AN ELECTRICAL MEGAPHONE

by J. de BOER.

621.395.61

A portable electrical voice amplifier, the "Portaphone" Type No. 2 831, has been devised to obtain a greater range of the human voice than when speaking normally without directive aids or when using an ordinary megaphone. This apparatus increases the intensity of the sound energy 30 to 100 times the gain realised with an ordinary megaphone. Hence, the range of the voice is 5 to 10 times larger with the "Portaphone" than with an ordinary megaphone.

In ordinary speech the range of the human voice is not very great, and various means have therefore been devised for increasing the range to which the voice will carry. The oldest of these aids is the speaking tube or megaphone which was invented about the middle of the seventeenth century by the German divine Kircher and the Englishman Morland. Its action consists in imparting a directivity to the sound waves so that they are concentrated into a narrow beam with a small solid angle. Recent developments in amplifying technology have, however, raised the question whether better results in the transmission of the human voice over great distances could not be realised with the aid of a simple electrical amplifier. While retaining the concentrating effect of the megaphone horn, an apparatus of this type would moreover provide a source of sound which is more powerful than the human voice.

In constructing such a simple voice amplifier, the first requirement is to arrive at maximum convenience in use. The loudspeaker, horn, and microphone should form a compact unit which can be conveniently carried in the hand, while the electrical amplifier may be accommodated in a separate case. The „Portaphone", Type No. 2 831, which has been designed on these general lines, is shown in *fig. 1*; the carbon microphone is mounted in the loudspeaker which also carries a horn and a handle with switch. The flat case containing the electrical amplifier is carried by a strap; its total weight is 6.8 kg. and in addition to the amplifier also holds a 2-volt accumulator to furnish the filament current and to feed the microphone, as well as dry batteries for the grid and anode voltages up to 150 volts. The electrical gain is approximately 40 decibels. The acoustical gain is somewhat lower owing to losses in microphone and loudspeaker (*cf.* at the end of

