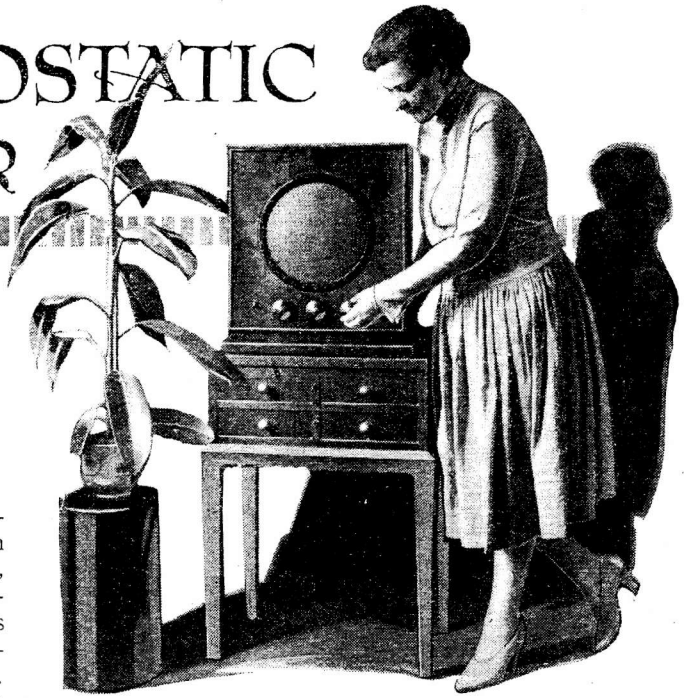
VOGT ELECTROSTATIC LOUD SPEAKER



Technical Details of a New and Improved Type with Differential Movement.

(From a Berlin Correspondent.)

THE earliest type of Vogt loud speaker was described in *The Wireless World* in connection with the report of the 1927 Berlin Radio Exhibition, so that readers will be already acquainted with its principle. In its new form the Vogt loud speaker functions on the differential system, and the quality of reproduction and sound output have been considerably improved. Herr Vogt is one of the three inventors known as the "Triergon" who have recently come to the fore as a result of their work in connection with talking films. The differential Vogt loud speaker has been developed primarily for talking films, and the output obtainable is stated to be comparable in quality and volume to that of the moving coil loud speaker.

The new loud speaker is about 15in. in diameter and only 2in. in thickness. The weight is approximately 9½ lb., and the electrostatic capacity is of the order of 0.001 mfd. On account of its simplicity of construction it is readily fitted to a baffle, and only a small space is occupied behind the board.

The construction of the electrostatic loud speaker is as simple as its external appearance would suggest. It consists, as shown diagrammatically in Fig. 1 (*a*), of the two plates P_1 and P_2, both of which are perforated with large holes. Between them is stretched a very thin metal foil M, which serves as the diaphragm, and is separated from the plates by the two rings I_1 and I_2 of insulating material.

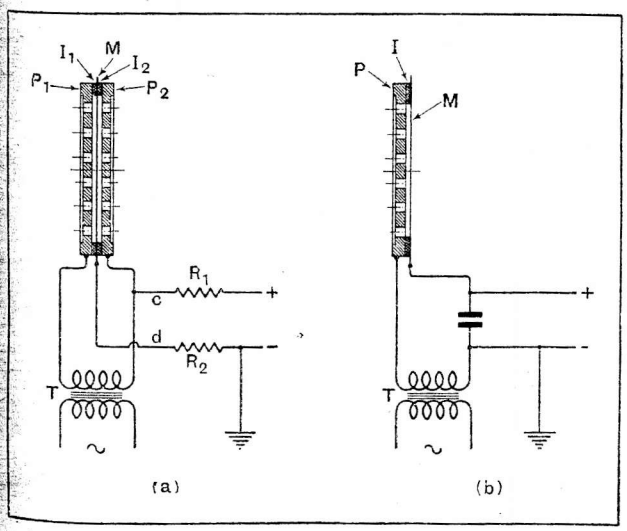


Fig. 1.—Diagrammatic cross-sections of the new differential and earlier single-acting Vogt electrostatic loud speakers.

