Dec. 10, 1940. C. R. JACOBS 2,224,651

ACOUSTICAL APPARATUS

Filed Nov. 9, 1939 3 Sheets-Sheet 1

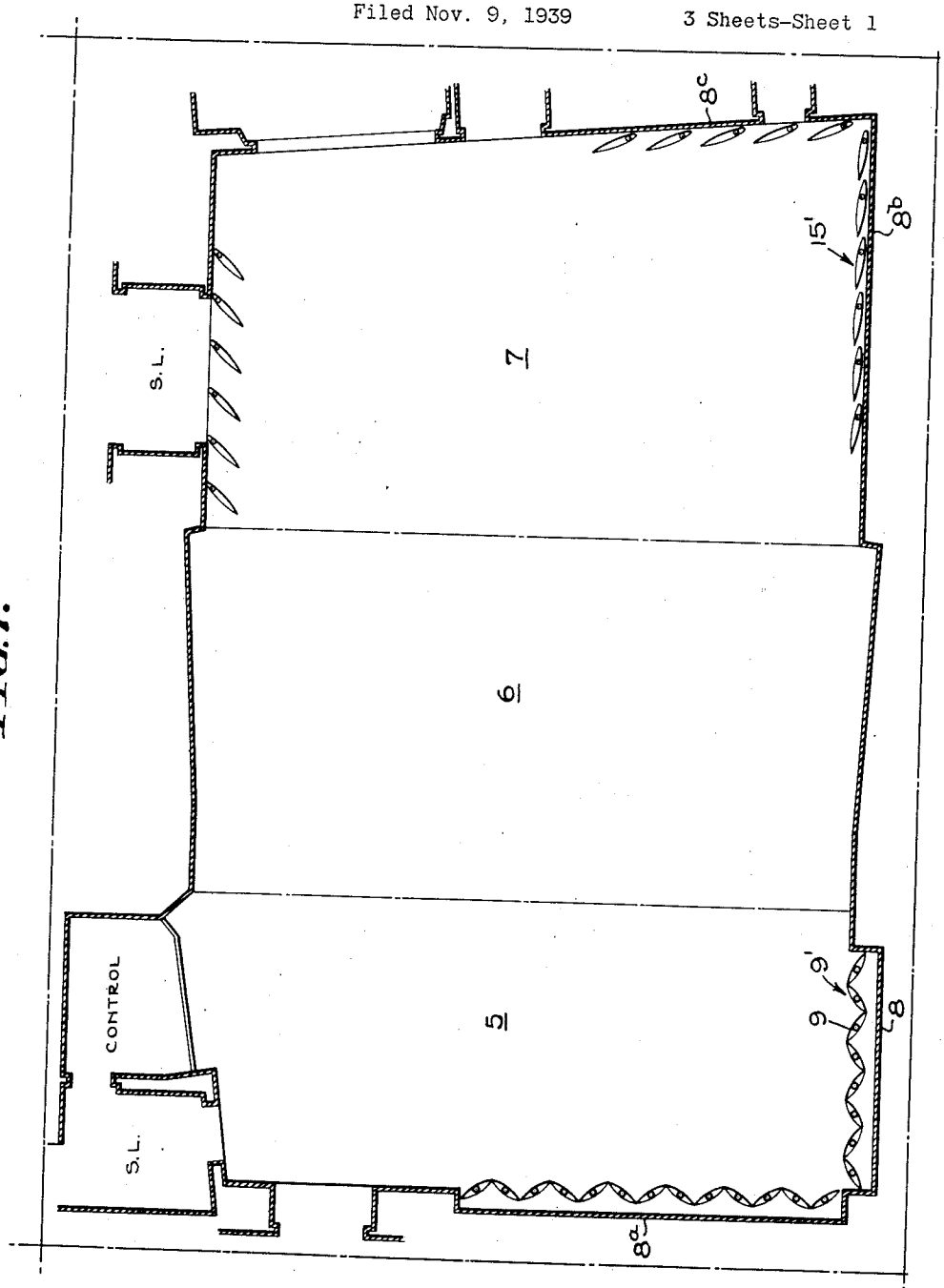


Fig. 1.