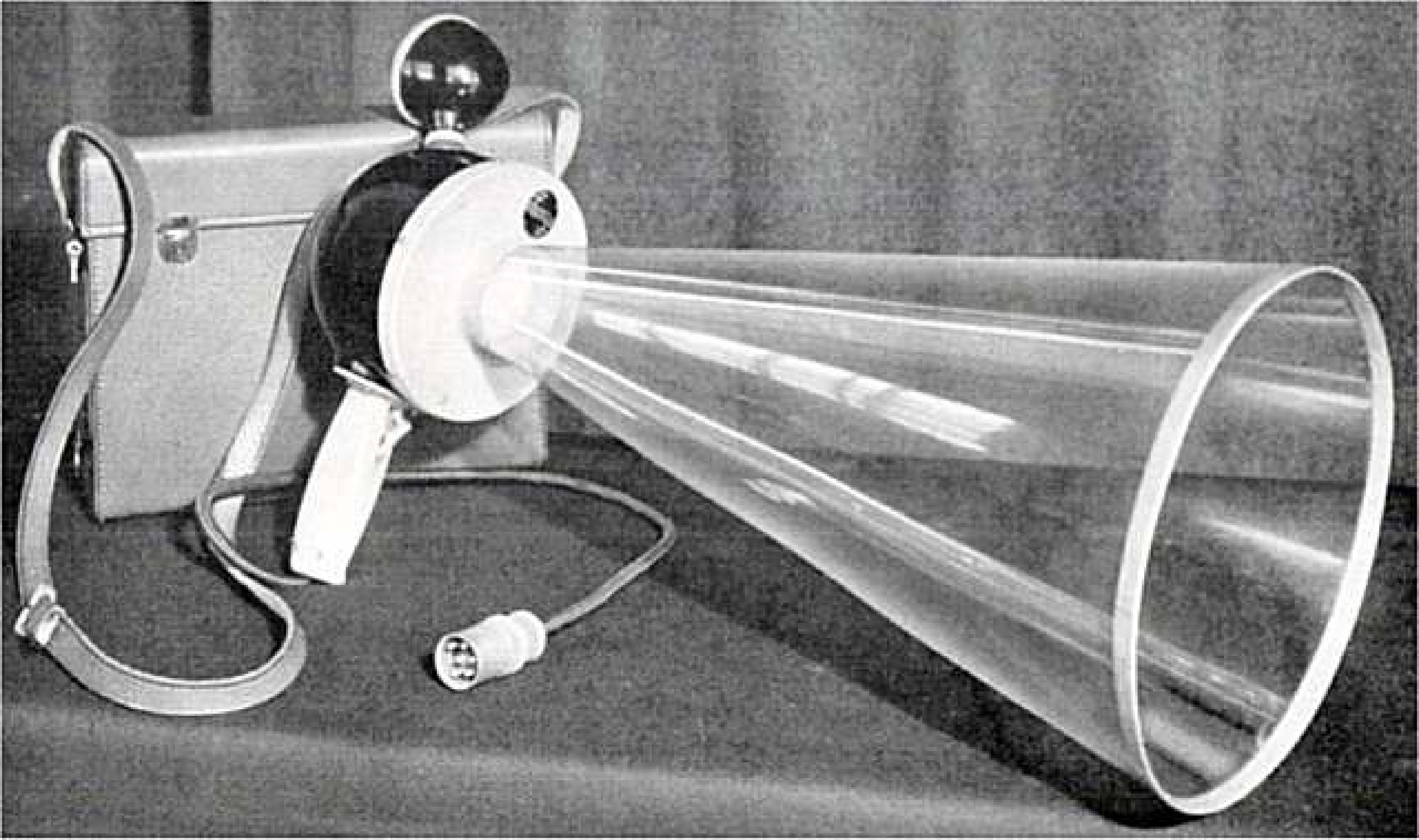

Fig. 1. The "Portaphone", Type No. 2831, consisting of a microphone attached to a horn loudspeaker mounted on a handle, and an electrical amplifier in a flat case carried by a strap.

this article). The amplifier furnishes an output of 3 watts with a non-linear distortion factor of 5 per cent, and an output of 4 watts with a non-linear distortion factor of 12.5 per cent. The accumulator requires recharging after every five-hours use.

An important factor in the construction of a simple voice amplifier of this type is the method of fixing the microphone on the loudspeaker; for, if suitable precautions are not taken, the mechanical or acoustic coupling between these components may be made too rigid. A mechanical coupling may result by the loudspeaker frame imparting vibrations to the microphone, and an acoustic coupling by the sound waves on leaving the horn being deflected to such a degree that part of them again strike the microphone. The two couplings must be sufficiently reduced, so that the whole system, with a given sensitivity, remains stable.

To reduce the mechanical coupling the microphone is given a spring suspension, whose action may be discussed with reference to *fig. 2* in which the principle of the arrangement is shown. The amplitudes y produced in the microphone with mass M should be small as compared with the deflections x of the frame C to which the microphone is attached by a spring with a rigidity S. If the frame is subject to harmonic oscillation with a frequency $\omega/2\pi$, x may be represented by the expression:

$$x = a \sin \omega t. \quad . \quad . \quad . \quad . \quad . \qquad (1)$$

Neglecting damping the deflection of the microphone will then be:

$$y = \frac{a \sin \omega t}{1-\left(\frac{\omega^2}{\omega_0^2}\right)}, \quad . \quad . \quad . \quad . \quad . \qquad (2)$$

where $\omega_0/2\pi$ is the resonance frequency for a mass M attached to a spring with rigidity S. If a sufficiently slack spring is used to make this resonance frequency much lower than the lowest frequency at which it is sought to avoid mechanical coupling ($\omega_0 \ll \omega$), the amplitude y of the microphone will be much smaller than that of the frame. In fact at very high frequencies the amplitude y will diminish with the square of the frequency: $y \sim -(\omega_0/\omega)^2\, x$.

The acoustic coupling can be limited in magnitude by making the horn not too short, so that the mouth of the horn and the microphone are placed far enough apart; on the other hand if the horn is made too large the apparatus becomes too clumsy to handle and acoustic coupling must then be avoided by other means. A very important factor here is the point at which the microphone must be attached to the loudspeaker. The sound pressure is the same in all spacial directions behind the loudspeaker when the wave length is large compared to the dimensions of the loudspeaker, *i.e.* for sufficiently low-pitched notes; thus, for these notes it is immaterial where the microphone is attached to the loudspeaker. For high-pitched notes, however, the sound pressure behind the