Polarising Potential.

A supply of constant voltage is required for the electrostatic speaker. There is, however, no current consumption from the source of direct voltage, but the latter must provide from 500 to 700 volts. As the speaker will usually be used in connection with a receiver or amplifier fed from A.C. mains, this steady voltage can conveniently be drawn from the H.T. supply provided by the battery eliminator. The positive potential is usually applied to the two plates, reaching one of them, as Fig. 1 (*a*) shows, through the secondary winding of the transformer T, while the diaphragm is connected to the negative pole. The two high resistances R_1 and R_2 in the leads *c* and *d* carrying the voltage are placed there to prevent a heavy current flow such as might arise by accidental contact between the plates or breakdown by sparking. If the current taken persists more than a few moments one of these resistances is burnt out, thus isolating the instrument from the high potential source.

The positive potential on the two plates naturally exerts an attractive force on the negatively charged membrane. But these two attracting forces nullify each other, provided that the membrane is situated exactly centrally between the two plates. This conveys the principle of differential control, which is that the *difference* between the potentials on the two plates alone

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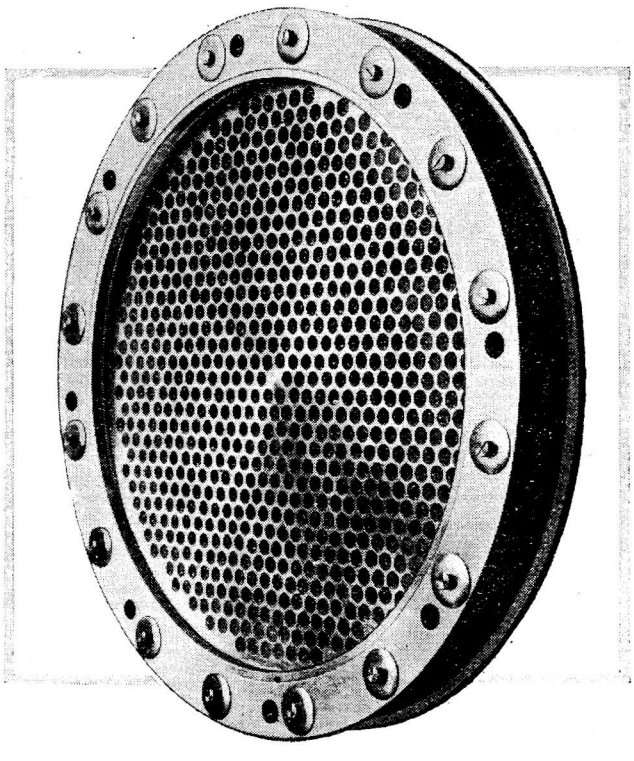
affects the membrane. So far as the steady voltage is concerned this difference is zero, so that the membrane remains quite flat so long as no alternating currents are applied.

The alternating (signal) voltages from the output valve are transmitted to the loud speaker through the transformer T. As the load provided by the loud speaker is that of a condenser, and so is very high compared with the internal resistance of the last valve (0.001 mfd. = 330,000 ohms at a frequency of 500 cycles per sec.), it is necessary that the number of turns on the secondary of the transformer should be many times greater than on the primary. The transformer thus steps up the signal voltage.

The alternating voltages delivered by the transformer are superimposed in opposite phase upon the direct voltage of the two plates. Fig. 2 makes this clear; Fig. 2 (*a*) represents the conditions at the plate P_1, and Fig. 2 (*b*) those at plate P_2. The dotted curves represent the signal voltages at the ends of the transformer secondary, and therefore at the plates themselves. The dotted straight lines correspond to the direct voltages on the plates, and, by combining this with each of the



The movement of the new differential Vogt loud speaker is simple in design and can be easily mounted in a baffle.

two signal voltages, we obtain the total voltages indicated by the full lines.

