PRELIMINARY EXPERIMENTS WITH THE FABRE GLOTTOGRAPH.

Eli Fischer-Jørgensen, Børge Frøkjær-Jensen, and Jørgen Rischel

In November 1966 we had the opportunity to work with F. Fabre's glottograph for a week thanks to a visit by Dr. J. Ondráčková, supervisor of the Phonetics Laboratory of the Academy in Prague.

Dr. Ondráčková gave a lecture on her work with the glottograph, and brought with her the instrument belonging to the laboratory in Prague, which we were allowed to keep for a few days after her departure.

The Fabre Glottograph measures the electrical resistance in the larynx, and can, in principle, be used to record either the vibratory movements of the vocal cords during the production of voiced sounds, or the slower variations observable in sequences of sounds.

As we had at that time no means of photographing the vibrations from the oscilloscope screen, we concentrated on experiments with slower movements, i.e. the gross variations in level of the curve in consonants and vowels, which could be recorded directly from the glottograph on the mingograph.

The plates of the glottograph in question were 3 cm high and 1 cm broad (effective area about 2 cm^2). They were in most of the experiments mentioned here below placed according to the directions of Dr. Ondráčková on either side of the throat, so that they reached somewhat above and below the glottis. The curves were recorded at a paper speed of 100 mm/sec. They were, in various instances, combined with simultaneous recordings of air flow (Electro Aerometer) and recordings of intra-oral pressure (Manometer).

The Fabre Glottograph has appeared in several slightly different designs (1),(2),(3) based on the same principles. The main problem in designing this apparatus is to obtain a stable zero-line. Firstly, it is very difficult to keep the contact resistance between the glottograph plates and the skin constant. Variations in contact resistance are mainly caused by ultra-slow variations in skin humidity, and it is hardly possible to overcome this problem. Secondly, we observed that the zero potential varied due to properties of the electronic part of the instrument; it should be possible to remove these fluctuations rather easily.

The glottograph we tried operated in the following way:

A high frequency alternating voltage is applied between the contact plates, which are connected to the input terminals of an amplifier in such a way that an increase in current from one plate to the other reduces the signal. After amplification the high frequency signal (modulated by the variations in plate-to-plate current through the throat) is detected, and via a high-pass filter with a very large time constant (4 sec.)* the output is recorded on the mingograph. The resulting curve is considered to indicate the degree of electrical resistance in the glottis.

The instrument has the great advantage of being without any inconvenience for the speaker, as he is not able to feel the weak alternating current passing his throat. It is, however, a problem whether the glottograph, in its present form, gives a reliable record of the degree of opening in the glottis, or whether other factors intervene to obscure the picture. Such factors could, e.g., be voice modulated variations in the electrical contact to the skin, the gross movements of the larynx, the conditions of the pharyngeal cavity (internal circumference and humidity), and contraction of the muscles above and around the larynx.

2.

2.1. A good many of the phenomena observed can easily be interpreted as conditioned by the degree of opening of the glottis.

This is true of the curves of Danish consonants. The Danish consonants <u>p t k b d g f s h v</u> were recorded initially in a syllable in small sentences of the type: "det er falle, det er palle" etc. [de: 'falə de: 'palə] 'it is Falle, it is Palle'). These sentences (except those with <u>k</u> and <u>g</u>) were spoken 6 times each by JR and all were spoken 8 times by OT. - It was very clear that <u>f s p t k</u> showed

----

*) For recordings of vocal fold vibrations the apparatus was provided with an AC amplifier (including a high-pass filter with a time constant of 25 msec., which would give a more stable zero-line). For recordings of slower movements a separate channel had been incorporated at the Speech Transmission Laboratory in Stockholm (3). Because of insufficient information about the instrument we have not tried the original channel (with short time constant).

