with four or five sudden jerks, then, after one or two minutes' interval, when the mole is collecting more loose earth, another sausage will appear as before, and so on until the work is complete. After the nest-cavity comes the excavation of the bolt-run, and finally, to make all safe and waterproof, the mole piles up a mass of earth, often amounting to a large barrow-load, by means of tunnels around the base of the existing heap. These tunnels sometimes break into one another and sometimes into the nest-cavity, and so cause a labyrinth which has given rise to much erroneous speculation in the past.

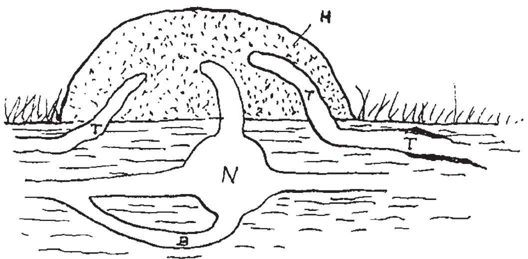


FIG. 3.—Sectional view of the completed fortress. T T, Tunnels formed in piling up earth from outside to make the nest rainproof.

A fortress is often completed in a single night. The young are not born in the winter "fortress," but in a separate habitation made by the female alone. It is built on the same plan as the "fortress," but usually simpler in construction and without the bolt-run. The female produces only one litter a year, and the young, which are born from the end of April to the end of May, vary in number from two to six. Naked, blind, and pink, they turn lead-colour in ten days; after a fortnight a grey velvet pelage is visible, which becomes black at the end of three weeks, when the eyes open. The ears are opened on the seventeenth

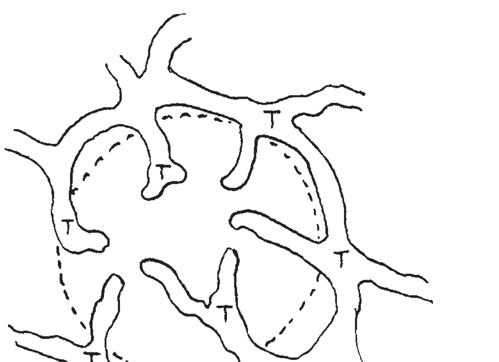


FIG. 4.—The completed fortress viewed from above, with the tunnels T T, &c., laid bare.

day. Attempts to rear the young by hand have hitherto proved futile, for, though they will suck freely from flannel or cotton wool soaked in warm milk, they pine and die on the third or fourth day.

There has always been much discussion as to the mole's power of sight. Dissection has shown that the size of the eye is greater in the embryo than in the adult, indicating that the sight of the race has deteriorated. From numerous experiments the writer is convinced that the adult mole is practically blind. Moles encountered in the day-time have taken no notice of a human being waving a hand close in front, nor at night do they show signs of consciousness of a light waved before their nose; but, if the slightest sound is made, the greatest excitement is instantly shown. The writer has often thrown down worms before a captive mole to test the sight. At once the mole becomes aware of the worm, but the haphazard way in which he will poke about for it with his snout shows clearly that he is guided by scent, and perhaps by hearing, but not by sight. It is true that at the least excitement the fur will radiate round the minute eye, and it has been suggested that the animal thus clears his eye to see; most probably, however, this mechanical action is retained though no longer of use, since the blind eye cannot benefit thereby. When, after a hurried and blundering search, the worm has been located, the mole holds it down with his fore paws and eats it from end to end with quick, jerky bites. When the animal's immense appetite is at length satisfied and worms are still being supplied, the mole will often give the worm several bites to disable it, and will then cram it into the earth, presumably to bury it for future use—after the manner of the dog with bones and the squirrel with acorns.

The senses of smell and hearing must be very acute to enable the mole to locate a pheasant's or partridge's nest above his run. That this is the case is testified

Photo. by *T. Bellchambers.*

FIG. 5.—Young moles ready to leave the nest.

by two gamekeepers in different parts of the country, both of whom state that the nests are often entered from below and the eggs eaten.

It is surprising how soon a captive mole becomes indifferent to being handled. Within half an hour of capture it may be stroked and scratched without causing alarm; the writer has even suspended one by the tail without causing the animal to cease from lapping water. Of course, gentle handling is necessary, and avoidance of any sudden or jerky movement. Another mole soon learnt to come out of his nest and look for worms when the writer scratched the side of the packing-case in which the captive dwelt.

LIONEL E. ADAMS.

THE SOUNDS OF THE HEART.[1]

THE sounds of the heart have always occupied the attention of physiologists both as regards their cause and as to their relations in time to other phenomena of the circulation, such as the impulse of the heart on the wall of the chest, and the pulse in arteries and other organs more or less distant from the heart. During the last few years much attention has been paid to these time-relations, and much

[1] Phono-Kardiogramme von Prof. Otto Weiss. (Jena: Gustav Fischer, 1909.) From Prof. E. Gaupp and Prof. W. Nagel's *Sammlung Anatomischer und Physiologischer Vortrage und Aufsatze.* Heft 7. A full bibliography will be found in Prof. Weiss's paper. Pp. 37. Price 1.50 marks.

ingenuity has been shown in devising methods by which the vibrations of those sounds, as distinct from the movements of the heart itself and the pulse in vessels, can be recorded. The older methods were subjective, and were consequently deficient in scientific accuracy. Thus, if even a skilled observer listened to the heart sounds and endeavoured to register their sequence by closing a key which acted on a recording lever, and if he endeavoured thus to register the moment of the occurrence of the first or second sound, or both, there was the inertia of the apparatus and the possibility of personal error, which made the observations of little value. It was desirable to have objective methods by which the vibrations could be actually recorded, and when one listens with the stethoscope to the strangely muffled sounds, one realises that to record the vibrations of such sounds is a remarkable achievement. At all events, the beginning and the end of the sounds can now be recorded.

