EXPERIMENTAL PHONETICS AND ITS UTILITY TO THE LINGUIST.[1]

THE art of speaking a foreign language demands (among other things) an ability to perform all kinds of difficult movements with the tongue and other parts of the speech-mechanism. Such ability may be acquired by the learner, if he is provided with precise instructions as to what he must do. It is the function of the phonetician to supply these instructions.

Instructions as to how to pronounce must, in order

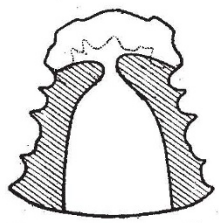

FIG. 1.—Palatogram of *s*.

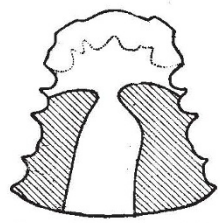

FIG. 2.—Palatogram of the English sound of *sh*.

to be efficacious, be based on accurate analysis of the pronunciation. Many of the facts of pronunciation can be ascertained by direct observation (by auditive, visual, tactile, and muscular sensation) on the part of those who have a specially trained ear and a highly developed control over their vocal organs. These methods are extremely important, and no satisfactory analysis of a language can be made without them. Other methods, however, may be used to supplement these, namely, mechanical analysis by means of a specially designed apparatus. Analysis of this kind constitutes the branch of phonetics known as experimental phonetics. It is with these mechanical aids to analysis that we are here concerned.

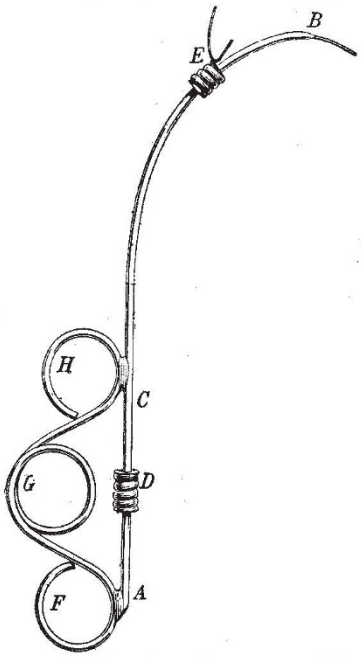

FIG. 3.—Atkinson's mouth-measurer. ACB, tube; D, handle of wire; E, tooth-stop; FGH, handle.

It will be well to give first a few examples to show how information regarding *tongue-positions* may be ascertained experimentally.

One way of getting information is that known as *palatography*. It consists in using a special kind of artificial palate, in order to find out what parts of the roof of the mouth are touched by the tongue in the production of different speech-sounds.

The requirements of this special type of artificial palate are that it should be very thin, should fit very accurately, should be dark coloured, and should cover the whole of the hard palate, alveolars, and the underside of the upper front teeth. Such palates may be made of vulcanite, or metal, or other substances.

When the palate is to be used, it is dusted over with powdered chalk; it is then inserted into the mouth; the sound to be studied is pronounced, and the palate is taken out. It will be found that the chalk has been removed by the tongue at every point which the tongue has touched in articulating the sound. So the areas touched by the tongue appear dark, while the parts of the palate which are not touched remain white.

The shapes of the dark areas may be recorded by photography if desired, but it is generally sufficiently accurate, and a good deal more convenient, simply to copy the dark areas on to a previously prepared outline diagram of the palate. (The result is, of course, a projection of the true shape.) The finished diagrams are called *palatograms*. Palatograms will be found to corroborate observations of tongue-positions made by other methods.

Figs. 1 and 2 are examples of palatograms.

We will now turn to methods of ascertaining the *shapes* assumed by the tongue in the articulation of speech-sounds, and more particularly the shapes of a section of the tongue down the mesial line, and their relations to the centre-line of the palate.

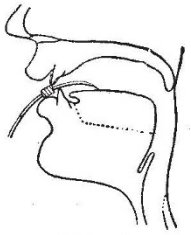

FIG. 4.—Atkinson's mouth-measurer in position.

One method of ascertaining these shapes was invented by Dr. E. A. Meyer, of Stockholm. It consists in using an artificial palate down the middle line of which are fixed some lead threads which hang vertically. These threads are of such a thickness that the pressure from the tongue will bend them when a speech-sound is produced; but they are strong enough to remain in the position into which they are pushed. So that if the palate is taken out of the mouth after pronouncing a speech-sound, the lead wires show the outline of the tongue-position compared with that of the palate. There is a means of transferring these outlines to paper.

