Oct. 21, 1958 J. B. HARRIS 2,857,478

CO-PLANAR LOUD SPEAKER

Filed Sept. 13, 1954 2 Sheets-Sheet 1

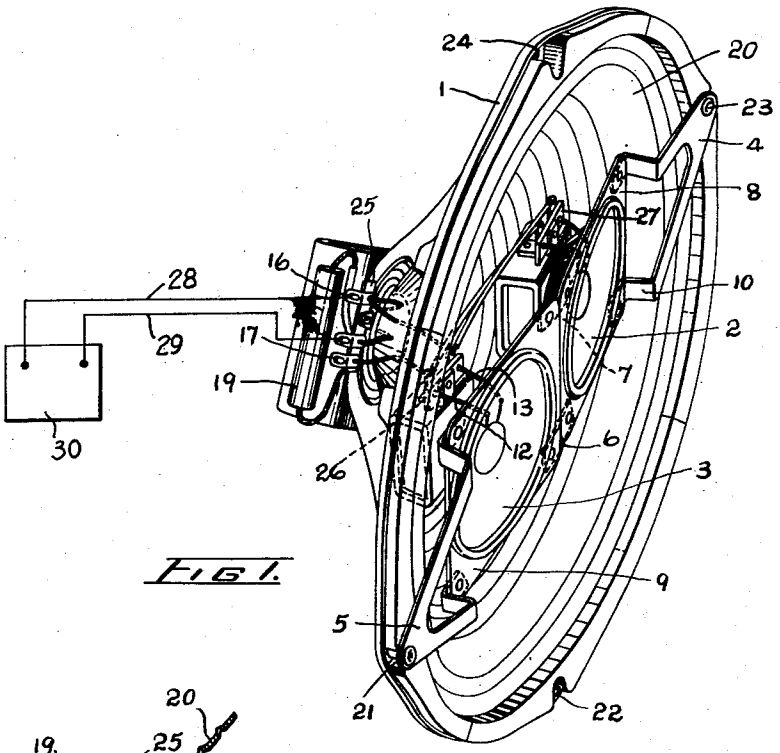


FIG 1.

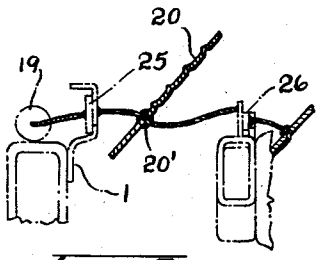


FIG 6.

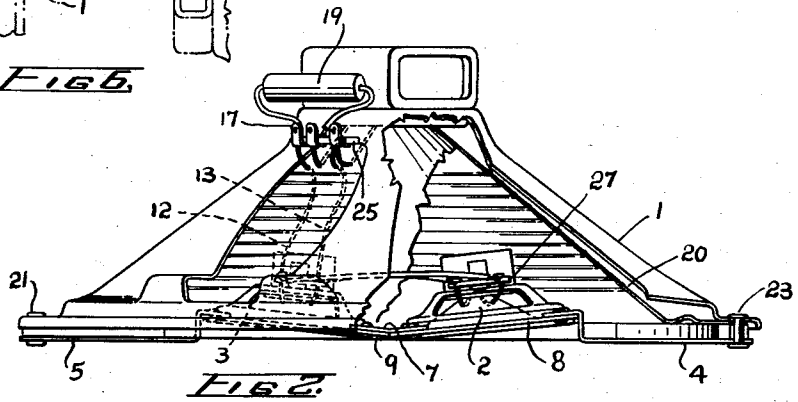


FIG 2.