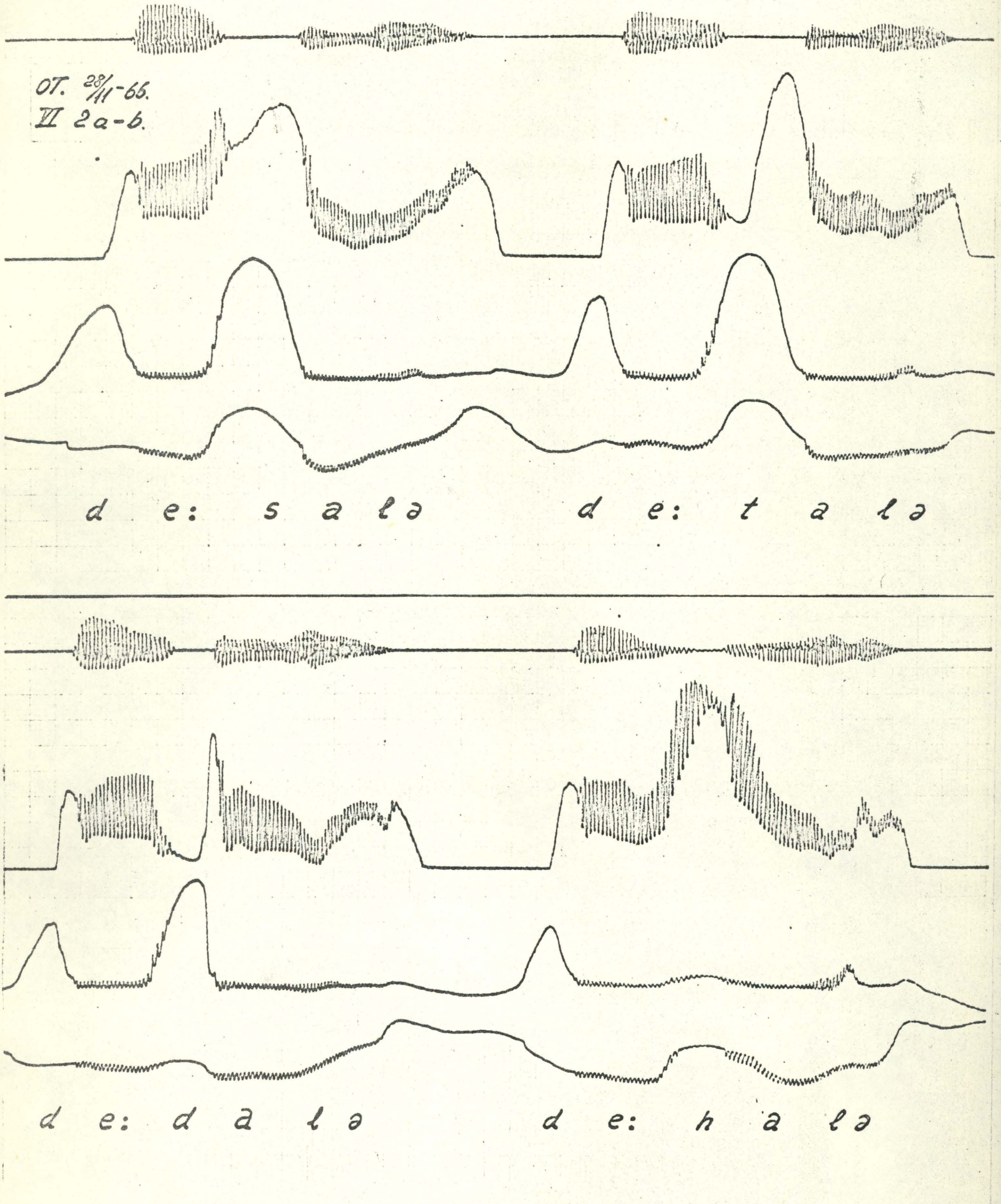

Fig. 1.

