SCIENTIFIC APPARATUS AND LABORATORY METHODS

DEMONSTRATION OF BEAT NOTE AND OTHER ACOUSTIC PHENOMENA

THE phenomenon of beats and the principle of interference of sound waves is well known to every student of acoustics. It is commonly recognized that beats may give rise to a differential tone when the difference in frequencies of two loud sources of sound is sufficiently great to make a musical tone. However, the student is seldom given an opportunity to observe such tones for himself. A simple and convincing demonstration of beat-note and other phenomena is possible with an inexpensive apparatus, which may be readily constructed. It consists of two shrill variable-pitch metal whistles blown simultaneously through a T-tube. On account of the high frequencies emitted, only a small musical interval is required to produce a loud beat-note sufficiently removed in pitch from the whistles to be readily recognized by even an untrained ear. Furthermore, the beat-note may be caused to rise and fall two or three octaves by altering the pitch of one whistle only two or three half-tones, while the other whistle remains steady. It is easy to show that the variable low-pitch sound is in reality a Helmholtz combination tone by observing its disappearance when either whistle is silenced while the other continues to emit sound.

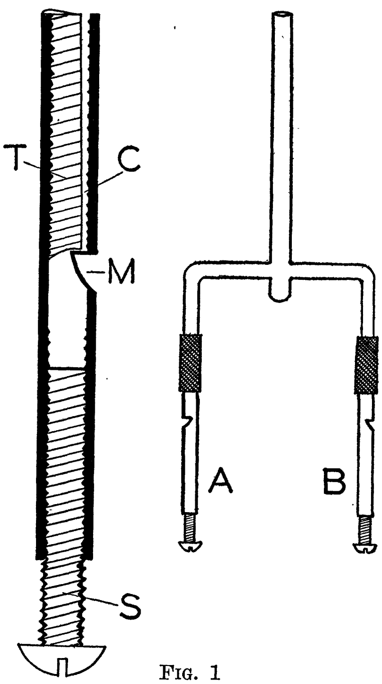

FIG. 1

Each whistle consists of a 6 cm length of brass tube, 4 mm internal diameter, threaded internally by a 10-32 tap. The speaking mouth *M* is a v-shaped cut filed half way through the tube at its midpoint (detail, Fig. 1). A piece of 10-32 screw, *T*, flattened on one side to make a narrow air passage, *C*, is inserted in the upper end of the tube to direct the air against the lip of the pipe. It is held in position by a bit of solder. A movable 10-32 screw, *S*, controls the resonant length of the pipe and hence the pitch. The end of this screw is filed flat to make a smooth stop for the closed pipe. A drop of machine oil on the threads helps to lubricate the screw and make it airtight. Such a whistle gives a loud fundamental with an approximate range from 2,500 to 5,000 vibrations per second corresponding to an octave which includes the highest notes on the piano. It emits a tone rather free from harmonics unless strongly "overblown."

Three or four interesting phenomena may be effectively shown with this simple apparatus. (1) *Beat Note.* While maintaining whistle A at constant pitch, change whistle B from a pitch above to a pitch below A. Observe the beat-note, which sounds much like the whistling of the wind on a gusty day: at first this note falls in pitch, then disappears and finally returns to rise in pitch as B continues to fall below the pitch of A. It is especially striking to observe the change of B and the beat-note in opposition to each other. The whistle of the beat-note sounds very much like the heterodyne whistle obtained in tuning a regenerative radio receiver. (2) *Temperature Effect.* Tune the whistles to unison by eliminating the beat-note. Then, while both are sounding, hold a lighted match under one whistle. The differential tone again asserts itself, due to the increased velocity of sound and the consequent rise of pitch in the heated whistle. The flame of a Bunsen burner accentuates the effect. Both whistles should be blown through the T-tube to avoid spurious pitch variations due to change of blowing pressure. (3) *Gas Density Effect.* After tuning the whistles to unison, blow one whistle with air, the other with illuminating gas passing through a long rubber tube. At the moment the gas expels the air from the tube, the pitch rises markedly in the gas-blown whistle. Disconnect the tube from the gas outlet and again blow the whistle by air, noting the sudden fall in pitch which occurs when air again fills the whistle. The influence of gas-density on the velocity of sound is thus convincingly demonstrated; it may be rendered still more pronounced by using compressed hydrogen or carbon dioxide, the first to cause a rise in pitch, the second to cause a lowering. Incidentally, these whistles may be operated on the gas supply to produce steady high-pitched sources: simply ignite the gas to prevent its escape into the room. (4) *Doppler Effect.* Attach one whistle to a piece of rubber tubing 1.5 meters long. Swing the whistle in a horizontal circle while blowing steadily through the tube. An observer seated outside the circle will hear the periodic rise and fall of pitch accompanying the approach and recession of the whistle. For this experiment a medium pitch is preferable to a high, since the *ratio* of pitches for approach and recession, $n_1/n_2 = V + v/V - v$, is independent of the "rest pitch" of the whistle, whereas the ear is more sensitive to variation of pitch at 2,500 vib./sec. than at 5,000.

