sein Verlangen, hereingelassen zu werden, auszudrücken. THORNDIKE dressierte eine Katze darauf, dass sie aus einem Käfig befreit wurde, wenn sie sich kratzte; Bären lernen in der Gefangenschaft oft zu tanzen, um Futter zu bekommen. In allen diesen Fällen kann man sagen, dass die Tiere durch das Machen einer für sie konventionellen Gebärde oder Bewegung einen Wunsch ausdrücken. Hier hat die Tiersprache gewiss eine höhere Stufe erreicht als im Naturzustande.

Interessant sind nun besonders die Fälle, in welchen das Tier, um einen Wunsch auszudrücken oder etwas mitzuteilen, menschliche Wörter benutzt. Es ist klar, dass dann eine noch höhere Stüfe der tierischen Sprache erreicht ist. Nach dem Vorhergesagten werden wir dies nur bei den Papageien erwarten dürfen. In der Tat sind nun bei den Papageien einige Fälle bekannt, in welchen das Tier sich menschlicher Wörter bediente, um einen Wunsch auszudrücken. Nun muss man hier sehr vorsichtig sein; denn die vielen anekdotisch beobachteten und unkritisch interpretierten Fälle aus der populären Tierpsychologie halten nicht immer der Kritik stand. Doch gibt es einige zweifellose Beispiele hiervon. Ich selbst habe z.B. in darauf gerichteten Experimenten einen Fall wahrgenommen, in welchem ein Papagei menschliche Wörter, die er immer benutzte, wenn man ihm Futter gab, aussprach, um den Wunsch auszudrücken, Trinken zu bekommen, als ich ihn Durst leiden liess. Es scheint mir wichtig, dass in diesem und anderen Fällen, auf welche ich nicht näher eingehen kann, es stets ein Wunsch war, den das Tier mit seinen Wörtern äusserte. Beim Kinde geht bekanntlich das Stadium des Aussprechens von Wünschen dem der Bezeichnung von Gegenständen zeitlich voraus.

Unter Einfluss des Menschen kommt also die Sprache des Tieres auf eine höhere Stufe als im Naturzustande. Die Ursache davon muss sein, dass zwischen dem Menschen und seinem Haustier ein Band ganz anderer Art besteht als zwischen den Tieren untereinander. Der Mensch interessiert sich für das Tier, sucht ihm zu helfen und seine Handlungen zu beeinflussen. Dadurch lernt das Tier, bestimmte Laute, Haltungen oder Bewegungen mit der darauf folgenden Belohnung zu assoziieren, und durch die wiederholte Belohnung kommt das Tier dazu, durch seine Haltung u.s.w. die Belohnung herauszufordern. Nun kommt aber eine ähnliche Beziehung, wie zwischen Mensch und Haustier in der Natur, sei es auch in geringerem Grade, auch bei der Beziehung zwischen Mutter und Jungtier vor. Und wirklich finden wir auch bei dem Verhältnis Mutter und Kind bei den Tieren wohl Fälle, die auf eine absichtliche Mitteilung von seiten des Kindes hinweisen. Das ist dann der Fall, wenn das Kind mit Laut oder Gebärde um Futter bettelt. Doch sind diese Fälle immer etwas zweideutig, da die Möglichkeit offen bleibt, dass es hier sich doch nur um Ausdrücke des Hungergefühls, also um eine nicht beabsichtigte Mitteilung handelt, da es schliesslich immer doch natürliche, nicht erlehrte Bewegungen und Laute sind, mittels deren das junge Tier seinen Wunsch äussert.

Mit dem Vogel, der in echten Wörtern absichtlich ein Verlangen ausdrückt hat die tierische Sprache ihre höchste Stufe erreicht. Können wir nun sagen, dass sie hier mit der menschlichen Sprache gleichzustellen ist? Fraglos ist dies nicht der Fall. Denn eine wichtige Eigenschaft bleibt ihr fehlen. Nie finden wir beim Tiere die schöpferische Fähigkeit, die Wörter bildet, Sätze aufbaut und sich einen Wortschatz von wachsendem Reichtum

und Ausdrucksmöglichkeit entwickelt. Nie wird auch die Sprache Mittel zur Bildung und zum Ausdruck von Gedanken und Urteilen. Und so lange eine tiefe Kluft zwischen dem Geistesleben von Mensch und Tier bestehen bleibt, so lange wird diese Kluft sich in ihrer Sprache widerspiegeln; die tierische Sprache bleibt auch in ihrer höchsten Stufe nur die Sprache eines Tieres.