The *difference* between the voltages on the two plates is therefore alone effective in causing movement of the membrane, and this difference is shown in the curve of Fig. 3. First one plate and then the other has momentarily the higher voltage, so that the membrane must alternately approach one plate or the other, moving in sympathy with these voltages. It is clear that in this way the diaphragm will make equal excursions outwards in both directions from its central position of rest, provided that it was originally exactly midway between

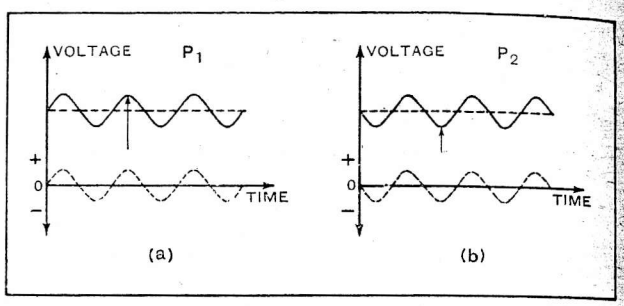


Fig. 2.—Curves representing the voltage conditions at the two outer plates of the Vogt differential loud speaker.

the two plates. This condition is naturally very carefully fulfilled in the construction of the electrostatic loud speaker, as otherwise the " bias " of the membrane, which has been so carefully eliminated by the differential principle, will once more make its appearance.

The Differential Principle.

In Hans Vogt's earlier electrostatic loud speaker, and also in that of Eugen Reisz, the well-known inventor of the famous Reisz microphone, there was only one plate, situated, as seen in Fig. 1 (*b*), on one side of the membrane. The voltage on this single plate, acting on the membrane from one side, pulled it into a concave form, so giving it a mechanical bias.

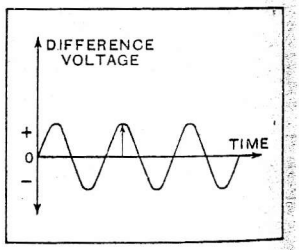


Fig. 3.—Resultant force on the diaphragm due to the alternating voltage applied to the two plates of the differential loud speaker.

For the complete avoidance of movements of the membrane corresponding to higher harmonics, which would result in spurious overtones, the absence of a bias on the membrane is not, strictly speaking, alone sufficient, although very great importance must be attached to the fulfilment of this condition. A diaphragm free from bias will certainly make equal excursions in both directions, but it does not necessarily follow that these movements will have the right form. It is also required that the movements of the diaphragm shall be exactly proportional to the alternating voltages applied to the speaker, so that the movement shall be a faithful reproduction of the wave-form of the voltages. This second condition is not fulfilled by the differential loud speaker as such, for the forces operating on the membrane are not solely dependent upon the difference between the voltages on the plates, but depend also upon the difference of the two spaces between membrane and plates. The attractive force exerted upon the membrane by one of the

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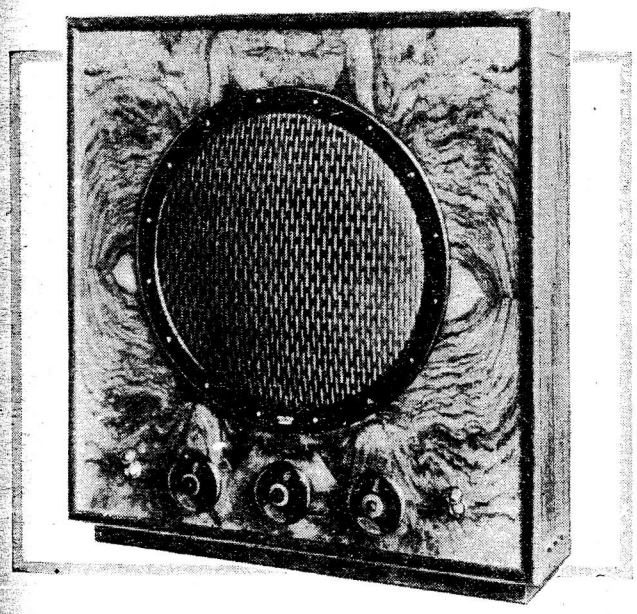
plates increases with increase of the voltage on the plate, and also increases as the membrane approaches the one plate and recedes from the other. For small oscillations, during which the membrane moves but a little to either side of the central position, the difference of the separation between the membrane and the two plates remains within very narrow limits, and so may be ignored. For larger movements, however, this difference becomes appreciable, rising to the same order of magnitude as the distance between the two plates. Under these conditions the plate which has the higher voltage and is at the smallest distance from the membrane attracts the latter considerably more strongly than it really should. Thus if the alternating voltage applied to the loud speaker is a pure sine-wave, the diaphragm will depart