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CO-PLANAR LOUD SPEAKER

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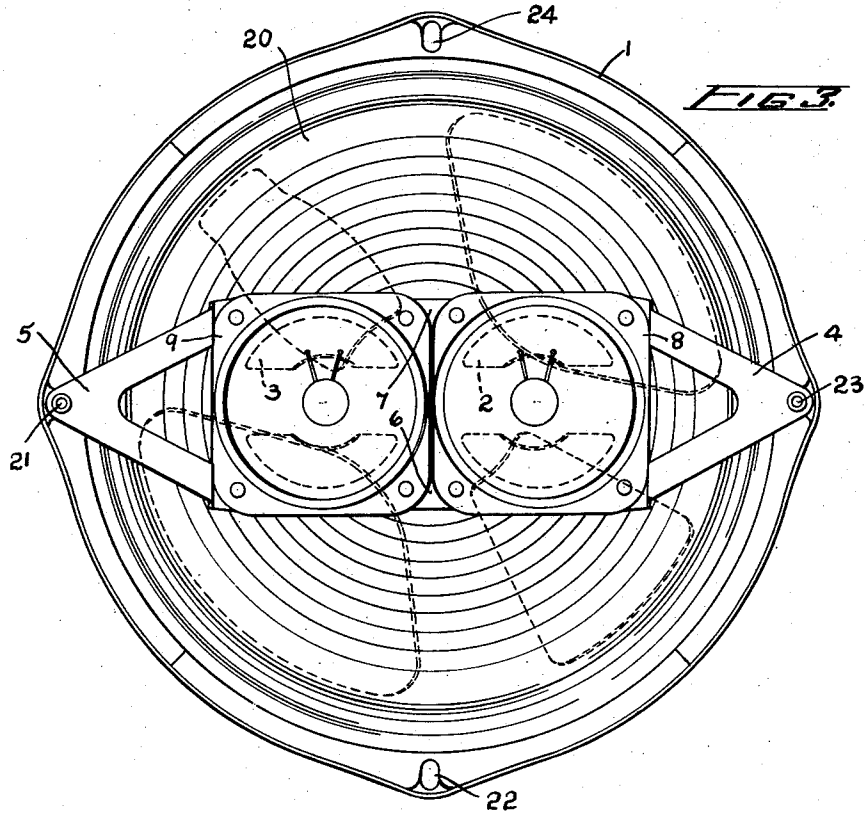


FIG. 3.

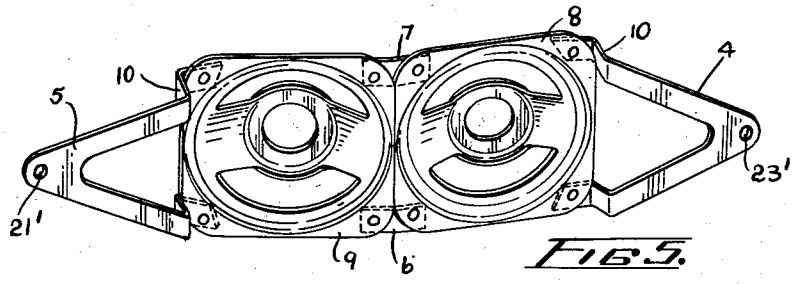


FIG. 5.

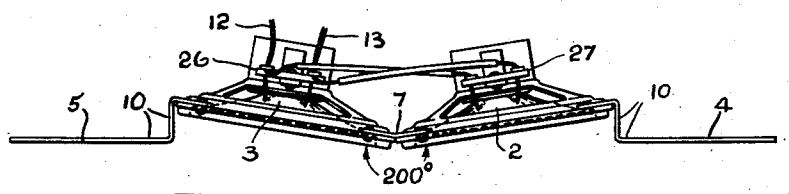


FIG. 4.

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2,857,478

CO-PLANAR LOUD SPEAKER

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Application September 13, 1954, Serial No. 455,651

4 Claims. (Cl. 179—116)

This invention relates to loud speaker arrangements and is especially directed to arrangements for reproducing sounds in the music range of frequencies.

It is well known that it is difficult to provide faithful reproduction of sound over the complete range from about 40 cycles to beyond 12,000 cycles, using only a single speaker. Many attempts have been made in this direction but with a degree of success which proved to be indifferent when supplied with electric wave energy derived from high quality sources such as have recently been made available.

In an effort to provide improved response over a wide frequency range many workers have disclosed arrangements employing concentric piston arrays, two or more air impelling agencies being usually tied to the same motor or "voice coil." This has not proved satisfactory to discriminating listeners for the reason that, although by this means cone break-up is diminished, there remains a substantial degree of amplitude intermodulation distortion to which trained human ears are quite sensitive. This form of distortion is due to the fact that while the voice coil is moved out of the dense part of the fixed magnetic field under the urge of a low frequency wave of high intensity, the voice coil is also urged to oscillate, while so disposed, at a high frequency, and at a considerably lower intensity. Normally such oscillations occur continuously while the voice coil is moving in and out of the field at the lower frequency. The result is that the higher frequencies are modulated in amplitude by the low frequency impulse, causing a spurious harmony which the human ear readily detects as an objectionable quantity not scored in the music; engineers have already taken great pains to prevent such intermodulations from existing in the wave translation networks of the sound systems and it has been rather discouraging to find these distortions turning up in the speaker system itself.

