A STUDY OF THE ACTION OF SOUND WAVES ON UNIGNITED JETS OF GAS.

By F. L. Tufts.

IN this work the Schlerin method of investigation, used and described by Toepler, C. V. Boys, R. W. Wood and others, was applied to the study of the behavior of unignited jets of gas when subjected to the action of sound waves. Photographs were taken, giving a number of instantaneous positions of a jet of unignited illuminating gas when acted on by the sound waves from an ordinary organ pipe. The orifice from which the gas issued was rectangular in shape and was 4.0 mm. by 0.5 mm. in cross section. It was placed about 6 cm. from the open end of an organ pipe which spoke a fundamental note of 100 vibrations per second. A thin rubber diaphragm was placed across the inside of the pipe at the node of the fundamental note, and thus protected the jet from the action of direct currents of air while it did not interfere with the speaking of the pipe. The jet tube was placed so as to expose the broad side of the gas stream to the to-and-fro motion of the air particles in the sound wave.

The photographs taken showed the sinuous shape of the jet near the orifice, the fan-shaped spreading of the gas particles as they recede from the orifice and, for low velocities of efflux, the division of the jet into two.

Plates I. to IV. are reproductions of some of the photographs taken. Plates I. and II. show two successive positions of the gas stream. In Plates III. to IV. the velocity of efflux was less and the tendency of the stream to divide into two is evident. This is particularly prominent in Plate IV. The sinuous structure of the stream near the orifice is noticeable in all of the photographs, and in most of them traces of it can be found even in the diffused upper portions. The disturbed condition shown in the upper portions of

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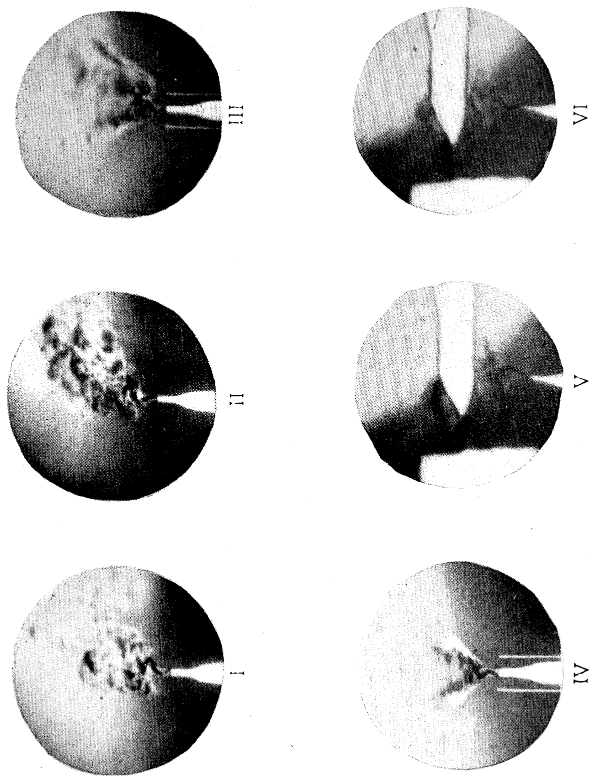

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Plates I. and II. is probably due to air currents in the room. The two pins, shown at the sides of the jet tube in Plates III. and IV., are just one centimeter apart and serve to give an idea of the actual magnitude of the phenomena.

A simple geometrical construction, shown in Fig. 1, gives positions for the gas stream which agree well with the actual positions shown in the photographs. The assumptions upon which the construction is based are the following:

1. Each particle of gas as it issues from the tube moves forward in a straight line, and with a velocity which is the resultant of the combination of the velocity of efflux of the particle and the instantaneous value of the harmonically varying velocity of the air particles about the jet at the instant the gas particle issues from the orifice.