Discussion:

R. MEYER: Wie kann man erklären, dasz ein Hund einem Kommando gehorcht, wenn das Tier die Worte nicht versteht.

Dr. J. A. BIERENS DE HAAN: Es scheint mir dass ein Hund der auf den Kommando „geh dorthin" in die angegebene Richtung geht, dies tut weil er darauf dressiert ist, oder sonst die Gebärde seines Herrn versteht. Dass ein Tier diese Wörter direkt verstehen würde, scheint mir nicht sehr wahrscheinlich.

15. Dr. V. E. NEGUS, London: *The Evolution of the Larynx and the Voice in Animals.*

Advantages of the larynx as a means of producing sound.

The larynx is described frequently as "the organ of voice". This is a misnomer, because the organ was not evolved for vocal purposes and in many animals is not used at all for the production of voice. In a large number of species however, and particularly in Man the conveyance of messages and ideas is carried out by means of this organ and the reason for the description referred to is easily understood.

The use of the larynx for phonation offers many advantages, particularly because it leaves the rest of the body free for other purposes and because sound can be produced without the cessation of the ordinary bodily functions.

Advantages of sound as a means of communication.

The great reason for the value of the larynx is because it provides a means of producing sounds of varying pitch, quality and intensity. Sound is a most excellent method of inter-communication. It travels in all directions; it can be used to convey messages to others out of sight, either because of darkness or the obstruction of vegetation; it leaves the body free.

It thus has very great advantages over the senses of smell, touch or sight.

Gesture is of course used considerably to supplement phonation but it is not a necessary method of expression and is of limited value.

Sound production in Animals without a larynx.

A larynx is possessed only by a few fish, amphibians, reptiles, birds and mammals. Other animals have to make use of the best organ available if they desire to produce sound; examples are to be found of a variety of methods. Grasshoppers rub the wing cases together; some lobsters snap their claws, others use rasps on the legs or antennae; Cicadas have specialised vibrating diaphragms; quills are rattled by the porcupine and a jointed tail by the Rattlesnake; while Snipe drum with their tail feathers.

All these mechanisms and many others too numerous to mention are of limited utility; they all sink into insignificance when compared with laryngeal phonation. Consequently animals provided with the latter organ make use of it for sound production if they have the necessity.

Relation of hearing to sounds produced.

In general it appears that the hearing of an animal is most sensitive to those sounds which it wishes to hear. The pitch and quality of the sounds are determined by details of anatomical structure; these are determined by factors other than those connected with phonation. Therefore the hearing has to adapt itself to the sounds in use; the larynx does not adapt itself to the range of hearing.

Reasons for presence of Larynx.

The larynx was evolved as a respiratory organ and did not come into existence for the production of sound. It was first called for by the necessities of certain fish inhabiting shallow rivers liable to dry up. If these fish could not breathe air they would die and the species would become extinct. Therefore, by a series of evolutionary changes, a respiratory apparatus in the form of lungs came into existence.

The necessity immediately arose for the protection of the lungs against the entrance of water and food, which would render them useless and would lead to the drowning of the fish. This protection is afforded by the larynx, which in its most simple type takes the form of a sphincter or muscular valve at the entrance to the air tract, where the latter opens into the food passage or pharynx. The muscular sphincter consists of specialised fibres derived from the pharyngeal musculature. When closed it effectually shuts the air passage or trachea; and when relaxed it allows air to enter the lungs.

Examples of this mechanism are found in the Dipnoi or lung fish of which three examples – widely separated – are in existence. They are Ceratodus, the Australian Lung fish; Lepidosiren, the Amazon Mud fish; and Protopterus, the African lung fish. The wide geographical distribution and anatomical similarity of these fish point to their ancient origin.