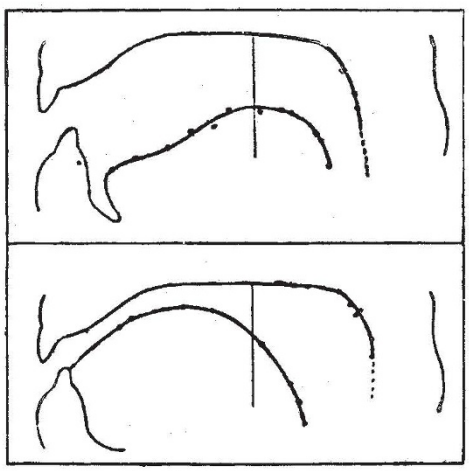

FIG. 5.—Tongue-positions of the English vowels in *bath* and *beat* as ascertained by Atkinson's mouth-measurer.

A second apparatus for obtaining similar results is the "mouth-measurer" invented by H. W. Atkinson.[2] There is a tube of the shape ACB, shown in Fig. 3, and inside the tube is a wire which can be pushed along (by means of the handle D) and made to project to different lengths from the end of the tube. A projecting piece of metal, called a "tooth-stop" (E), is

[1] Abridged from a discourse delivered at the Royal Institution on February 9 by Mr. Daniel Jones.

[2] Obtainable from Mr. H. W. Atkinson, West View, Eastbury Avenue, Northwood, Middlesex. (Price 5*s*. 6*d*. for set of two mouth-measurers, with accessories.)

attached to the tube; it can be fixed at various points. FGH is a wire handle.

To use the instrument, it is placed in the mouth either in the manner shown in Fig. 4, or else so that

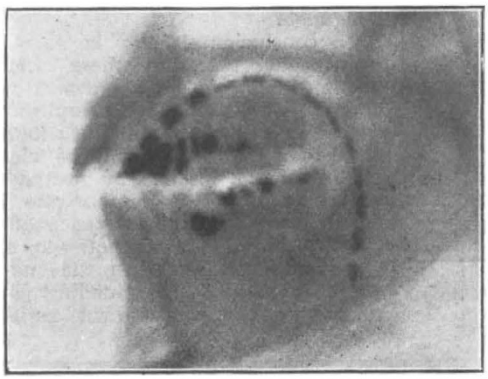

FIG. 6.—X-ray photograph of cardinal vowel *i* (as in French).

the tube is in contact with the teeth at the tooth-stop and also in contact with some point of the palate (the position of the apparatus depending on the nature

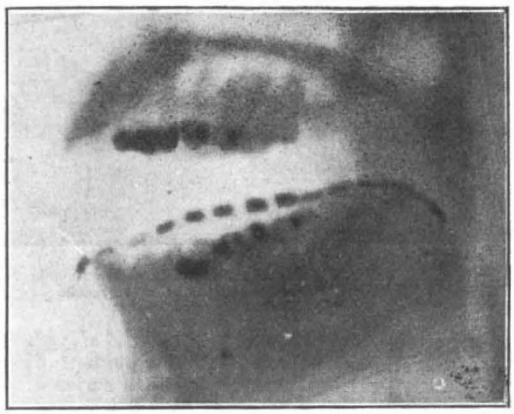

FIG. 7.—X-ray photograph of cardinal *a*.

of the sound to be analysed). The wire is then pushed along until the end of it is felt to touch the tongue. The instrument is withdrawn and applied to a pre-

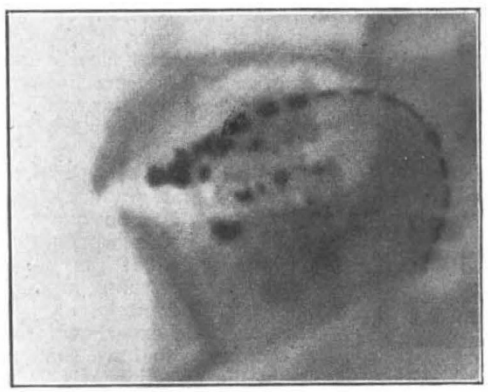

FIG. 8.—X-ray photograph of cardinal *u*.

viously prepared diagram of the shape of the observer's palate. The position of the end of the wire is then marked on the paper.

Further observations are then taken with the tooth-stop fixed at other points. In this way the positions of other points of the surface of the tongue are ascertained. In the end we get on our paper a series of, say, ten or more points which show with fair accuracy the shape of the most important part of the tongue.