Completely enclosed and shock-proof unit comprising loud speaker, receiver, amplifier and battery eliminator.

in its movement from the pure sine-wave. This distortion of the shape of the oscillation implies the introduction of higher harmonics.

Distortion Correcting.

As a set-off to this fault we must not forget the elastic force set up in a membrane stretched tight and held by the edges. This force tends to hold the membrane back as soon as it tries to approach one of the plates. Like the electrical attraction, this force increases as the membrane bulges out and approaches the plate, but it acts in opposition to the electric force. By suitable choice of the material for the membrane, and of its thickness, it is therefore possible to arrange that the increase of the attractive force as the diaphragm approaches one of the plates is approximately counterbalanced by the corresponding increase in the elastic pull. It would appear that in the construction already detailed of the new Hans Vogt speaker this condition is very nearly fulfilled, for even at great signal strength, equal to that which can be obtained from a moving coil speaker, no trace of the production of overtones can be detected.

In order to see quite clearly the difference in the mode of operation between the older types of electrostatic loud speaker and the latest differentially operated pattern, Figs. 4 (*a*) and 4 (*b*) should be compared. In the earlier type (Fig. 4 (*b*)), which has only one plate, the membrane, even in the absence of alternating voltages, is bowed by the polarising voltage. On the application of a sine-wave voltage the amplitude of movement of the membrane is not the same in the two directions, so that harmonics are introduced to a very appreciable extent. On account of the rapid increase in the elastic force the movements of the diaphragm towards the plate, which involve an increase in the bending, are definitely smaller than the movements away from the plate, during which the bending is decreased. This effect is only very inadequately compensated by the increase in the electrical attraction brought about by the approach of the membrane to the plate. In the differential loud speaker the membrane makes equal excursions in both directions. Distortion of the wave-form can here only enter to a much smaller extent, through a too rapid increase of the attractive force as the membrane approaches the plates. This, however, can be compensated through suitable choice of the size of the membrane and correct adjustment of its elasticity, as has apparently been done with complete success in Hans Vogt's latest model.

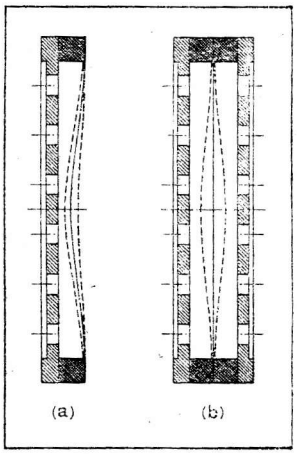


Fig. 4.—Comparison of the diaphragm movement in the earlier and new type Vogt loud speakers.

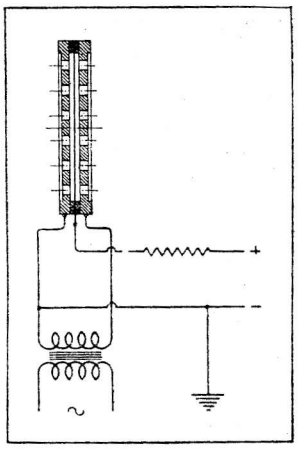


Fig. 5.— Circuit in which the outer plates are kept at low D.C. potential.

From the point of view of efficiency the electrostatic loud speaker must be regarded as good. Copper and eddy-current losses do not arise. Only dielectric losses need to be taken into consideration, and even these must be negligibly small, for the dielectric is nearly all air. Losses through imperfect elasticity of the membrane will not be greater than with any other type of diaphragm. On the other hand, it must not be forgotten that the high ratio of the transformer which is necessary with an electrostatic loud speaker will introduce losses that will at least be appreciable.