Inventor
C. R. Jacobs

By R. Yates Dowell
Attorney

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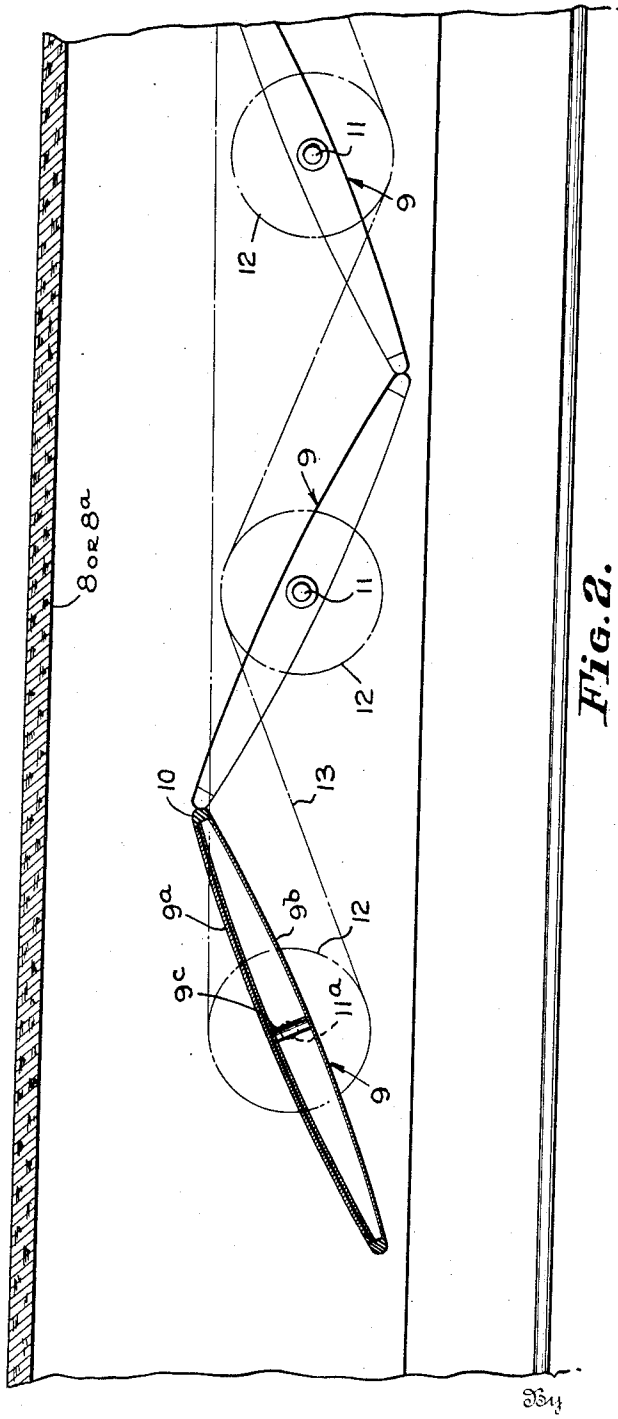


Fig. 2.

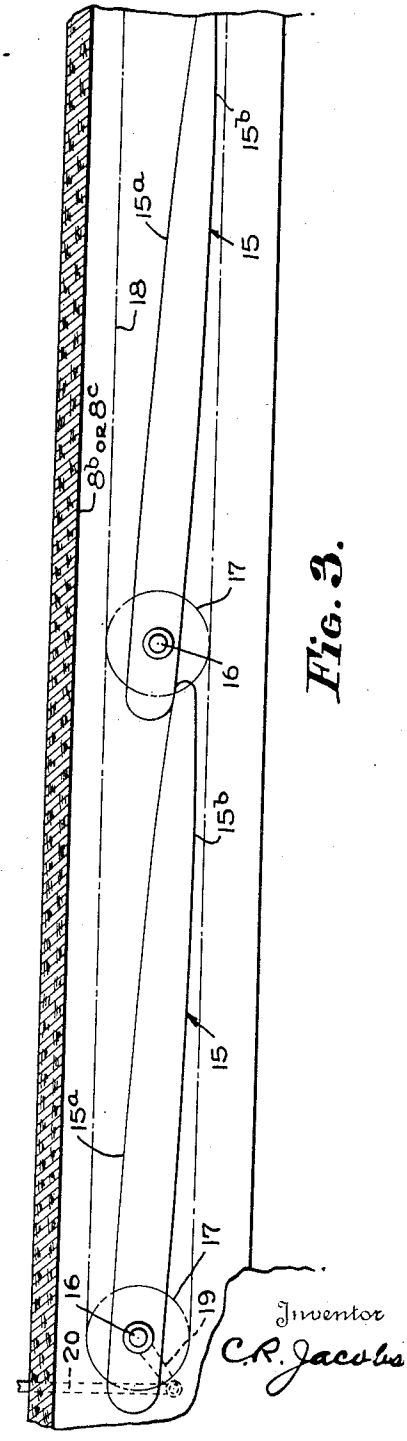


Fig. 3.