If air escapes from the lungs of a fish through the partially closed laryngeal aperture or glottis a sound is produced, although it is probably never made on purpose.

Modifications of the Larynx in Amphibians, Reptiles and Birds.

The larynx is most definitely a respiratory organ in origin, controlling the passage of air into and out of the lungs and preventing the entrance of harmful substances. To facilitate opening of the glottis for the entrance of air muscle fibres came into existence for the purpose of pulling the glottic margins apart. These fibres are, in lung fish and some amphibians, part of the pharyngeal constrictor and are not specialised respiratory muscles; in higher species they become separated as the abductor or dilator muscles, corresponding to the posterior crico-arytenoid muscles of Man.

To obtain better opening of the glottis it is found that in amphibians bars of cartilage make their appearance, one on either side of the laryngeal aperture. The dilator muscle fibres pull on these and are thereby enabled to give a wider passage for the entrance of air.

In some Reptiles such as snakes the lateral cartilages are long and rod like; they are known as the arytenoids and are accompanied by a crico-thyroid ring of cartilage. The latter provides a fixed point on which the arytenoids may rotate, and at the same time it prevents the trachea or air passage from collapsing.

Birds have a larynx of similar nature; there is a supporting scaffold in the form of a crico-thyroid ring or plate, two very long arytenoid cartilages,

a pair of dilator muscles to pull on the tips of the latter so as to open them, and a sphincteric band of muscle to bring the arytenoids together and thus close the glottis.

Disadvantages of long arytenoid Cartilages for sound production.

Long cartilaginous rods do not vibrate well and are therefore not well adapted for the production of sound. Consequently it is found that if the larynx be used for phonation, reptiles such as snakes can do no more than hiss; birds are under the same disability.

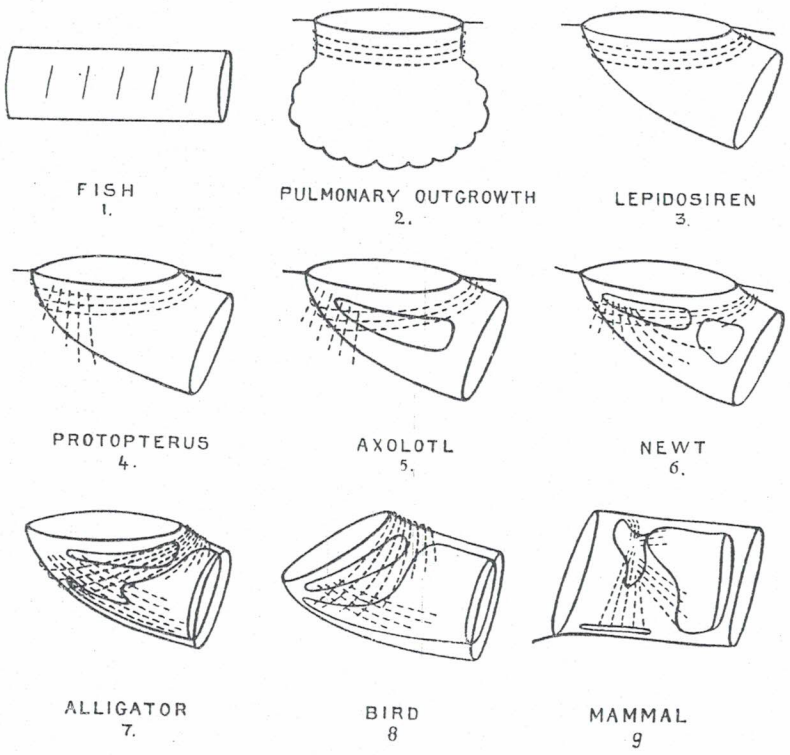

Fig. 7.

To overcome this disadvantage some other means of sound production is made use of in certain cases.

Frogs have a specialised method of respiration; they use a bellows mechanism in the floor of the mouth and blow up their lungs. Air is prevented from escaping from the lungs by the action of two down-turned folds. These folds are really respiratory valves, but they can be put to good use for voice production, thereby enabling many Frogs and Toads to be highly gifted vocally.