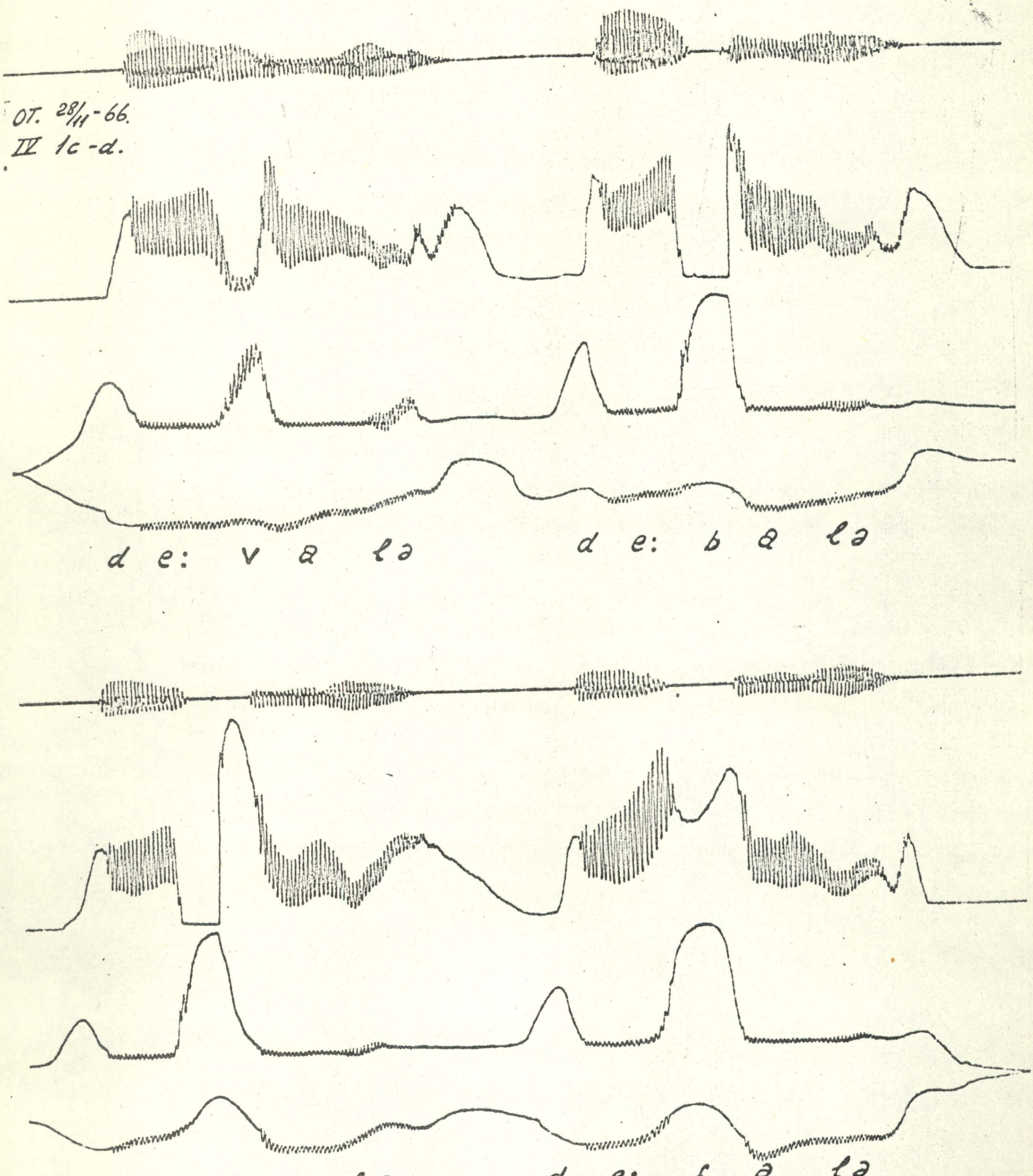

Fig. 2.