Fig. 5 shows specimens of results obtained by this means. They were prepared by Mr. Atkinson, and are reproduced here by his kind permission.

A third method of obtaining sectional diagrams of tongue-positions is X-ray photography. In order to

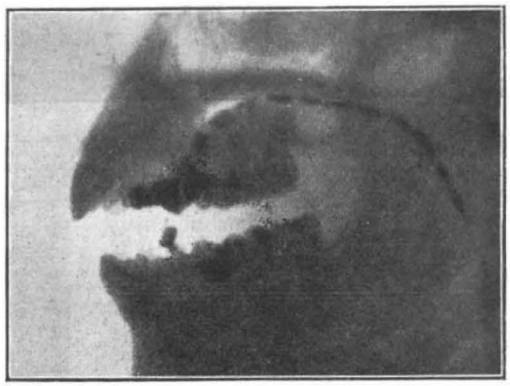

FIG. 9.—X-ray photograph of the sound *k* as in *cave*.

get good results by this process it is necessary to make use of some opaque substance to show the outline of the tongue. The plan which has given the most successful results is to place on the tongue a little chain of small lead plates. (This plan was originally devised by Dr. E. A. Meyer.)

Figs. 6 to 10 are photographs of this description taken by Dr. H. Trevelyan George, of St. Bartholomew's Hospital, who has displayed much ingenuity and patience in getting over the numerous difficulties which present themselves in the course of work of this nature.

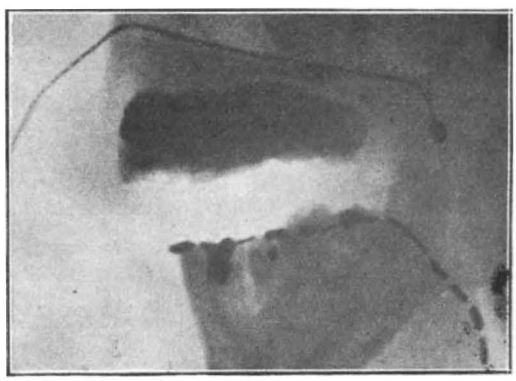

FIG. 10.—X-ray photograph of Welsh *o*, as in *ton*, "wave." Said by Mr. Stephen Jones, Assistant for Experimental Phonetics at University College, London. Tongue-position shown by lower chain. The upper chain passes through the nose, and shows the shape of the upper side of the soft palate.

Another element of speech which can be successfully studied by the methods of experimental phonetics is the vibration of the vocal chords. Some speech-sounds (*e.g.* normal *v* or *z*) are accompanied by vibration of the vocal chords, others (*e.g. f, s*) are not; others, again, are accompanied by vibration during a part of their length. It is important for linguistic purposes to ascertain with accuracy the precise points where vibration of the vocal chords begins and ends in connected speech.

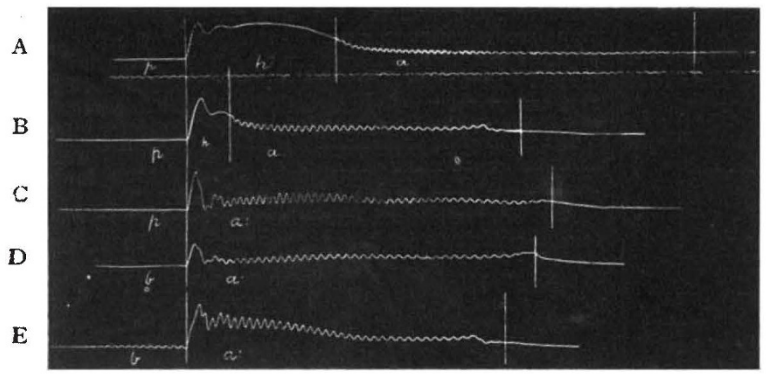

FIG. 11.—Mouth-tracings of (A) fully aspirated *p*; (B) partially aspirated *p*; (C) unaspirated *p*; (D) unvoiced *b*; and (E) fully voiced *b*—each followed by the vowel *a*.

There are several ways of recording mechanically the presence or absence of voice. The method which gives the most satisfactory results from the point of view of the linguist consists in using a kymograph fitted with one or more tambours of Marey's model. This method was described in NATURE for June 9 last, and readers are referred to that article for details.

Figs. 11, 12, and 13 are some additional kymographic tracings illustrating linguistic phenomena.