Birds have adopted other means of producing sound. They have evolved

a specialised vocal organ at the division of the trachea into the two bronchi; it consists of a series of membranes and muscles and is known as the syrinx. It is present in the most elaborate form in song birds which live amongst trees, and is absent in some birds which inhabit open spaces, as for example some vultures.

Larynx of Mammals.

There is no basic difference between the larynx of a lower animal and that of a mammal. In both there is a scaffolding to hold the air tube open, an aperture or glottis bounded by cartilages, a pair of dilator muscles to open the glottis and a sphincteric band of muscle to close it. In mammals the sphincter is not a single band but is divided up into components, namely a pair of thyro-arytenoid muscles bounding the glottis; a pair of lateral crico-arytenoids to rotate the arytenoid cartilages inwards, and a single inter-arytenoid muscle to draw the bodies of the arytenoids towards one another. When all the members of this group contract together they close the glottis in a manner similar to that described in the case of the simple sphincter of lung fish.

Almost any larynx will serve for the production of voice, but one in which the arytenoid cartilages are relatively short, while the membranous portions of the glottic margins are relatively long, is better adapted for phonation than one in which the arytenoids are long. The reason is first that membranous folds vibrate more readily than cartilages; and secondly that the elasticity of the membranous folds can be altered so as to produce variations in pitch.

Marsupials have long arytenoids and in them the larynx is therefore not very well adapted for voice of wide range; it can serve the purposes of phonation sufficiently well however if called upon. These animals inhabit country which is fairly open, and are active only in daylight, so that their vocal necessities are slight.

The Cat tribe (Felidae) possesses a simple type of larynx with long membraneous folds. It is one well adapted for voice and is extensively used by many species, particularly those which inhabit wooded country and are of nocturnal habits. Voice is required by these animals for purposes of co-operation.

In other animals with a larynx of somewhat similar nature voice is not made use of except on rare occasions. Examples are seen in the Cheetah (Cynoelurus jubatus) and the Mongoose (Herpestes). It is readily understood by studying various species, that there is no strict relationship between the anatomical structure of the larynx and the vocal powers of the animal. Many species are extremely vocal, although possessing a larynx ill-adapted for phonation, while others are silent, although they could if they wished, utter sounds of wide range.

As in the case of birds, so in mammals it is in those which live in trees and are therefore often out of sight of one another, that voice is called for most; nocturnal habits supply another reason, as for instance in such Lemurs as Galagos.

Modification of Larynx for Prehension.

Animals which make independent use of the fore limbs, either for grasping or climbing, require to fix the chest, so as to give a firm support to the muscles which move the fore limbs. Assistance is given in this fixation by closure of

the glottis, whereby air is prevented from entering the lungs. If the lungs cannot expand, the thorax as a whole cannot expand and the ribs are steadied. To prevent extrance of air, there is developed in the larynx of many animals an inlet valve. It consists of two folds with upturned edges, so designed as to come together and effectively to prevent passage of air. These are the inferior thyro-arytenoid folds, corresponding to the vocal cords of Man.

They are found best developed in Arboreal animals such as Monkeys, and they provide an excellent means of sound production, because they vibrate well when air is blown through them. Although the possession of such valves confer a vocal advantage, yet it does not mean that use will be made of voice. Some animals, such as many bears (Ursidae) have excellent folds of this description and yet are silent.

When the folds have very sharp edges they give to the voice a harsh quality, as in Gibbons (Ateles). Man has abandoned an arboreal existence and his laryngeal fixation valve has degenerated in consequence; for this reason his voice has a more mellow quality than those of Lemurs and Monkeys.

Determination of Pitch.

The pitch of a note produced by the larynx depends on the elasticity of the glottic margins. The degree of elasticity is determined by the degree of contraction of the thyro-arytenoid muscles, which lie on either side of the glottis and are covered by a layer of connective tissue, known in Man as the vocal cord.

The possession of long thyro-arytenoid folds means therefore that an animal can produce sounds of varying pitch, if it so desires. Examples are found among members of the Cat tribe, and in Lemurs, Monkeys and higher apes.

Shortening of the arytenoid is a necessity if the membraneous thyro-arytenoid folds are long and therefore opening of the glottis is less wide than in animals with long arytenoids.