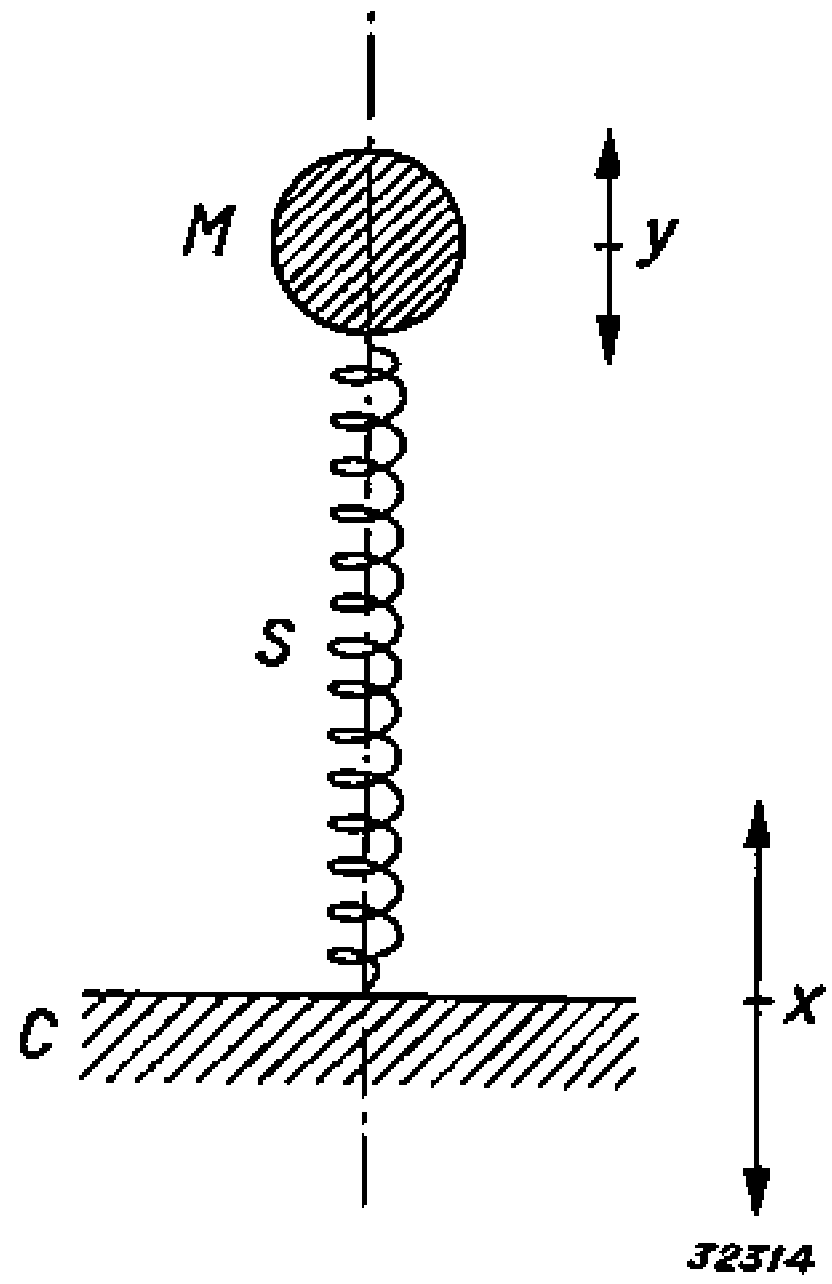

Fig. 2. Sketch of the spring suspension of the microphone of mass M at a spring with a rigidity S, which is attached to the frame C. A displacement x of the frame causes a displacement y of the microphone, which must be much smaller than x.

loudspeaker is by no means constant, and the microphone preferably must be fixed in a point, where the sound pressure is a minimum. Except for simple geometrical bodies, such as a sphere or a cylinder, a calculation of the pressure at the rear of the speaker is usually not practicable. It may only be stated that in the case of a solid of rotation the sound pressure is a maximum along the rear axis. On a model of our loudspeaker, the distribution of sound pressure was therefore measured at different frequencies, the results being shown in *fig. 3* with frequencies of 1 000 (A) and 2 000 cycles per sec (B). The best position for the microphone is roughly at an angle of 45 deg. to the rear and is marked with a circle.

To limit the acoustic coupling at low frequencies, the sensitivity of the amplifier must be reduced for these frequencies, which can be done without affecting the intelligibility (*cf.* R. Vermeulen, Philips techn. Rev. 3, 140, 1938). This cutting-off of the low-pitched notes may be done in either the amplifier, the loudspeaker (by introducing a high resonance frequency), or the horn: according to the dimensions of the latter, notes below a certain frequency will be radiated with a lower intensity. In our design we used a conical horn with an angle at the apex of approximately 20 deg., the limiting frequency being in the region of 300 cycles. The electrical amplifier and the loudspeaker, also, are less responsive to tones below 300 cycles than to higher tones.