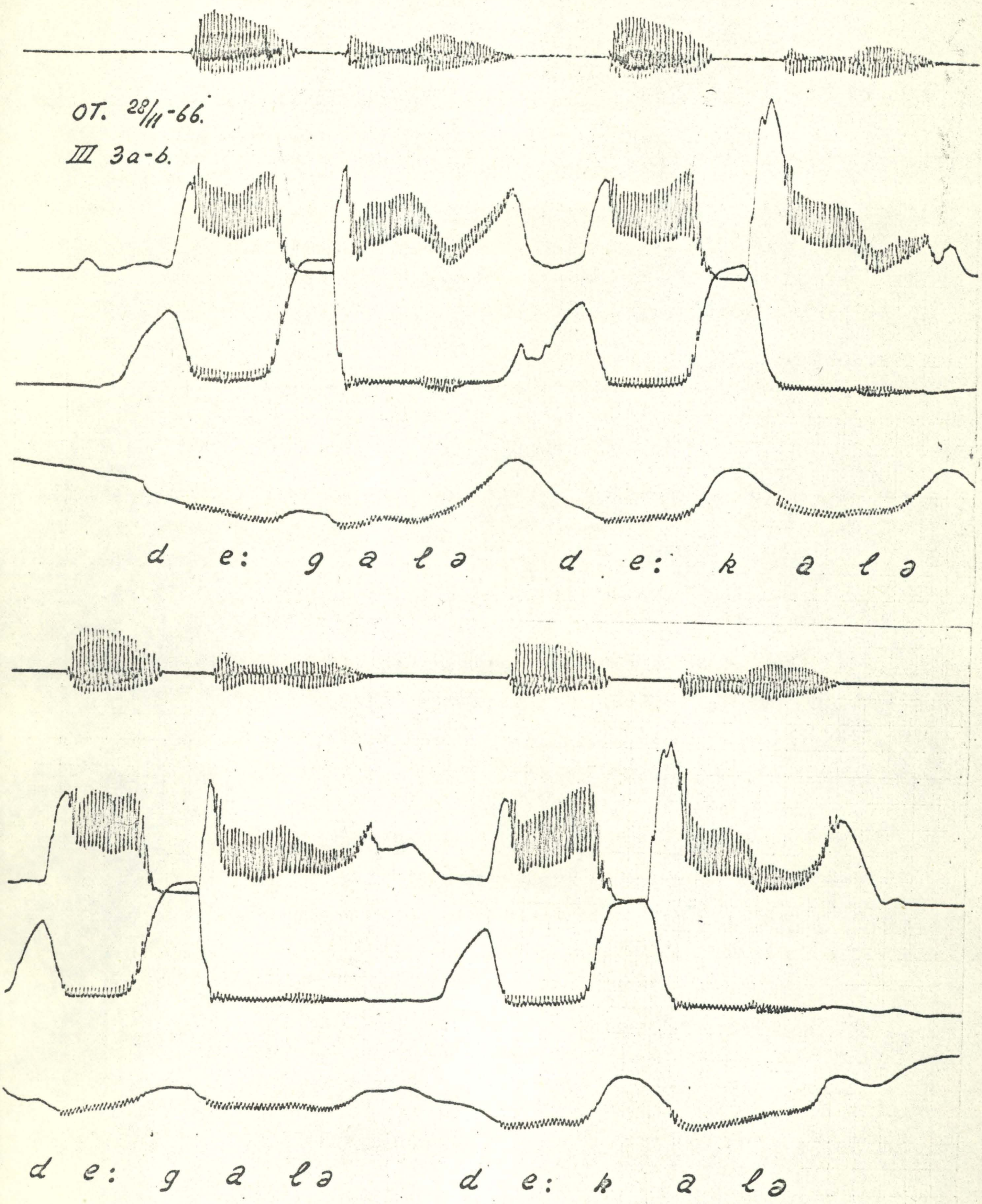

Fig. 3.

a higher rise of the curve (possibly due to higher resistance) than bdg (cp. Figs. 1, 2, and 3), but all of the just-mentioned consonants have a higher curve (i.e. electrical resistance) than the surrounding vowels; h is relatively high in OT's curves, lower in JR's. Danish fs are voiceless and spoken with open glottis, ptk are aspirated, and it has been found by endoscopic examination that the glottis opens widely during the closure of p and closes slowly during the aspiration. The glottogram also shows a rise - fall with a turning point at the moment of explosion. Danish bdg are also voiceless, but endoscopic investigations have shown that b is spoken with closed or almost closed glottis. - h is characterized by a strong air stream and there is a good agreement with the air flow curves, but, particularly for h and v, not with the curves of intra-oral pressure (see Figs. 1 and 2).

2.2. Similar short sentences with stops only were spoken by three French subjects (SRO, P, and CHH). Endoscopic examination has shown SRO to have a slightly open glottis in p. She has less difference between ptk and bdg than the Danish subjects. For the other two no endoscopic examination could be made. CHH is bilingual and has also spoken the Danish sentences (with aspirated ptk). Her Danish labials are relatively low compared to those of the Danish subjects, but the dentals and velars are higher. The unaspirated French p and t are lower than the Danish sounds, but this is not true of k.

2.3. Three Danish subjects have spoken the syllables a?a and aha a number of times. The curves show a fall for ? and a rise for h. - A few words with "stød" (phonetically creaky voice) show a drop for the stød. The curve rises between words and sentences to a high position of rest.

2.4. A Gujrati speaker (RD) has spoken a series of normal and breathy vowels. The latter show slightly higher glottograms and stronger air flow than the normal vowels. This is what might be expected.

2.5. Finally a German subject (WS) has spoken a series of words with different German vowels. For the front unrounded vowels the lax vowel [ɪ] shows more resistance (and stronger air stream) than [i:], [e:], and [ɛ:], which is in agreement with E.A. Meyer's theory that the glottis should close less firmly in lax vowels. For the rounded vowels, however, the relations do not hold.