Arboreal animals have degenerated as regards speed in comparison with quadrupeds such as the Horse (Equus caballus); this degeneration however has conferred a vocal advantage.

Role of Abductor Muscles in Phonation.

In Lung fish, Reptiles and Birds the Abductor or dilator muscle fibres are inserted near the anterior end of the glottic aperture with the function of pulling it open during respiration; they have no vocal function. In mammals the abductor or dilator muscles have migrated backwards and pull on the arytenoid cartilages in such a way as to rotate them outwards and thus open the glottis.

Having undergone this modification they can take part in phonation by bracing back the arytenoid cartilage, so as to hold it in position when the thyroarytenoid muscle contracts; the latter can thus alter its degree of elasticity, because it has a firm attachment against which to pull.

Effect of Change in Position of the Larynx.

The quality, and to a certain extent the intensity, of voice depends greatly on the resonating cavities above and below the larynx, in which sound is produced. Vibration of the margins of the glottis gives rise to sounds consisting of a fundamental and overtones. The sound would however resemble that of a gramophone without a trumpet, if the larynx were isolated. The

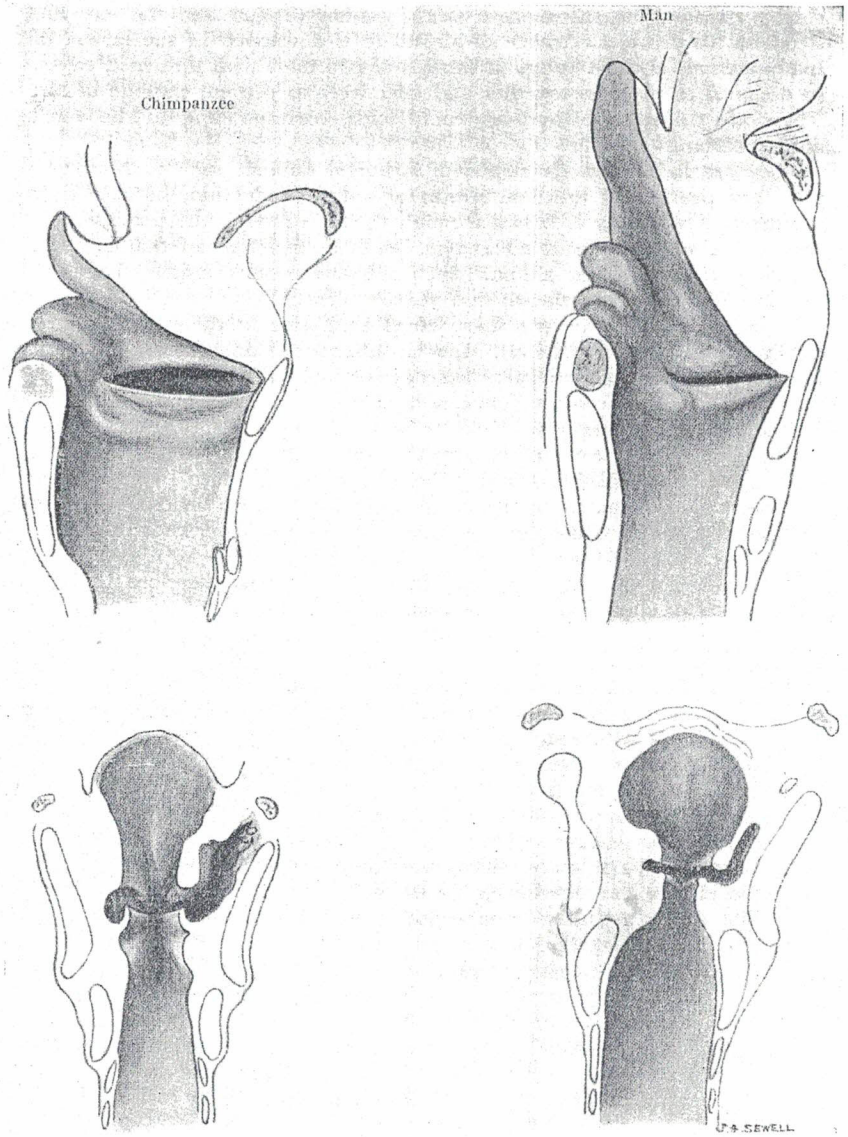

Fig. 8.

cavities of the mouth, pharynx and nose have a great influence on the quality and volume of the voice.