By

Inventor
C. R. Jacobs

Ayatos Dowell
Attorney

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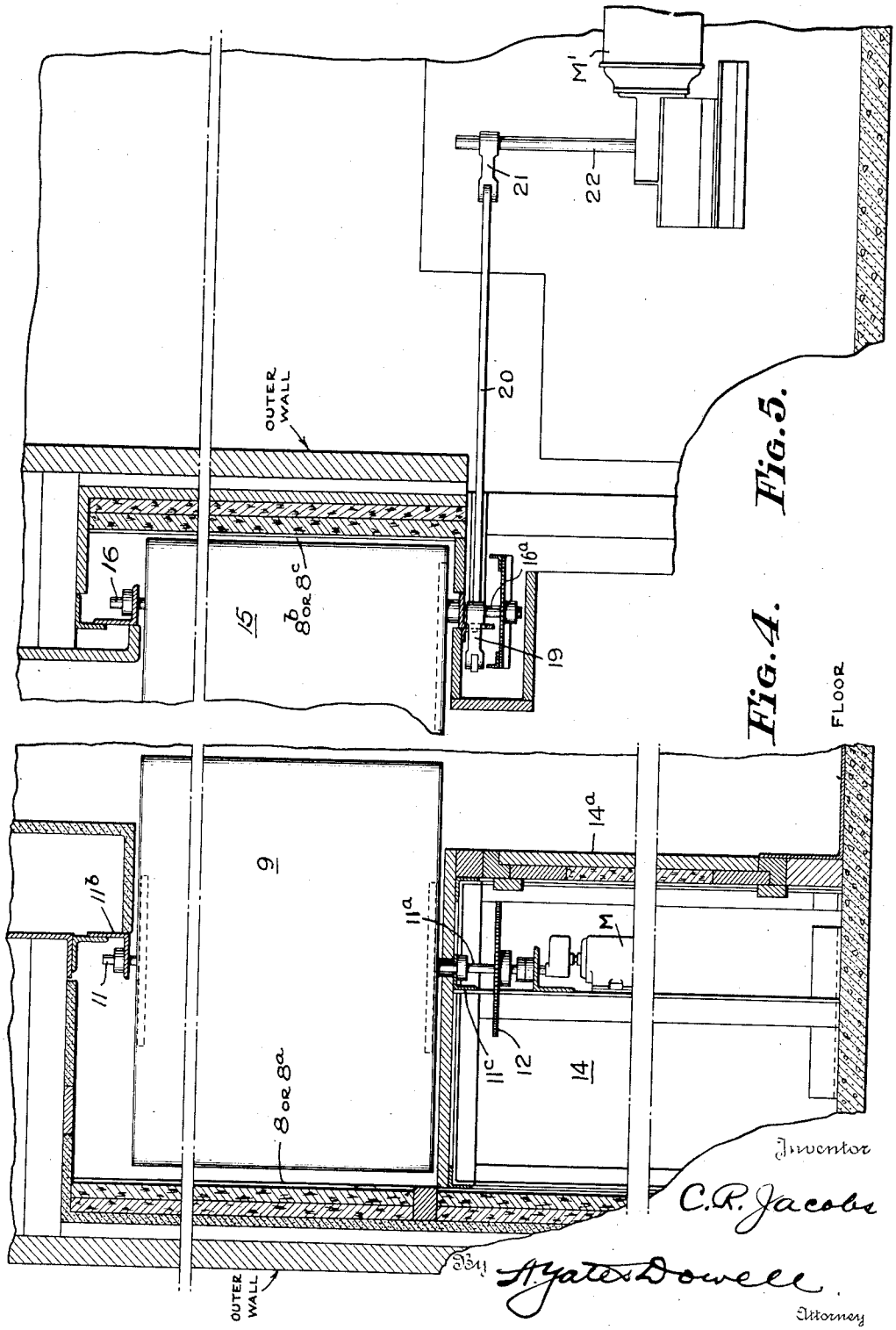


Fig. 5.

