FURTHER EXPERIMENTS WITH SINGING TUBES

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Two years ago at the Rockford meeting of the Academy of Science the writer listed 32 experiments as suitable for lecture table use, and also set down a short series styled "Sleight-of-hand in physics", centered around the singing tube.[1] Since only isolated demonstrations of the singing tube have been given before the Physics Section it was thought desirable to complete the series to date.

The results that may be obtained are surprising and rather mystifying. The energy that motivates these tubes comes from a difference in temperature of the air within two parts of the tube. At room temperature this difference, sufficient to make the tube sing, is obtained by heating the closed tip, Fig. 1, with a Bunsen burner (or an electric heater) to about 320° Centigrade. Just why the tube sings has not yet been completely or satisfactorily determined, though numerous physicists, including several theoretical workers, have given it attention. The most satisfactory experimental explanation, in the writer's opinion, is that by the late Professor Jakob Kunz[2].

The tip must always be warmer than the body of the tube. Two cases may be cited: **Case I.**—Heating the tip. The body is kept at room temperature, while the tip, to cause the tube to sing, must be heated to about 320° C. The essential requirement is to maintain a considerable temperature difference. The exact value of this difference in temperature depends on the physical dimensions of the tube, and these are quite critical.

Case II.—Cooling the body of the tube (with liquid air). From the statements made above it is reasonable to expect that a tone also should be emitted if we leave the tip at *room* temperature (20° C.) and cool the body of the tube to the temperature of liquid air (Figs. 4 and 5), i. e., to —180° C. With a carefully constructed tube this *temperature difference*, 200° C., was actually found to cause the tube to sing. The mechanism of the vibrating air is exactly the same as in the first case, except that the temperature difference is now between different limits. This is made

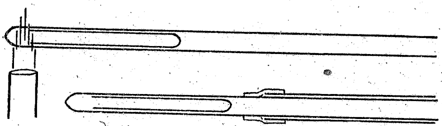

Fig. I

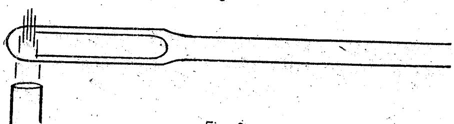

Fig. 2

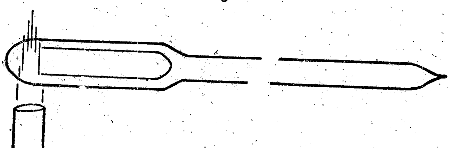

Fig. 3

Fig. 1.—Original of the straight form of the singing tube, styled the "Vest pocket" size. They are made in pairs. One tube has a sliding sleeve for tuning when the two are sounded simultaneously, (beats).

Fig. 2.—A larger form (but one shown). In addition to the sliding sleeve there are extensions for showing the relation of pitch to length, (low pitch, very loud, beats).

Fig. 3.—Large form with open end *closed*. This corresponds to a closed organ pipe, except that the tube is *entirely* closed. Vibrates but no sound is audible, (uncanny). May be made audible by setting the cold end of tube on a resonator—a table top, or against a wooden blackboard. Two such tubes simultaneously operated as above produce audible beats.

[1] *Trans.* Ill. State Acad. Science, XXX, p. 253, 1937.
[2] C. T. Knipp and Jakob Kunz, NATURE. CXX, p. 362, Sept. 10, 1927.

clear by the following tabular presentation:

	Temperature of tip		Temperature of body		Difference in temperature
Case I	+ 320°	—	(+ 20°)	=	300° C.
Case II	+ 20°	—	(— 180°)	=	200° C.

Further, the magnitude of the temperature difference in the two cases is less, as the tabulation shows, by about 100° C. And further still, the pitch is much reduced, however, this is what one should expect, since the pitch of an organ pipe is lowered with lowering temperature. In addition to the above the tube sings apparently on a less expenditure of energy. A burning match applied to the tip (Case II) makes the tube roar.

In case the tube is cooled with liquid nitrogen, which is colder than liquid air, the intensity of the tone emitted is increased, attended by a lowering of the pitch.

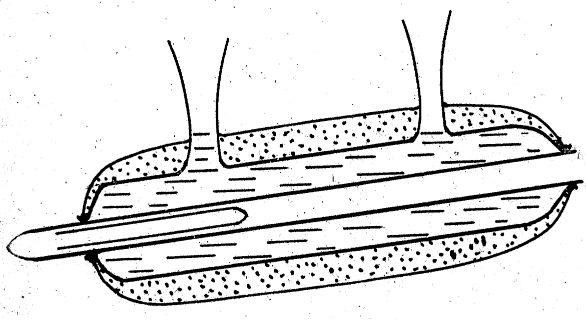

Fig. 4

Fig. 4.—Tubes in Figs. 1, 2, and 3 are made to sing by *heating* the tips, while the tube sketched here (Case II) will emit a musical note by leaving the tip at room temperature and *cooling* the body of the tube to the temperature of liquid air, as shown. Two tubes thus mounted and simultaneously cooled will produce beats, (effect surprising).

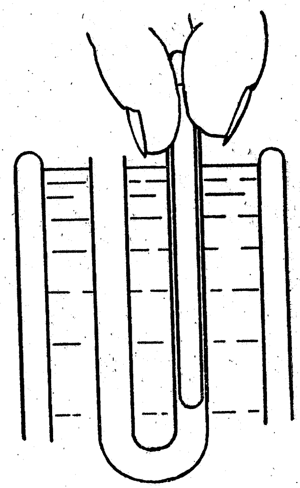

Fig. 5

Fig. 5.—The straight tube of Fig. 1, or Fig. 4, is bent in the form of a U. The body of the tube (the U portion) is then cooled to the temperature of liquid air (Case II), while the tip is kept at room temperature. To operate grasp the tip by the right hand between the thumb, fore and middle fingers and lower into a Dewar ask filled to the brim with liquid air as shown. The tube will begin singing in about 45 seconds. Two such tubes lowered in liquid air simultaneously will produce beats.