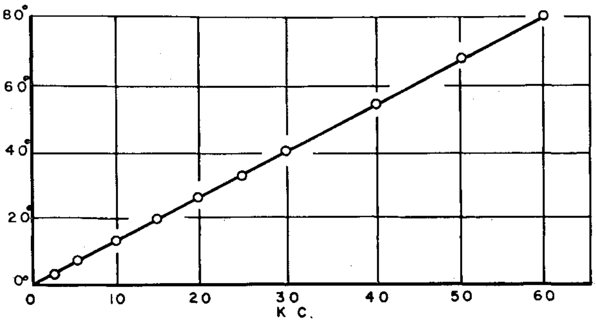

Fig. 3 Multiplier phase lag.

The performance of the multiplier, as indicated in Fig. 2, seems satisfactory for turbulence measurements. The frequency response was obtained under the most strenuous conditions, the squaring of a sine wave which involves doubling of the input frequency. The response is acceptable up to 50 kc, a value rarely exceeded in subsonic flows. A 50 fold range, flat within 0.5 db, is indicated for the amplitude response. There is an undesirable loss in gain near zero input voltage. However, if the signals to be multiplied cover the whole amplitude range, then only an insignificant portion of the desired product is affected. When working with random signals, such as encountered in turbulence measurements, the exact amount of the error is indeterminable since the wave forms and amplitudes are unknown. For the case when $e_1 = e_2 = E \sin\omega t$, the error in the product is 20% for $E = 0.07$ v, only 3% for $E = 0.10$ v, and rapidly goes to zero for increasing E. The gain of the amplification stage determines the usable amplitude range and was chosen to conform with a particular hot-wire anemometer in mind. It can easily be set at any desirable level by change of the feedback resistors.

For measurements of triple voltage products, two multipliers are used in series. Care must then be taken in regards to phase shifts between the first product (e_1e_2) and the new signal e_3. Figure 3 gives the phase lag of the multiplier output as a function of frequency. The phase shift is substantial, but up to 50kc it is linear with frequency. Thus a simple, constant-time delay circuit can be used to put e_3 in phase with the product (e_1e_2).

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Structure of Gaseous Detonations in a Convergent-Divergent Channel

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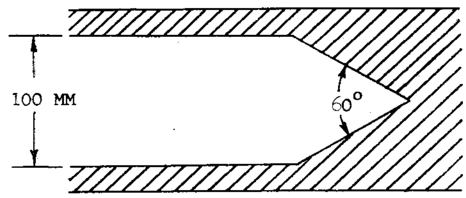
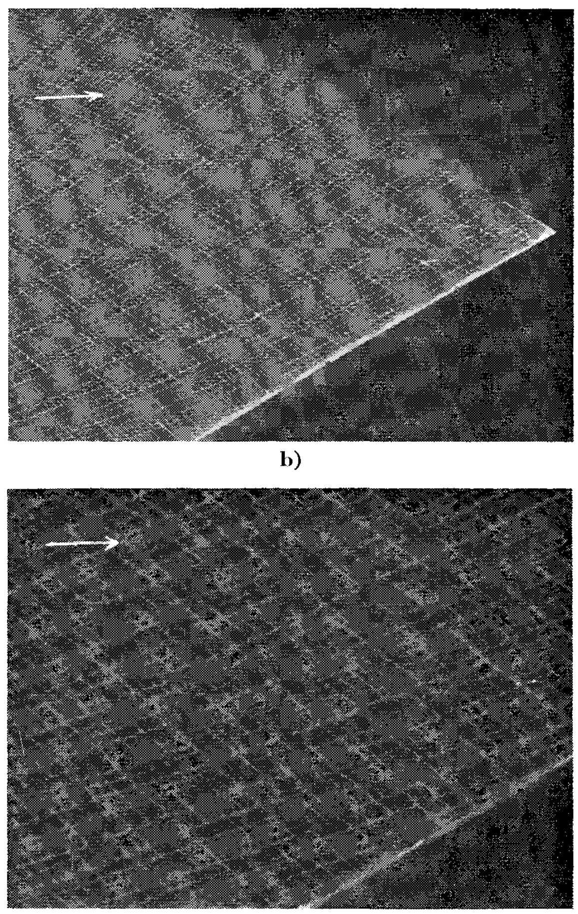
SUFFICIENT evidence has been gathered in recent years to show conclusively that gaseous detonation waves are unstable.[1] The structure of the detonation wave is extremely complex, consisting of localized ignition heads. Combustion spreads in the transverse direction along the shock front and results in a highly turbulent reaction zone. A technique to achieve a laminar detonation was proposed by White[2] utilizing a convergent-divergent channel. The concept behind this technique is to produce a highly overdriven detonation wave in the convergent channel so that the detonation wave in the divergent channel remains sufficiently overdriven to retain a laminar structure, at least as a transient condition. The spark interferogram of White does indicate that a laminar reaction zone was achieved. In this note, some experimental observations of the structure of a gaseous detonation wave propagating in a convergent-divergent channel are reported. Equimolar acetylene-oxygen mixtures were used, and the experiments were performed at subatmospheric initial pressures ranging from 4- to 8-cm Hg.