All this can be explained by assuming that the curve reflects the degree of opening of the glottis.

3. A series of other differences observed in the curves can, however, not be explained in this way.

3.1. All the French subjects show higher resistance for velars than for dentals and labials. The same is true for CHH's Danish curves, but a similar difference is not found for the Danish subject OT. This difference can hardly be due to differences in the opening of the glottis, but may perhaps be explained by movements of the whole larynx. The larynx is moved upwards when the tongue is raised to the top of the palate as in k and g, and this seems to influence the glottogram.

3.2. Very strongly voiced b, d, g spoken by three different Danish subjects show a definite rise in the curve of the stop. In these cases one should rather expect the larynx to go down (and this can also be directly observed). It is not very probable that both a rise and a fall in the position of the larynx should cause the glottogram to go up. - In the case of the strongly voiced bdg there is also a distention of the pharynx, which might influence the glottogram.

3.3. Various persons (OT, JR, EFJ, WS, RD) have spoken series of different vowels or series of words with different vowels. There is a clear tendency for narrower vowels to have the glottograms at a higher level. This is particularly true of u and y. - It is rather dubious whether this could be due to differences in the glottis, particularly as the differences in the glottograms are very pronounced. One might rather think of differences in the parynx. Here again, as in the voiced bdg a certain distention of the pharynx in the narrow vowels may play a role.

The role of the pharynx can be made probable by the observation that if the upper part of the plates is covered with isolating tape, so that only the part situated below the glottis is accessible to transverse current, the rise in voiced bdg does not take place (tried on JR) whereas this rise is very pronounced when only the higher part of the plates is used. The difference between the vowels is also less clear when only the lower part of the plates is used.

3.4. Most of the persons used in the experiments pronounced the short sentences on a rather level tone, but with a slight rise on the syllable with a (de: 'palə). On the glottogram a is in almost all cases lower than e (which may be due to the vowel quality, or to tone, or to intensity). But one subject (P) has spoken the sentences once with falling and once with rising intonation, and one more Danish subject (BST) has spoken the French sentences with falling tone. In the sentences with falling intonation, there is a very strong rise of the whole curve, whereas there is a strong fall in the curves with rising tone. If this has anything to do with raising or lowering of the larynx, it would show (as in the strongly voiced bdg) that the glottogram goes up when the larynx goes down, since persons not trained in singing generally tend to raise their larynx when the pitch is raised. In the sentences with rising intonation spoken by P, the whole glottogram goes down, but the stops (and particularly k and g) show a very pronounced rise.

This type of glottograms thus raises a long series of questions. Probably various factors influence the glottograms at the same time. For the purpose of measuring these changes it would be more appropriate to use smaller electrodes placed at well-defined places.

It is now our intention to build a glottograph according to the principles used by Ohala (4) and others (5), (6) (i.e. measuring the amount of light passing through the glottis) and to attempt to throw light on some of the problems mentioned above by comparing the two types of glottograms.

References:

(1) On the principle of design, see for example Ph. Fabre, "Glottographie respiratoire", Comptes Rendus des Séances de l'Académie des Sciences No. 6 (1961), pp. 1386-88; id., "La glottographie en haute fréquence, particularités de l'appareillage", Comptes Rendus de la Soc. de Biologie CLIII, 7 (1959), pp. 1361-64.

(2) R. Husson, Physiologie de la phonation (1962), pp. 32-4o.

(3) Quarterly Report 4/1966, Speech Transmission Laboratory, RIT Stockholm, pp. 15-21.

(4) John Ohala, "A New Photo-electric Glottograph", Working Papers in Phonetics 4/1966, University of California, pp. 40 ff.

(5) B. Sonesson, "On the Anatomy and Vibratory Pattern of the Human Vocal Folds ...", Acta Oto-Laryngologica Suppl. 156 (Lund 1960), pp. 46-77.

(6) A. Malécot and K. Peebles, "An Optical Device for Recording Glottal Adduction-Abduction", Zeitschrift für Phonetik, Sprachwissenschaft und Kommunikationsforschung 18 (1965), pp. 545-550.

ACKNOWLEDGEMENTS: Our thanks are due to Dr. J. Ondráčková and to the Academy in Prague for the kind permission to test the glottograph of the said institution.