Efforts have been made, in another direction, to provide several independent speakers, separately disposed spacially and to connect the driving coils in different parts of a frequency separating network so that each of a plurality of speakers receives only a restricted range of frequencies suited to its particularly selected talents. This has proved to be a better arrangement but has displayed a new fault almost equally noxious to the ear: this fault may be described as "instrument-creep." When listening to systems of this type on, for example orchestral music, when the dynamic range of the music is great, the instruments seem to be moving about in the listening room in a most disconcerting manner as the sound volume of the various instruments varies. This has been found due to the habit of arranging so-called "two-way" and "3-way" speaker systems with a considerable spacial disposition of the respective units. Whereas some workers, notably Briggs and Klipsch have provided "multi-way" arrangements in which this effect has been reduced, the price at which this has been achieved has proved to be very high.

It is an object of this invention to provide a low cost "multi-way" reproducer system wherein a plurality of

speakers, each operating independently over a specified range of frequencies, are grouped spacially in over-lapping relation so that the various frequencies are initiated from a restricted area. This provides the well known, "hole in the wall" effect so widely held as a desirable contribution to realism in the presentation of recorded sound in small rooms, and avoids both the phenomenon of instrument-creep, and also entirely eliminates amplitude intermodulation products from the speaker system when supplied with distortion-free electric wave energy.

It is another object of the invention to provide a system of the kind proposed wherein the various speaker units are so disposed one with the other that the whole ensemble can be treated as though it were a single speaker of current size and form, thereby making the present arrangement capable of being substituted in an existing single-speaker equipment without any modification thereto other than an exchange of the old unit for the new one.

The various ingenious means whereby these objects are achieved will be more readily understood by perusal of the following description of a typical construction in accordance with my invention, the text being aided by reference to the accompanying drawings wherein:

Figure 1 is a perspective view of a complete two-way speaker system in accordance with my invention.

Figure 2 is a side elevation partly in section of a speaker system according to my invention.

Figure 3 is a face view looking into the spacially overlapping cones of my arrangement.

Figure 4 is a side elevation of a pair of tweeter units forming part of the arrangement depicted in the previous figures and showing especially the stepped support bracket whereby the tweeters are nested within the arch of the woofer cone.

Figure 5 is a perspective plan view of mounting brackets and tweeter chassis arranged in accordance with my invention.

Figure 6 depicts in detail a preferred method of bringing the signal leads through the woofer cone and onto the terminals of the tweeter units.

Referring now to these figures, **1** is a main woofer frame of conventional form having mounting holes **21, 22, 23, 24** which conform to the manufacturing standards currently approved by the American Radio and Television Manufacturing Association. The woofer assembly may be of the size marketed at this time as a "twelve inch" unit; the driver piston and motor may have a combined mass and characteristic such as to provide a resonant tendency in the region of 50 cycles, and a useful response, when fitted to a suitable baffle or enclosure, of from 30 cycles to 5000 cycles; this is a preferred but not limiting specification.

The tweeter units are, typically, of the kind well-known as a 3½ inch P. M. dynamic speaker. Two such units having frames **8** and **9** and cones **2, 3** are mounted side by side within the arch of the woofer and strapped together at **6, 7**. Their distal sides are attached to respective mounting brackets **4** and **5** and the mounting holes **21'** and **23'** are spaced so that when the two tweeters reside centrally within the arch of the woofer frame **1** the holes **21, 23** therein coincide with the holes **21', 23'** and the support members are eyeleted to the woofer frame so that clearance holes in the eyelets allow the holes **21, 23** to be used for mounting the whole assembly in a cabinet in the same manner as is commonly practised in connection with conventional single speaker units. In order to further this latter object, the brackets **4, 5** are stepped inwardly at **10** so that the tweeters do not extend beyond the plane of the woofer frame, i. e., beyond the gasket face of the woofer.

In a further aspect the tweeter frames **8, 9** are disposed

within the arch of the woofer so that their respective planes intersect to bound an exterior angle of approximately 200 degrees so that the cones **2**, **3** radiate a dispersed train of sound waves.

The motors and pistons of the tweeters are, in a typical case arranged to have a useful frequency range from about 3,500 cycles to 17,000 cycles in a preferred but not limiting specification. A capacitor **19** is connected in series with a feed wire to the tweeters which nominally are connected in parallel and are phased so that their respective cones move always in the same direction under the urge of a wave of energy. The capacitor **19** functions to restrict the influence of frequencies below the desired operating range of the tweeters, in the manner well known.

The three speakers are all normally connected in parallel to the load connections **16**, **17**, with the modification that capacitor **19** is inserted in series with the tweeters as and for the purpose above noted. The combined phasing is normally such as to cause all the speaker cones **2**, **3** and **20** to move co-phasally, when connected by lines **28**, **29** to the audio signal wave source designated **30**.