The electrical megaphone, shown in fig. 1, amplifies the human voice by 25 or 30 decibels, according as the electrical gain is partly or wholly utilised. This efficiency is quite satisfactory, if it is remembered that an ordinary megaphone gives a gain of only 10 decibels corresponding to an increase of the range of the human voice by about three times. With the "Portaphone", however, this range is increased 15 to 30 times. If there is little extraneous noise in the vicinity, the voice can thus be heard intelligibly to a distance of over 300 m when speaking normally.

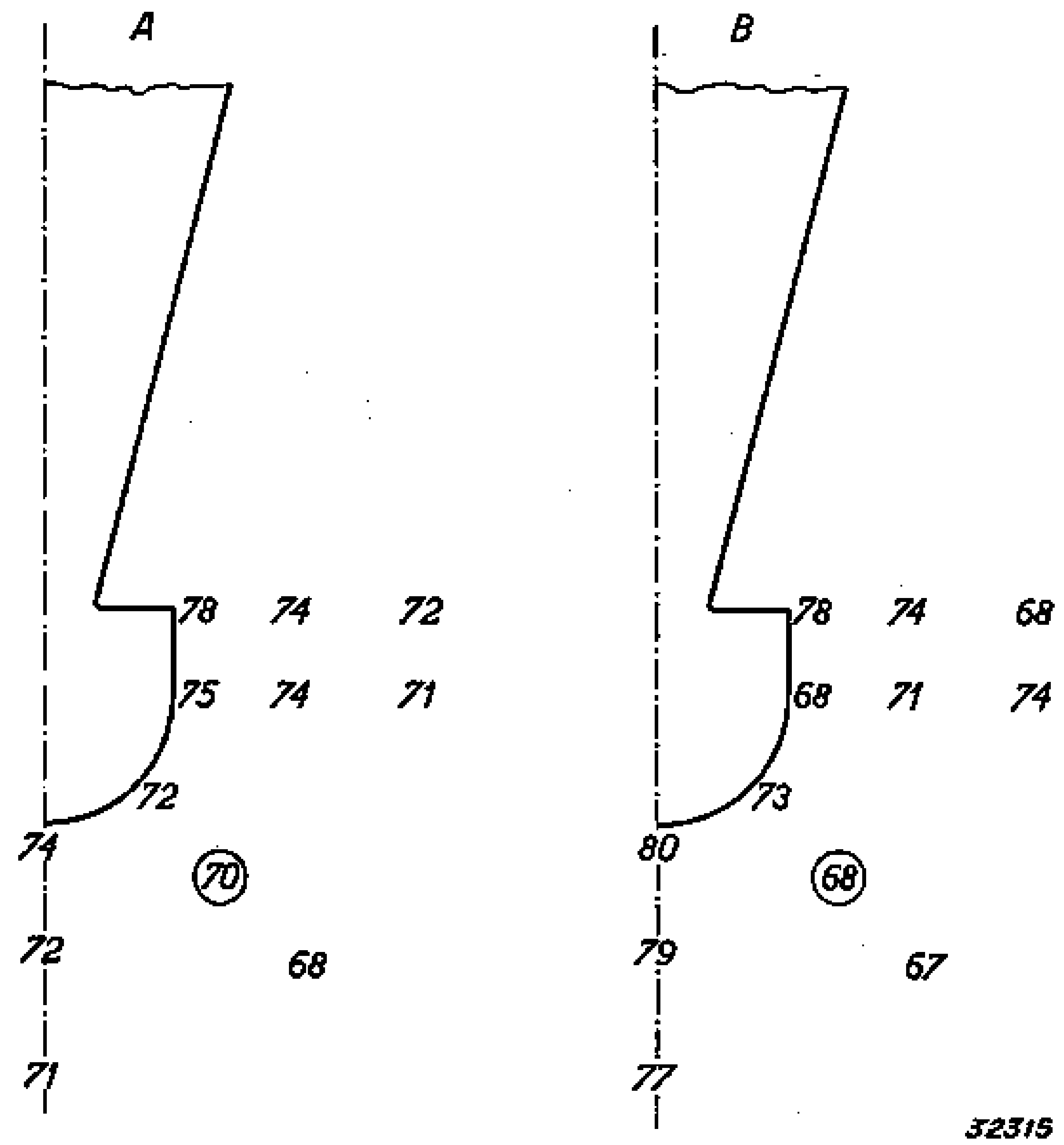

Fig. 3. Measurements of the sound pressure in the neighbourhood of the "Portaphone", this pressure being expressed in decibels above an arbitrary base level, A at 1 000 and B at 200 cycles per sec. The best position for the microphone is marked by a small circle.