In some Reptiles such as snakes the larynx lies far forward and the buccal resonating cavity is relatively small; in many animals this cavity is more capacious. It is in the higher Apes (Simiidae) and in Man however that the pharynx comes into play, because of the descent of the larynx in the neck.

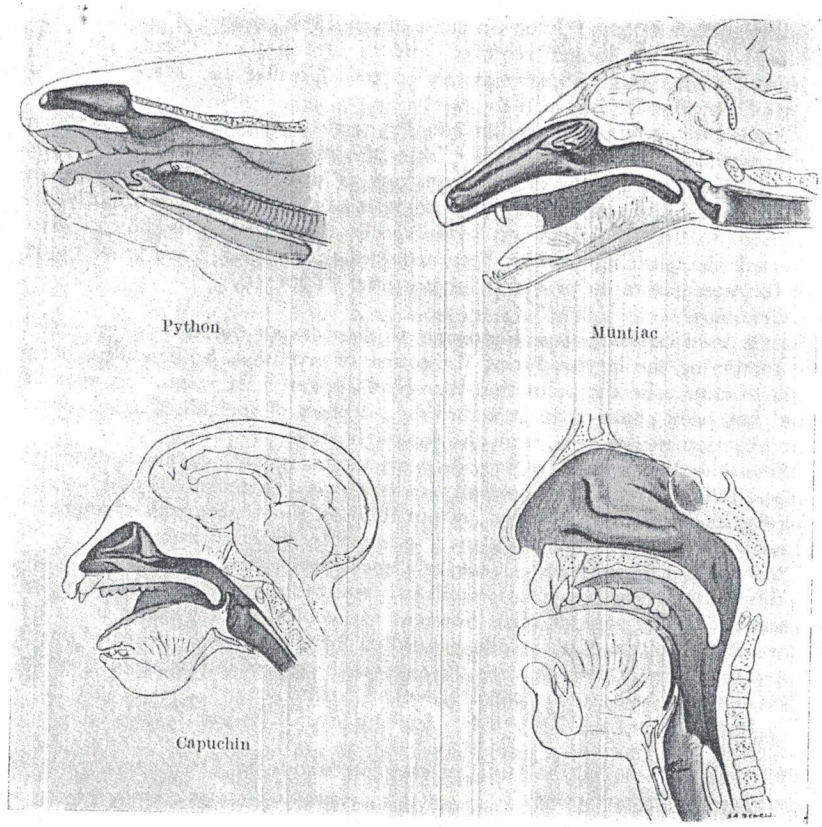

Fig. 9.

This alteration in position is caused partly by the assumption of the erect position and tilting down of the head, but mainly by shortening of the snout. If the latter recedes the tongue becomes arched and occupies a more backward position and pushes the larynx downwards in the neck.

It is interesting to note that after complete removal of the larynx in man, the voice which may be produced by the escape of air from the gullet has a quality similar to that heard before operation.

Effect of disuse of Olfactory sense.

The sense of smell is not used much by the higher Apes or by Man, because the assumption of the erect posture enables the eyes to be employed to great advantage; as the use of vision increases so that of olfaction diminishes.

A modification is found in the larynx of such animals with an important bearing on voice. In animals with a keen sense of smell the epiglottis is in contact with the soft palate, in order to ensure that inspired air shall pass through the nose and thus keep up the activity of the olfactory sense. In animals which do not rely on the sense of smell this contact of epiglottis and soft palate is no longer required, and in Orang-utans (Simia satyrus), Chimpanzees (Anthropopithecus troglodytes), Gorillas and Man there is a gap of varying size between the two.

The result is that respiration can be carried on and that sounds can escape through the mouth. This enables the tongue, cheeks and lips to be brought into use for the alteration in quality of sounds during phonation.

The possibilities of varying the range of sound is thus enormously increased, with great advantage to the species concerned. It is only in Man that sufficient intelligence has been acquired to enable full use to be made of the possibilities so provided for purposes of speech.