2. This resultant velocity decreases in value as the gas particle recedes from the orifice.

In Fig. 1 the ordinate, *jd*, represents the velocity of efflux of the gas particles. The abscissæ, *dg*, *df*, *de*, *dc*, etc., represent suc-

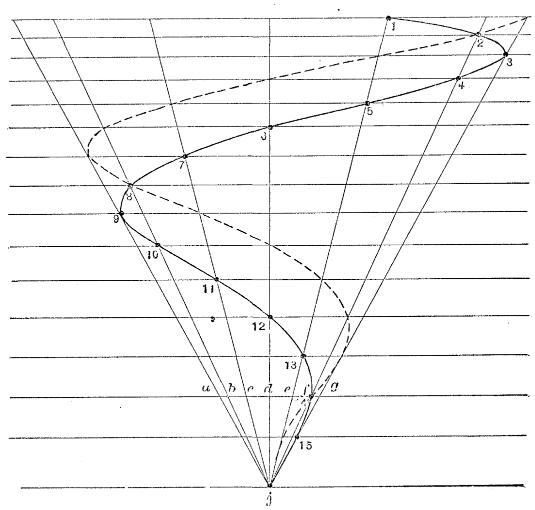

Fig. 1.

cessive values of the harmonically varying velocity of the air particles, due to the sound wave. The lines *jg*, *jf*, *je*, etc., represent the resultant velocities of successive gas particles as they issue from the orifice. The decrease in the velocity of the gas particles on receding from the tube is taken account of in the spacing of the horizontal lines. The lengths of a radial line intercepted between successive horizontal lines are assumed to be proportional to the velocities with which the gas particle moves as it recedes from the tube.

Suppose the organ pipe used gives a fundamental note of 100 complete vibrations per second, and it is desired to find the positions of successive gas particles following one another from the orifice at intervals of 1/1200 of a second. An inspection of the figure will show that if the distance traveled by a given particle during 1/1200 of a second after leaving the orifice is represented by the line, *j* 15, then the particles which preceded this one at intervals of 1/1200 of a second will occupy the positions marked 14, 13, 12, 11, etc. A curved line connecting these points represents the position of the gas stream at a given instant. Two twelve-hundredths of a second later the position of the gas stream will be that of the dotted line in the figure. The curves thus obtained are very similar to those actually observed in the photographs.

This construction also explains the apparent division of the gas stream into two when the velocity of efflux is small. A low velocity of efflux would be represented by a closer spacing of the horizontal lines in the figure. Under such conditions it is evident that the gas particles would be crowded closer together along the radial lines *jf*, and *jb*, than along any other radial lines and would thus give the gas stream the appearance of dividing into two. The photographs which show a division of the gas stream, show traces in each jet of a structure like that at 2, 3, 4, in the figure.

If the source of sound contains over-tones which are at all comparable in intensity to the fundamental, a construction similar to that of Fig. 1, will account for the division of the gas stream into three or more jets, a phenomenon which has been noticed.

In a number of cases the velocity of efflux of the gas from the orifice was measured by means of a gas meter, the pitch of the organ pipe was determined, and the angle *ajg*, Fig. 1, was measured on the photograph of the gas stream. From these data calculations of the amplitude of vibration of the air particles in the sound wave were made, based on the geometrical construction given above. The results agreed very well with those obtained by other methods.

The Schlerin method was also employed in studying the vibrations of the tongue of air in the mouth of a speaking organ pipe. A stopped flute pipe of rectangular cross section was used. The two sides of the pipe were of plate glass and the air with which the pipe was blown passed over a surface of ether before entering the pipe, thus changing its optical density and making it readily visible in the Schlerin apparatus. A number of instantaneous photographs were taken showing different positions of the tongue of air in the mouth of the pipe. The direction of the vibration within the pipe was obtained by introducing a small jet of unignited illuminating gas in the pipe near its mouth and photographing it on the same plate with the tongue of air.

Plates V. and VI. are copies of two of the photographs showing the tongue of air in the two extreme positions of its swing. The only portions of the pipe shown in the photograph are the lip and a part of the butt containing the air slot. The curve of the gas stream serves to indicate the direction of the vibration within the pipe.