Fig. 1. The KB-2C Bantam microphone compared in size and appearance to the familiar 44-BX.

The Bantam Velocity Microphone

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and

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Design details for a miniature velocity microphone are discussed by the engineers who developed the KB-2C.

THE INTRODUCTION of the Type KB-2C Microphone has provided the broadcast industry with a valuable tool. This new microphone, about the size of a package of cigarettes, in many respects approximates the performance of the popular Type 44-BX Velocity Microphone and offers some further operational advantages. It is so small that the artist's or speaker's face is not hidden, a feature which is valuable on remote programs and on television pick-ups where the microphone must be in the picture. It is also very light and requires no special amplifiers or cables, thereby simplifying transport, in addition to making possible the use of light supporting means.

Small size, as shown in *Fig.* 1, and weight have been obtained without sacrifice in output level. Compactness has actually resulted in directional characteristics which more nearly approach the ideal for a velocity microphone over the entire frequency range (see *Figs.* 2 and 3). The frequency range is fully adequate for all operations. Aside from its small size, the microphone contains many interesting mechanical features. It incorporates a sponge rubber mounting between the head and the shank assembly, and additional cushioning should be necessary only when the microphone is used on a boom where the location of the microphone is changed frequently and rapidly. The usual unsightly cable and plug connection is "built-in" to the shank portion of the microphone, which in addition to serving as a mounting may also be used as a handle when one is required. Access to the connecting plug is obtained by means of a hinged cover forming the rear portion of the shank. The Cannon Type XL Connector was chosen for the application because its small size and quality are in keeping with the purpose of the design.

The microphone also contains electrical features which are equally as useful as the mechanical features previously described. The low-frequency response is readily adjustable for either voice or music operation by means of a switch that may be operated from the outside of the microphone by use of a small screw driver. The characteristic for the voice position has been selected so that response is approximately flat when the sound source is located about nine inches from the microphone (see *Fig.* 4). The design of the coupling transformer has resulted in a sensitivity to stray 60-cps magnetic fields low enough for any normal application. Since the sensitivity of the microphone to stray fields is a function of the direction of the field, it is possible in many applications where high intensity fields are encountered to minimize the pick up by rotating the microphone. Sensitivity to high-frequency fields is kept low by proper grounding and complete enclosure of the microphone parts in the external metal screen and case.

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Design Features

The question naturally arises as to how all of these things can be accomplished in a microphone of such small size without any apparent sacrifice. The answer lies in painstaking design—the careful selection and use of materials in the most advantageous places. Involved in the design, and all interrelated, are acoustical, electrical, magnetic, and mechanical problems.

In a velocity microphone, the response-frequency characteristic will be flat over the frequency range in which the moving system is mass controlled, and the pressure gradient applied is directly proportional to frequency.[1] In the case of a plane-wave sound field this means that the response will be constant for any frequency well above the resonance of the ribbon and below the frequency at which the gradient is no longer proportional to frequency due to the physical dimensions of the parts surrounding the ribbon.

Because of its relationship to the low-frequency response, the resonant frequency of the ribbon was the first characteristic considered in the design of the microphone. The ribbon is clamped at the ends, and the system is a combination of a stretched string and a bar clamped at the two ends.[2] The lowest resonance frequency will be obtained when the tension is zero, and this resonance will largely determine the absolute limit of the low-frequency response. The resonant frequency for the condition of zero tension is

$$f = \frac{3.56}{l^2}\sqrt{\frac{QK^2}{\rho}} \qquad cps$$

For an aluminum ribbon 0.0001 in. thick,

$K = 7.3 \times 10^{-5}$ Radius of gyration
$Q = 5 \times 10^{11}$ Modulus of elasticity, dynes/cm^2.
$\rho = 2.7$ Density, grams/cm^3.
l = length of ribbon, cm.

In most of the microphone structures, the air load will approximately equal the ribbon density for a ribbon 0.0001 in. thick. The effective value of ρ will therefore be about 4. Substituting in the above

$$f = \frac{93}{l^2} \qquad cps$$

[1] Dr. H. F. Olson, Elements of Acoustical Engineering, 2nd Edition. Chapter VIII, pp. 237-252.

[2] Dr. H. F. Olson, Unpublished Technical Report.

Since it is impracticable to install the ribbons without tension, and because of the stiffness coupled into the mechanical system from the electrical load, the following expression is more realistic

$$f_o = \frac{4.5 \times 93}{l^2}$$

cycles per second.

The low-frequency limit, f_o was set at 60 cps on the basis of satisfying most requirements. Substituting this value into the formula, the minimum ribbon length is found to be approximately one inch. Thus it was possible to use a ribbon only one-half the length of that in the Type 44-BX Velocity Microphone, providing the same sensitivity could be obtained.