To observe the structure of the detonation wave, the open-shutter technique was used. The technique is to focus the transparent window of the convergent-divergent channel onto a stationary film. The shutter of the camera is kept open throughout the duration of the experiment, and the aperture is adjusted so that normal burning is not recorded and only the highly luminous ignition heads can cause sufficient exposure on the film. This technique works best when the



a)



b)

c)

Fig. 1 Open-shutter records of the propagation of a detonation wave in a convergent channel. Equimolar acetylene-oxygen mixture at an initial pressure of 60-mm Hg is used. An enlarged view of the multihead structure of the detonation wave is shown in c). The thickness of the channel is 2 mm. The direction of propagation of the detonation wave is indicated by arrows.

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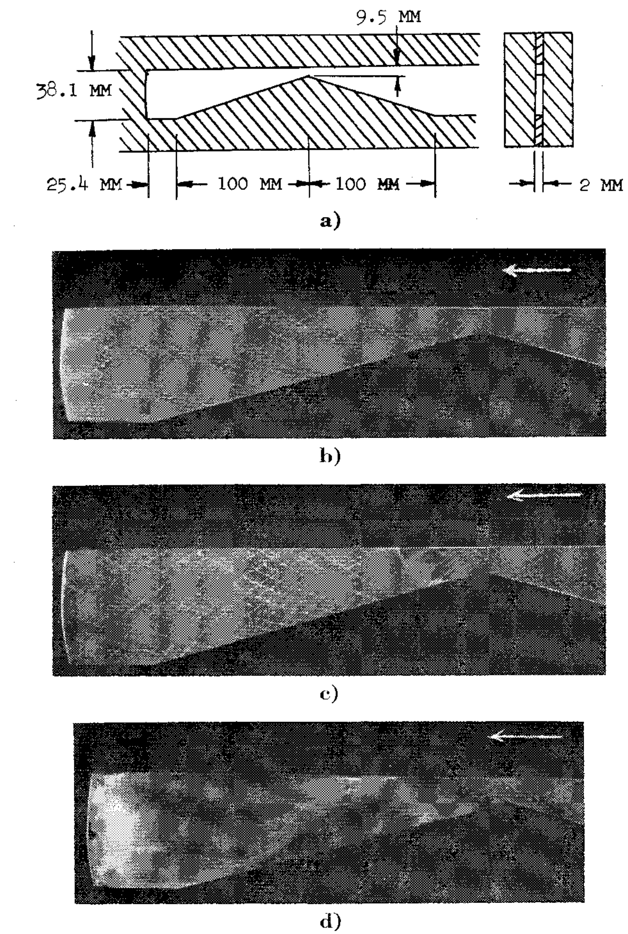

Fig. 2 Open-shutter records of the propagation of a detonation wave in a convergent-divergent channel. Equimolar acetylene-oxygen mixture at an initial pressure of b) 60-mm Hg, c) 50-mm Hg, and d) 40-mm Hg is used. The dimensions of the channel are given in a). The direction of propagation of the detonation wave is indicated by arrows.

thickness of the channel is of the order of the reaction zone thickness (~ 1 mm). From experience, it has been found that the best quality pictures could be obtained with equimolar acetylene-oxygen mixtures. The paths of the ignition heads recorded by the open-shutter technique were found to be identical to those obtained using the soot film technique.[3]

Typical open-shutter records of a detonation wave propagating in a convergent channel are shown in Fig. 1. In Fig. 1c the entrance of the detonation into the convergent channel is shown and a multihead structure is observed in the initial straight portion of the channel. As the detonation wave becomes progressively overdriven in the convergent section, one would expect the multihead spinning structure to become finer and finally reach the stage where it can no longer be resolved. However, this was not observed and the present results indicate that, in spite of the compressional effects caused by area convergence, the structure of the detonation remains uniform. This suggests that the multihead structure is not altered by the conditions behind the detonation wave.

The changes in the structure of a detonation wave propagating in a convergent-divergent channel are illustrated in the open-shutter records shown in Fig. 2. As shown in Figs. 2b and 2c, the overdriven detonation wave decays as it propagates past the throat into the divergent section. This attenuation is indicated by the reduction in the number of ignition heads per unit length of the detonation front. Further downstream from the throat, the detonation wave regains its regular multihead structure, which is a characteristic of the properties of the mixture itself (i.e., reaction zone thickness). The decay of the detonation wave in the vicinity of the throat in the divergent section is more severe with lower initial pressures. In Fig. 2d, the multihead wave, on emerging from the throat, decays to a single-head wave.

The present results show that area convergence does not seem to alter the multihead structure of a detonation wave. However, a sudden area increase results in a decay of the detonation wave, indicated by a reduction in the number of ignition heads per unit length of the detonation front. From the present experiments it does not appear that a convergent-divergent channel can produce a laminar detonation wave under all conditions. The laminar structure observed by White is probably taken on a single-head wave shown in Fig. 2d. These observations further substantiate the complexities involved in a detonation wave, and extreme care must be exercised in performing detonation studies of a quantitative nature.

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