Hürthle was the first to succeed in registering the vibrations of the heart sounds. This he accomplished in 1892. His method was dependent on the use of a microphone. A delicate microphone was placed on the prongs of a wooden tuning fork, and the latter was attached to the end of a large wooden stethoscope, resting on the chest wall, over the apex of the heart. The vibrations thus communicated to the microphone altered a current flowing through an electro-magnet, below which was placed a Marey's tambour (having a thin iron disc fixed to the india-rubber), and this, in its turn, transmitted its movement to a second very sensitive tambour, which recorded on a rapidly moving surface. In this way, vibrations of the heart tone were recorded, and information was obtained as to the exact moment when the tone began.

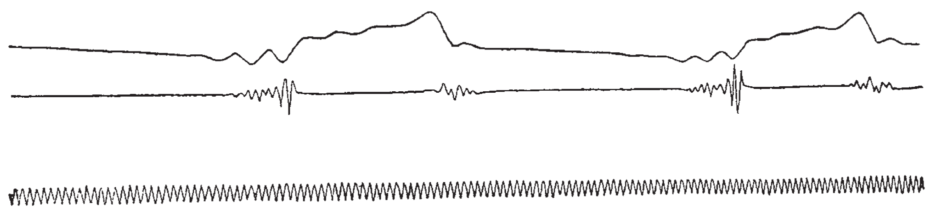
Soon afterwards, Einthoven investigated the subject by means of a microphone and capillary electrometer, and succeeded in registering with great accuracy the two tones. Then he employed his remarkably sensitive string galvanometer, and by means of this instrument, and with the aid of photography, the beginning, duration, and ending of the first and second sounds were recorded. Even in records from the impulse of the apex, which shows numerous vibrations, those associated with the heart sounds are readily identified. There can be little doubt that the string-galvanometer method is most to be depended on.

Holowinski developed a method by the construction of a kind of optical telephone. In the centre of a telephone disc, a plate of glass, like the cover-glass used in histology, was brought against a plano-convex lens, and in this way, when sounds caused the telephone plate to vibrate, the interference rings of Newton were produced. These varied with the heart tones, and, by a photographic method, when the picture of the variations was obtained, along with a superposed cardiogramme (registration of movements of apex impulse), Holowinski gave an interpretation showing the position of the tones. The picture so produced, although beautiful and interesting physically, is rather confusing.

Marbe devised a very delicate Marey's tambour, or rather capsule, by which the vibrations of the heart-tones regulated the flow of a current of acetylene gas. This passed to a burner. The flame moved up and down with each vibration, and it was allowed to impinge on a moving band of paper. On this, with each vibration, a ring of soot was formed, and a picture of the heart tones was imprinted on the paper. The method is easy, and the results are easily interpreted.

Another method has been devised by Gerhartz. He caused a membrane (which received the sound waves) to carry, vertically to its surface, a delicate glass rod, which, at the other end, bore a small metallic mirror, placed between the poles of an electro-magnet. The arrangement is somewhat complicated, and it did not give striking results.

The last method we shall notice is that of Prof. Otto Weiss. It is entirely mechanical, and is independent of microphones and electrical appliances, being a clever modification of the phonoscope, by which, some years ago, many were amused by watching the play of colours produced in a soap film by the sounds of speech. Weiss's method consists in the employment of a soap film, in the centre of which there is attached the end of a silvered thread. The other end of the thread is fixed to a lever connected with a carrier. Vibrations are carried by a special funnel-shaped tube from the heart to the phonoscope. This is enclosed in a box having in its walls lenses so adjusted that a photograph can be taken of the silvered thread and of its movements. The photograph, of course, is taken on a moving sensitive plate. The inertia of the system is remarkably small, the weight of the soap film and of the lever being about 0·000054 grm. All the parts are extremely light. The apparatus is so sensitive that the vibrations of a whisper can be recorded; the swing is aperiodic; and its moment of arrest is 0·01 sec. It is said to follow very frequent vibrations. An example of a tracing thus obtained is given in the figure.



Human Heart Sounds. The upper curve is a cardiogramme of the apex beat. The lower is that of 1/100 sec. The middle curve shows the heart sounds. Read from right to left. The first sound is the larger tracing. (Weiss.)

In his interesting monograph, Prof. Weiss gives examples of tracings of cardiac sounds along with the carotid pulse, of fœtal heart sounds, of the modifications of the sound caused by mitral insufficiency, mitral stenosis, aortic stenosis and insufficiency, and of anæmic sounds. All this shows the possibility of employing the method for clinical purposes. Finally, by an ingenious arrangement, Prof. Weiss has been able to reproduce the sounds by means of a telephone. A flame from a suitable lamp falls on a selenium cell in the circuit of which is a telephone. Interposed in the path of the beam of light, a disc is rotated having the curves of the heart sounds cut out on its margin. As it is rotated, the effect of the intermittent light on the selenium cell is such as to reproduce the heart tones in the telephone. Such an arrangement may be useful in teaching.

JOHN G. MCKENDRICK.