The generated voltage in the ribbon is

$$e = B\,l\,v \times 10^{-8} \text{ volts}$$

where B = Flux density in gap, gausses

v = Velocity amplitude of ribbon, cm/sec.

l = Length of ribbon, cm

A measure of the efficiency of the microphone will then be

$$Eff. = \frac{e^2}{R_R} = \frac{(B\,l\,v)^2}{R_R}$$

where R_R in the electrical resistance of the ribbon in ohms. The loss in generated voltage, because of the reduced ribbon length, must therefore be made up either by increasing the flux density in the air gap, by some change in the physical structure, or a combination which will increase B, the net increase of 1.4 being required.

The ribbon width was chosen so as to maintain approximately the same lateral stability as in the 44-BX microphone. Since the new ribbon is one-half the length of the ribbon in the 44-BX, as might be expected, a ribbon of approximately half the width was found to give the same stability. This reduction necessitates an additional increase of 1.4 in the factor $B\ l\ v$.

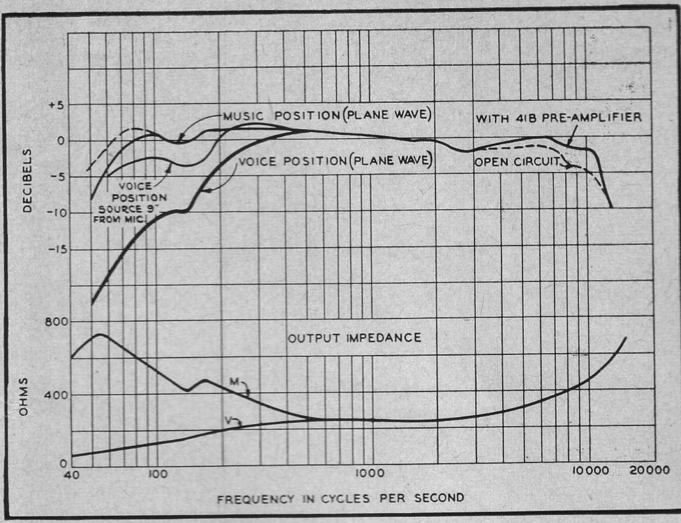


Fig. 4. (upper) Response-frequency characteristic for a plane wave, and for a source 9 in. from the microphone. (lower) Impedance-frequency characteristic.

The extent of the high-frequency range was tentatively established at 10,000 cps. The limit of the high-frequency response of the microphone is determined largely by the baffle area surrounding the ribbon, and good response will be obtained up to the point where

$$d = 0.5\ \lambda$$

d = the distance from the ribbon to the edge of the structure.

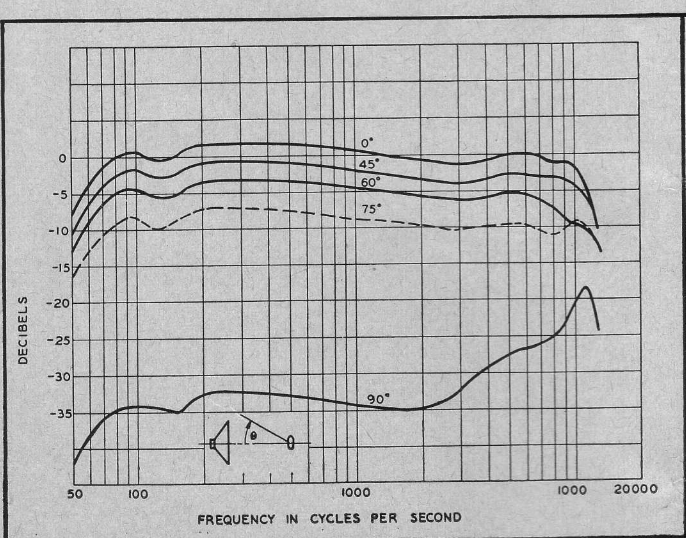
λ = the wavelength of the highest frequency at which good response is desired.

With 10,000 cps established as an upper frequency limit, d will be about 0.66 inch. In the actual structure it can be somewhat larger, because the path at the ends of the ribbon is less than this value, thus serving to lower the average.

Magnetic Circuit Design

The problem then remained to design a magnetic circuit which, within the established ribbon and baffle dimensons, would provide the desired output level. As mentioned, this level was tentatively set at being equal to that of the 44-BX microphone. The desired result was accomplished with a magnetic circuit of novel design in which the permanent magnet material forms the pole pieces and the return path is a part of the external microphone structure. Such an arrangement is efficient, both with regard to the amount of magnet material required and the amount of iron in the return path. The amount of magnet material required is reduced by virtue of the fact that the leakage flux can be decreased by placing the magnetic material as close to the air gap as possible; and since only a portion of the leakage flux returns through the iron path, the section of the magnetic return path is also small. The properties of Alnico V were ideal for the permanent magnet material.