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On account of the high voltages, both direct and alternating, that are applied to the loud speaker, touching the plates must be regarded as dangerous ; even the leads to it are not safe. For this reason Vogt builds the loud speaker, receiver, amplifier and battery eliminator all into one case.

The danger of receiving serious shocks from the plates of the loud speaker can be very considerably minimised by the writer's scheme of connections, shown in Fig. 5. In this circuit arrangement one plate, which would be the outer one in the case of a speaker built into a case, is at earth potential, while the other plate only carries the signal voltage, which would usually be considerably smaller than the direct voltage, which is here applied to the membrane.

THE INVENTOR AND THE MANUFACTURER.

The Development and Disposal of an Invention.

THE average impression that persists with regard to inventors in general is that they are people who light on brainy ideas whilst shaving in the bathroom, and who forthwith are able to retire on the proceeds. One seldom finds general impressions agreeing with the true state of affairs, and this particular one is as misleading as most. The lot of the free-lance inventor—as distinct from the inventor attached to a large organisation—is not a happy one. His resources are very limited, he has no capital to develop his invention, and invariably he is without facilities for collaboration or directing advice which in most cases are essential for the complete success of the invention. Once he has made his invention and satisfied himself that it is a practical and commercial proposition, then his real difficulties begin.

Many Wireless Inventors.

In the field of wireless there are perhaps more potential free-lance inventors than in other industries, owing to the large number of amateur and experimental investigators. Let us assume that one of these enthusiasts invents a novel construction of some wireless component. His first step—if he seriously wishes to develop it—is to file a provisional patent application. This he may do himself, but if he is wise he will seek the services of a patent agent. It is the more expensive course, but it is the wisest, and in the long run the cheapest. Having lodged his specification at the Patent Office, he is at liberty to divulge the invention, and should take steps to have his article manufactured and commercially developed.

His first impulse is to submit the invention to one of the large concerns whose names are household words in the wireless industry. Many hundreds are so submitted, but very few successfully. The reason is not far to seek, and lies in the methods of organisation which such concerns must of necessity adopt if they are to keep out of the liquidator's hands. For each particular product or article a certain procedure is adopted. Someone is detailed to design a suitable model to fill the particular need, and when this design is approved a model is built in the model shop. This itself is subjected to the inspection of various people, and when finally approved, with such modifications as are deemed necessary, is passed for standardisation. Plant is then laid down and manufacture begun. It will be seen, therefore, that a definite line of development is to be followed and a definite sum of money must be set aside for it.

Suppose the inventor submits his invention to such a concern. If it is an invention of detail not within one of their determined lines of development, there is little or no chance of inducing them to deviate upon another line which has not had the inspiration and direction of their own staff. It is most unlikely they will throw overboard plans which have been evolved after very careful consideration. On the other hand, if it is within their line of development, the device or article must be an equivalent of one already contemplated or manufactured. All inventions are, of course, submitted to the development or research department, and it will be seen therefore that the very people who are to adjudge the submitted invention are those who have been instructed to design a similar apparatus. There is no doubt that all submitted inventions are given most careful and conscientious consideration, but can it be expected that men whose whole time is spent on research and development will approve and adopt instead of their own design the design of an unknown outsider? It will be seen, therefore, that the inventor is either uselessly asking the firm to abandon a prearranged course of development, or he is actually competing with the firm's own research workers—the very people who are the ultimate judges of his own invention. The chances of an invention by a free-lance inventor being " taken up " by a large industrial concern are practically nil.

Final Advice.

What, then, is the best course to adopt? If the inventor has no facilities whatever for standardising and manufacturing his article, his best course is to approach a small firm or a local engineering concern. Such firms are only too pleased as a rule to be able to adopt and sell a new " line " ; they have no heavy commitments in the nature of manufacturing programmes ; they have no research staffs, who spend their lives doing what the free-lance inventor does in his spare time.

The best advice is, therefore, obtain provisional protection and then seek out some small local enterprising concern and submit the invention to them. The big firms should be left to themselves unless the invention is one of outstanding importance.