the flow lines radiate as diverging straight lines from the muzzle. These latter facts we can confirm by a photograph, reproduced in Fig. 9, in which we have made the flow lines directly visible. This was accomplished by removing the bullet from the cartridge and by replacing it with a wad in order to retain the powder in the shell. Then if this cartridge were used for ignition, the burning of the powder was not all complete as a consequence of the essentially lower pressure, and a large number of unburned powder particles flowed out of the muzzle, making the flow lines recognizable.

The probe method may also be used to demonstrate the pressure difference in the flow pattern in contrast with the surrounding air. If the probe is brought very close to one of the compression lines at the side, then the waves originating at the point of the probe are formed not only within the compression line but also outside it, the waves being broken in the manner shown in Fig. 10. Measurement of the interior wave-angle α and the exterior angle α' gives the ratio of the velocities of propagation of the gas particles within (v) and without (v') the flow pattern:

$$\frac{\sin \alpha/2}{\sin \alpha'/2} = \frac{v'}{v}$$

This ratio of the velocities of propagation probably offers the possibility of obtaining the pressure within the flow pattern, which in turn would permit an inference of the gas pressure at the muzzle. We intend to treat these questions in a special paper. For the production of the flow pattern, whose investigation is of the most importance to us in the present work, it is important, since it agrees with the rest of the results, that the pressure difference at the compression lines is quite large, and that these lines should represent a really sharp boundary of the flow pattern.

We can now proceed to explain in detail the origin of the flow pattern as it is schematically represented in Fig. 11.

When the body of the bullet just leaves the muzzle (Fig. 12), gases compressed to about 300 atmospheres are mechanically necessary to take the path