As mentioned previously, the resonant frequency of the ribbon occurs



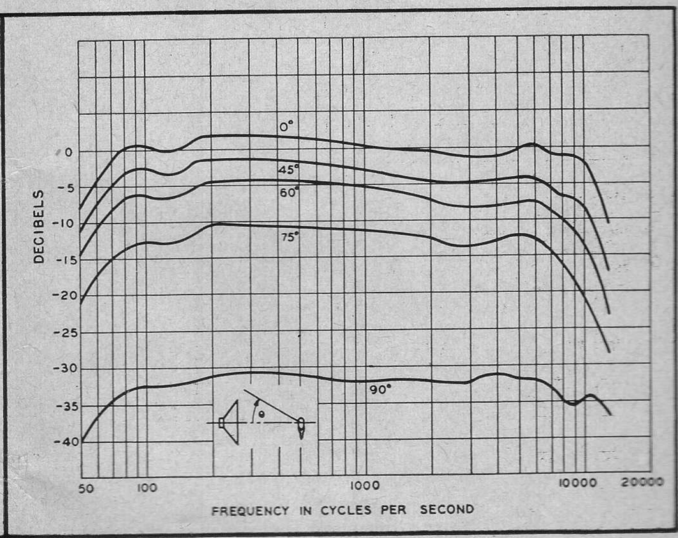


Fig. 2 (left). Directional characteristic of the KB-2C microphone when rotated about the vertical axis. Fig. 3 (right). Directional characteristic of the microphone when rotated about its horizontal axis.

Fig. 5. Miniature compensating reactor and impedance matching transformer employed in the KB-2C microphone.

at about 60 cps, well within the audio range, and must be critically damped through the use of a suitable acoustic resistance material. This arrangement materially reduces the sensitivity of the microphone to mechanical excitation by low-frequency building rumble, but does necessitate care in making ribbon replacements to assure the use of a correct value of resonance and acoustic damping. Failure to do so may result in a microphone whose low-frequency response is unsatisfactory because of its being excessively high.

In order to complete the small microphone, it was necessary to design an extremely small impedance matching transformer and compensating reactor, as shown in *Fig.* 5, as well as a switch, all of which are housed in the die casting immediately below the ribbon and magnet assembly.

Performance

These microphones have now been in service for a period of time, and an appraisal of some of the unforeseen difficulties with this radically small microphone can be made and remedies discussed.

The small size has resulted indirectly, in many cases, in an exaggeration of the low-frequency response, such as is always experienced when the speaker is close to a velocity microphone, and, in addition, the ribbon is excited by the breath puffs to a greater extent than with larger microphones, such as the 44-BX. This condition results from a combination of two things. First, the smaller microphone apparently invites the user to get much closer because it is possible to do so without feeling restricted by the presence of the microphone. Second, the small size of the microphone screen enables the user to get much closer to the ribbon. As an example, the 44-BX microphone limits the closeness of the user to a minimum of about 1½ inches, whereas the limit on the KB-2C averages no more than 3/4 inch. (The effect of source proximity on response is shown in *Fig.* 6.) In addition, the excitation by breath puffs is increased beyond the normal expectancy because the effectiveness of the windscreen is reduced by its closeness to the ribbon.

Considerable effort has been expended in trying to improve the windscreening without seriously affecting the response-frequency characteristic or increasing the microphone size, and apparently no good solution exists.

Out of this work, however, came one interesting and useful result. Where the microphone is always used for close talking applications, or where some attenuation of the low-frequency response is permissible, it is possible to improve the windscreening considerably by the addition of cotton, superfine fiber-glass, or similar acoustic materials between the inner and outer screens. In addition, other operational advantages result. *Figure* 7 shows the response of the modified KB-2C microphone to a plane wave and also the response when the microphone is used for close talking applications. As can be seen, the response-frequency characteristic obtained for close talking is substantially flat from 50 to 9000 cps.

Above 1000 cps, the discrimination against random unwanted sound is about 19 db better than that obtained with a conventional pressure microphone used at a distance of 6 inches. Below 1000 cps the discrimination increases gradually to a value of 44 db at 100 cps. The net result, for the first time, is a high-fidelity anti-noise microphone.

Numerous applications will no doubt suggest themselves, in addition to the following two. (1) In programming, where the announcer can work close to the microphone, background noise can be eliminated. (2) On programs where audience participation necessitates the use of a public address system in combination with a microphone which is circulated among the audience, feedback can be completely eliminated while maintaining a reasonably high level on the P.A. system.