The above examples show to what extent experimental phonetics may be useful to the language learner. It furnishes him with much of the information he wants in regard to pronunciation. The practical linguist should make these ascertained facts the basis of his study of the pronunciation of the language he is learning. He will be able to infer from them how he must proceed in order to get his own organs of speech to perform the movements required by the foreign language.

In conclusion, it may be as well to point out that as these scientific methods of analysis are useful to the linguist, so also the accomplishments of the linguist are sometimes found to have their uses to the man of science.

Thus it is possible by means of a speech process to demonstrate in a remarkable way the existence of harmonics in a musical note—to show, for instance, that if the note *c* is sung, there is sounding simultaneously the well-known series of harmonics, *c'*, *g'*, *c''*, *e''*, *g''*, etc. This fact is made evident by putting the mouth into a series of positions which will act as resonators and reinforce different harmonics one after the other. If only one position is taken up by the mouth, some harmonic or other is necessarily reinforced, though it is extremely difficult to detect which. But by making rapid changes from one mouth-position to another, the successive harmonics become clearly audible *by contrast*. The speech-movement which makes these harmonics come out most clearly is to start by holding the tongue in the position of the English sound of *ng* and rounding the lips and gradually separating them. At close quarters the effect is that of an arpeggio played on a tiny harp. If the voice-note is changed, the same arpeggio is heard in a different key.

This phonetic experiment may or may not prove to have some direct value in the direction of elucidating problems of sound-quality, but at any rate it is useful as a practical demonstration of the presence of harmonics in a musical sound.

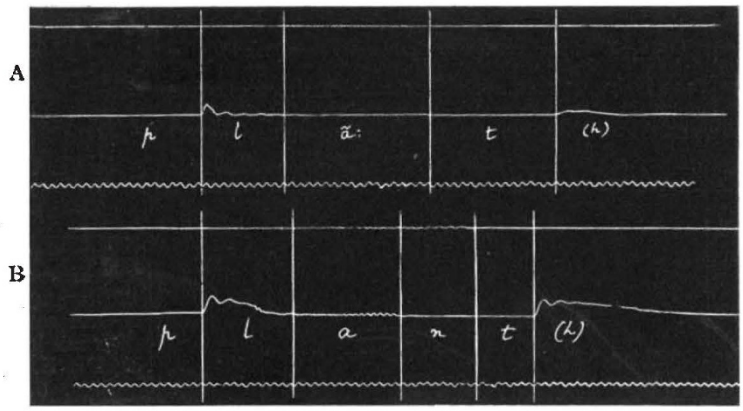

FIG. 12.—Simultaneous mouth- and nose-tracings of (A) French *plante* (female voice); (B) English *plant* (male voice). Note the absence of *n* in French.

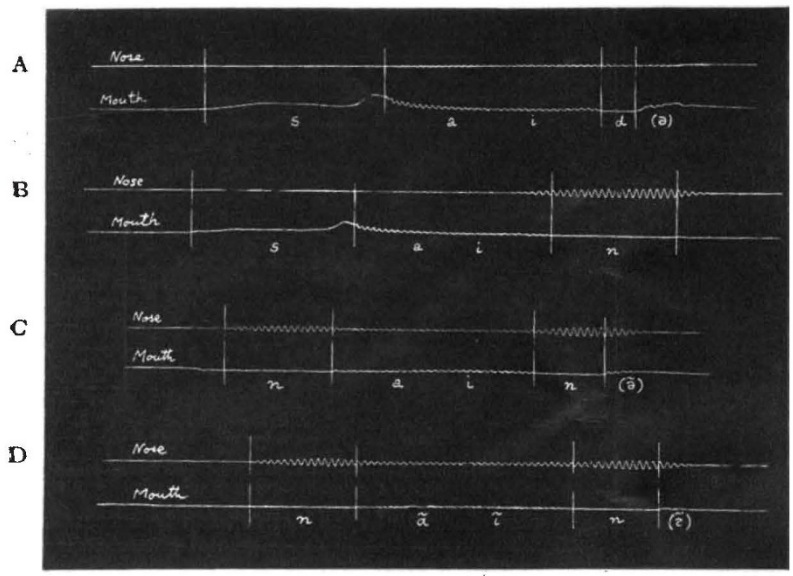

FIG. 13.—Simultaneous mouth- and nose-tracings of (A) *side*; (B) *sign*; (C) *nine*; and (D) *nine* pronounced in cockney-fashion. Note the difference in the nose-tracings. The words were all said on the monotone B♭  this being the note to which the nose-tambour happened to re-pond best.