A feature of the invention resides in the manner in which the feeder wires to the tweeters have been conducted through the woofer cone **20** to the terminal board **25**. It is desirable to keep these leads short, very flexible, and so nearly free from resonant effects as possible. The latter requirement is one which has plagued workers in this field for many years. In large speakers, and, in fact, in any speaker wherein the voice coil leads are required to be of any substantial length there is a tendency for them to whip and cause buzzy sounds which can be heard by the listener. These buzzy noises occur at certain frequencies only and are excited by the rhythmic excursions of the cone, particularly at the higher frequencies. In normal constructions designed to cover a wide frequency range one end of each voice coil lead is necessarily stationary at the load terminal, and the other end moves with the cone.

In the present construction, by passing the voice coil leads to the high frequency speakers through the woofer near its apex and sealing them to the cone **20** with cement, as at **20'**, where they pass through, the leads to the tweeter are made shorter than they would otherwise be and they therefore are less liable to buzz since the changes in attitude thereof are never influenced by the tweeter frequencies directly, since their moving ends oscillate only at the lower frequencies of the woofer cone **20**. The tweeters being small, their own leads to their respective terminal boards **26**, **27** are short and, these speakers being of proven design, the buzz problems have already yielded to manufacturing experience. Thus the new concept has not introduced any new problems of lead buzz.

The respective voice coil impedances of the three motors can be arranged in such a manner that the relative sound outputs are in good balance.

This may be accomplished by suitable choice of voice coil impedances, suspensions and the magnetic flux densities in the air gaps. These techniques are well known, per se, to those skilled in the art.

It will be evident that the arrangement is not limited to two-way operation. One or other of the tweeter frames, **8**, **9** may contain a different cone and voice coil system such that the one tweeter may function as what is currently referred to as a "middler," or middle frequency range reproducer. This unit may also include low frequency and/or higher frequency attenuators so as to provide three electrical divisions thereby providing three independent acoustical channels—a "three-way" system. If the middler is designed to operate usefully only in the range above 500 cycles, experience has shown that no baffle, per se, is necessary so the present construction is readily adaptable to such a modification.

It will also be evident that the tweeters may be bridged across the adjustable arm of a potentiometer whose maximum resistance is shunted across the leads **12**, **13** from the woofer cone. This will provide adjustable balance between lows and highs independently of amplifier equalizers. This is useful as it facilitates a sometimes desirable modification of the conventional 6 db per octave curve which characterizes most commercial audio equalizer arrangements. It should be noted that prior art systems using concentric cone arrangements tied to a single motor are not capable of being modified in response in this way. The present arrangement provides this valuable facility.

The construction above described may be made up to employ smaller or larger speakers and, as implied hereinbefore, the smaller speakers having ranges of operation limited to regions above 200 cycles, and for the purposes of this specification defined as "tweeters" may be of respectively different sizes. In another aspect the larger speaker which for the purpose of this specification I define as a "woofer" may have its upper frequency range extended to include at least a portion of the band constituting the lower region of the frequency range assigned to the said tweeters; this and similar arrangements can be varied without departing from the spirit of my invention as defined in the appended claims.

What is claimed is:

1. A loud speaker arrangement comprising a conical woofer characterised by a chassis including a mounting ring, a pair of tweeter units each characterised by a mounting frame and positioned to reside side by side within the arch of the woofer cone and laterally within the boundaries of said ring, a pair of V-shaped brackets having their respective apices attached to selected points on the periphery of said mounting ring and having their respective outer arms bent inwardly toward the woofer cone and then turned transversally thereof, means attaching respective ends of said arms to corresponding points on the mounting frames of said tweeters, means for joining the tweeter frames rigidly at adjacent sides of said tweeter frames, the mounting brackets and attaching means being so disposed as to position the said tweeters centrally within the said woofer mounting ring so that the faces of said tweeter mounting rings lie in planes which intersect to include a selected angle, and circuit and terminal means for connecting the respective voice coils of the woofer and tweeters jointly to an electric wave source.

2. A loud speaker arrangement in accordance with claim 1 the mounting brackets and attachment means cooperate to position said tweeters centrally within said woofer mounting ring with the faces of said tweeter mounting rings disposed in intersecting planes at an angle of substantially 160 degrees.

3. A construction in accordance with claim 1 in which the respective woofer and tweeter voice coils are connected in parallel to said circuit means, and in which the relative disposition of said woofer and tweeter voice coils enables all the cones to vibrate to-phasally at any frequency to which they are all responsive.

4. A construction in accordance with claim 1 wherein there is provided in said circuit means a frequency selective facility located between the woofer voice coil and at least one of the tweeter voice coils to limit the response of such tweeter voice coil to a specified range of frequencies.

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