The excellent frequency response, high output level, absence of excitation due to breath, and anti-feedback characteristics are decidedly advantageous. A temporary means of accomplishing approximately the same thing would be to enclose the screen portion of the microphone with a handkerchief which has been folded several times.

Using the standard stock microphone, satisfactory performance can be assured if the microphone is used at distances of 18 inches or more for the

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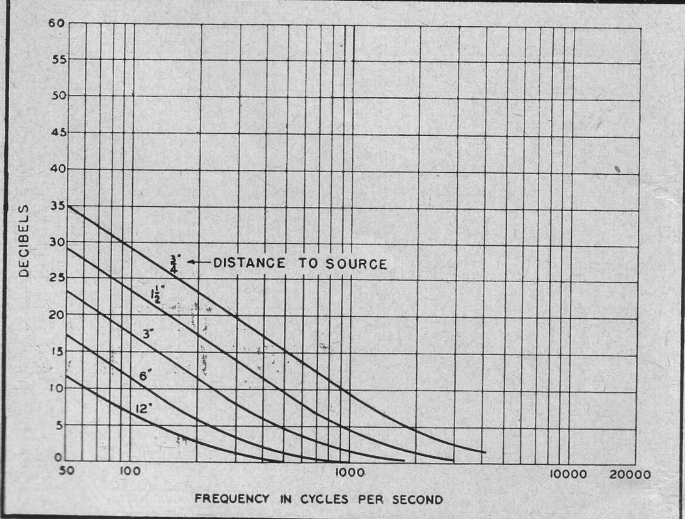

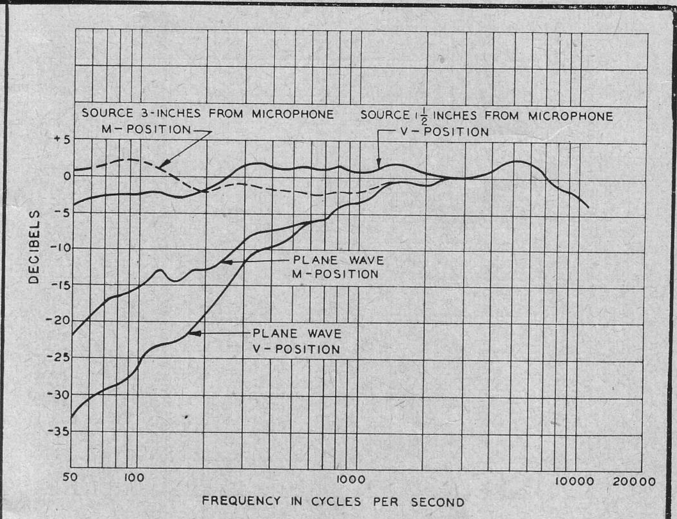

Fig. 6 (left). Curves showing increase in low-frequency response due to proximity of sound source. Fig. 7 (right). Response-frequency characteristics of KB-2C with special packing for plane wave and for close talking. Curves show how modification results in anti-noise characteristic.

BANTAM MICROPHONE

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"M" position, and not less than 9 inches for the "V" position.

The use of high flux density and a screen so close to the ribbon, as required in a miniature design, increases the likelihood of magnetic dirt particles entering the gap between the ribbon and the pole piece. Such particles, if in contact with the ribbon, inhibit its motion and result in loss of low-frequency response. The collection of particles in a more remote part of the gap might cause the microphone to become noisy when it is subjected to any motion which results in relatively large low-frequency movements of the ribbon.

Fortunately, a simple and effective method—a magnetic screen—eliminates this possibility, and KB-2C microphones thus equipped are practically impervious to the entry of magnetic dirt particles. The magnetic screen is simply a small piece of wire mesh of magnetic material, slightly bowed, and placed over each side of the ribbon inside the outer screen. The ends are lightly plugged with cotton to prevent entry of dirt. The presence of the screen wire in the magnetic leakage field serves to concentrate the flux at the points where the wires are located. This produces magnetic poles which prevent the magnetic particles that penetrate the outer screen from being drawn into the air gap of the microphone. All KB-2C microphones now being manufactured are equipped with magnetic screens.

The design of the Bantam microphone is providing broadcasters with a miniature unit which offers both excellent performance and reliability. Because of its light weight and small size, the KB-2C is ideal for remote applications, as well as for banquets, night club shows, or other occasions where it is important that the artist's face be in full view. In addition, the KB-2C is fast becoming a favorite for standard use in TV, AM, and FM studios and control rooms.

AUDIO INPUT SYSTEM

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audio facilities for special purposes, particularly where several input devices are involved, may find this unit the answer to many of their problems. To date, several versions of the unit have been built, and all have operated extremely well. This, and the fact that no "trick" circuits are involved, makes