Using whistles of smaller diameter than those described here, the author has pursued the beat-note phenomenon to the upper limit of audibility, where the beat-note disappears as soon as either whistle exceeds the audible range of the ear—in this case above 22,000 vib./sec.

RICHARD M. SUTTON

PHYSICS DEPARTMENT
HAVERFORD COLLEGE

AUTOMATIC HYPODERMIC INJECTOR

SELF-ADMINISTRATION of medicine by the hypodermic method has become very common in recent years. Ever since Dr. Banting, of Toronto, in 1922, isolated the hormone insulin from the islands of Langerhans in the pancreas, the injection of this substance before each meal has become the recognized treatment of diabetes. The hormones of other internal secretory glands are being isolated, and promise to become control medication in various deficiency diseases. Being of organic chemical composition, hormones are digested when taken by mouth, and must be injected subcutaneously to give their systemic effect. Patients who suffer from a hormone deficiency must have the substitute injections so frequently, usually several times a day, that it becomes impractical to have them administered by a doctor or a nurse, and necessitates the patients giving themselves the injections. Besides hormones, other substances that must be injected frequently over a prolonged period of time, such as hay fever vaccine, for example, are best administered by the patients themselves.

Hypodermic self-injection, however, has the drawback that ordinarily it is painful. And to inflict pain upon oneself is against the deep-rooted instinct of self-preservation. The fear of pain causes a hesitancy on the part of the patient when he is about to push in the needle. Hence the procedure becomes slower and more awkward than it need be. Slower penetration results in more distortion of the skin, more stretching and tearing of the sensitive nerve endings, and consequently more pain.

Due to this drawback many diabetic patients are denying themselves the health-preserving and life-saving benefits that insulin would give them. Diabetes is markedly on the increase, involving over a half million people in this country alone, and has climbed into tenth place in the list of death causes. In order to encourage diabetics to use insulin, an automatic injector has been perfected, which eliminates pain by the extreme rapidity with which the needle is plunged into the tissues, and which substitutes an automatic thrust for the fearful manual push.

The automatic injector consists of a compression spring, within a metal casing which fits around the upper end of an ordinary insulin syringe. The calibrated lower end of the syringe is left uncovered so that the dose of medication may be properly measured. The spring is released by means of a trigger. An adjustable foot-rest at the bottom assures the correct depth and angle of needle insertion, and makes it practically impossible to break off the needle in the tissues. The syringe as well as the needle are separately removable for sterilization purposes. The injector is easily operated by laymen, is very durable, and last but not least is reasonable in price.

It is hoped that this little device will save many a timid person from an early grave, and will dislodge diabetes from the upper part of the list of death causes.

HERBERT BUSHER

ST. PAUL, MINNESOTA

SPECIAL ARTICLES

THE ERGOT ALKALOIDS

A RECENT preliminary report[1] has been made of the isolation of proline (as the double gold salt of its methyl ester) after hydrolysis of ergotinine in methyl alcoholic hydrochloric acid solution and also from among the products of the reductive cleavage of this alkaloid with sodium in butyl alcohol. Among the products of the latter we have also obtained several other bases, one of which was interpreted as a substituted piperazine, $C_{14}H_{20}N_2$, resulting possibly from the reduction of the mixed anhydride of proline and phenylalanine and another base, a phenylpropanolamine, possibly a phenylalanine product. These interpretations have been more recently substantiated by the isolation of phenylalanine itself from the products of the alkaline hydrolysis of ergotinine. Thus ergotinine and therefore ergotoxine are built up of the four constituents, lysergic acid (as its amide, ergine) isobutyryl formic acid, proline and phenylalanine. The accepted formula for ergotinine, $C_{35}H_{39}O_5N_5$, is consistent with the conjugation of these components (in peptide linkage) with the loss of three moles of water.

We have more recently made a preliminary study of ergotamine (obtained from the ergotamine tartrate of the Sandoz Chemical Works) by the same methods.

1 W. A. Jacobs and L. C. Craig, *Jour. Am. Chem. Soc.*, 57: 383, 1935; *Jour. Biol. Chem.*, 108: 595, 1935.