Conclusion.

In a brief summary it is impossible to describe all the factors concerned in modifying the larynx during the course of evolution. Sufficient has been said to emphasise the point that the organ appeared for respiratory reasons and has been changed in structure for purposes of specialised respiration, for olfaction, prehension, and also for deglutition.

These modifications have provided various species with organs of differing adaptability as regards phonation. It depends much more however on the necessities for the use of sound, rather than on the anatomical structure of the larynx, as to of what use is made of voice by different animals.

Mammals have no need to evolve a specialised vocal organ because the mammalian larynx happens to fulfil its vocal requirements in almost every instance. In the case of birds however the evolution of what is in many cases a high order of social life has called for some better means of vocal expression than is possible with their reptilian type of larynx; consequently they have evolved a true vocal organ or syrinx.

No discussion.

Hereafter a special Meeting of the Internationale Arbeitsgemeinschaft für Phonologie took place.

WEDNESDAY 6th JULY.

President: Professor C. E. PARMENTER; Secretary: Dr. F. HOGEWIND.

16. Professor R. H. STETSON, Oberlin: *Breathing Movements in Speech.*

The syllable is produced by the movements of breathing, and the functions of the consonants in the syllable and the changes of the consonants are dependent on the movements of breathing. Therefore the production of the puffs of air from the chest, the chest-pulses, which constitute the syllables, is important.

The chest is not like the bellows of an organ which maintains a constant pressure. Rather it is like the hand bellows with which one blows the fire.

When the fire bellows is inflated the volume is large but the pressure is zero. The arms and hands holding the fire bellows maintain the fixation. So the large muscles of the chest and abdomen maintain the fixation when the chest is inflated and the volume of contained air is large but the pressure is zero.

While the arms flex slightly to maintain a slight rise in pressure, a rapid group of puffs may be made by repeated movements of the hands from the wrist; during this group of rapid puffs there will be a slight rise of the pressure level within the fire bellows but at the close of the group it will fall to zero.

Thus in speech the large muscles of the chest and abdomen contract against each other, to make single accented puffs, and to maintain a slight rise of pressure during a series of puffs, the syllables. This series of rapid puffs is made by the intercostals which correspond to the hands working at the wrist to make rapid puffs with the fire bellows.

Tracings made of the sub-glottal air pressure in tracheotomized subjects; tracings made of the sub-glottal pressure in patients speaking with an artificial larynx; tracings made from normal subjects with negative-pressure applicators on the body wall; all confirm this. And most important of all, the actual contractions of the large muscles, and of the intercostals, can be demonstrated by simultaneous action-current records made with a multiple-element oscillograph.

Discussion:

Dr. A. SCHMITT: Es wäre wichtig, die gezeigten Kurvenbilder noch genauer studieren zu können, weil sie für das Problem der Silbe so besonders wichtig sind. Wo sind sie oder werden sie veröffentlicht.

Professor R. H. STETSON: An article dealing with this subject has been published in Archives néerlandaises de Phonétique Expérimentale Tome 3, 1928. There a large number of curves have been reproduced.

17. Drs. H. D. BOUMAN, Amsterdam: *Action Current Studies of Speech Movements.*

This paper is a report of experiments done with Prof. R. H. STETSON in the Psychological laboratory of Oberlin College, Oberlin (Ohio) U.S.A. To get some more precise idea about the coordination of the muscles involved in the formation of the breathpulse, a method was developed to record the contraction of the individual respiratory muscles. The most accurate way to record muscle contractions in human beings, is by means of the electric phenomena that accompany muscular contraction, i.e. by means of action-currents.

The action-currents were lead off through the skin, by means of zinc electrodes wrapped in bandage. The bandage was soaked in saturated salt solution. For the electrical recording system the stringgalvanometer was not considered entirely satisfactory.

First because of the difficulty that arises, when the action currents of several muscles have to be recorded simultaneously, second because of the inertia of a stringgalvanometer. We used a Westinghouse nine-element-oscillograph, so that we could be assured of a distortionless recording up to 10.000 cycles per sec. The sensitivity of this oscillograph is low compared