Fig. 4.

Inventor
C. R. Jacobs
By Hyatt & Dowell
Attorney

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UNITED STATES PATENT OFFICE

2,224,651

ACOUSTICAL APPARATUS

Clarence R. Jacobs, Scarsdale, N. Y.

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12 Claims. (Cl. 181—30)

This invention relates to sound control or acoustical apparatus for use primarily in radio broadcasting studios, recording studios, theaters and analogous sound chambers.

An object of the invention is to provide acoustical apparatus for installation in a studio or other sound compartment capable of selective amplification or reinforcement and reflection of tones and selective variation of acoustical conditions within the studio.

Another object of the invention is to provide acoustical apparatus embodying control elements having resonating qualities at given frequencies which bring out the natural, true tones of the instruments from which the sound emanates, said elements being adjustable or movable to change their natural frequencies and also vary the reverberation time of the studio or other enclosure.

Another object is to provide a highly efficient sound control apparatus which is capable of silent operation and which is relatively simple in construction and installation.

More specifically, the invention contemplates sound control elements in the form of adjustable acoustical vanes or panels preferably of predetermined vibratory characteristics having predetermined resonating characteristics at given frequencies and arranged in cooperative relation with a sound absorbing surface, the vanes or panels when adjusted varying the degree of exposure of said surface to thereby vary the reverberation time of the studio. These vanes when in closed or substantially closed position provide a serrated or V'd wall creating a diffused sound condition within the studio or other enclosure. The panels or vanes preferably have absorption factors and characteristics of predetermined relative values, viz, they absorb a certain percentage of sound at a given frequency or cycle and reflect or in effect add a certain percentage of sound at another frequency or cycle, there being a definite relationship between the cycles of absorption and reflection which tend to bring out or emphasize tones which would otherwise be obscured in a broadcast while at the same time modulating other tones and merging the whole in proper harmony.

The various objects and advantages of the invention will become more apparent in view of the following description taken in conjunction with the drawings, wherein:

Fig. 1 is a schematic plan view of a radio broadcasting studio constructed in accordance with the features of the present invention;

Fig. 2 is an enlarged detail view in top plan and partly in section of a number of the panels or vanes of Fig. 1 and the sound absorbing surface or wall in rear thereof;

Fig. 3 is a view similar to Fig. 2 with the exception that it illustrates a different or alternate type of vane;

Figs. 4 and 5 are views in sectional elevation taken transversely of Figs. 2 and 3, respectively, Fig. 4 illustrating the operating mechanism for the vanes of Fig. 2 and Fig. 5 the operating mechanism for the vanes of Fig. 3.

Referring to the drawings in detail, in Fig. 1 I have shown a proposed plan for a radio broadcasting studio. For the purposes of illustration the studio is divided into three compartments 5, 6, and 7. The walls 8 and 8*a* of the compartment 5 may be provided with a sound-absorbing surface such as fabric, cork or other suitable material or may be comprised wholly or partly of sound-absorbing or deadening material. In front of these acoustical walls are mounted a plurality of vanes or panels, each of which is generally indicated at 9 and the preferred form of which is shown in detail in Fig. 2. These vanes or panels are at least in part constructed to have certain desirable resonating characteristics. Their function may be compared with that of the sound box or body of a violin. They may be constructed and arranged to absorb 11% of the sound at 60 cycles, reflect or, in effect, amplify or add 25% of the sound at 100 cycles; absorb 22% of the sound at 150 cycles; reflect or add 6% at 200 cycles; absorb 28% at 500 cycles; amplify 8% at 1000 cycles; absorb 13% at 1500 cyles, 7% at 2000 cycles and 3% at 4000 cycles. There is thus a definite relationship in the resonance of the panels at 100, 200, 1000, 2000 cycles which result in the emphasizing of certain tones and the modulating of others as will be more fully hereinafter described. The term "amplify" as used herein means that the tone is intensified or enriched by supplementary vibration.

The material of which the panels are made may of course vary. In practice, ply wood has proved satisfactory. One side or shell of the panel, for example the inner shell 9*a*, may be 7-ply with a total thickness of one-half inch. While, of course, the thickness or ply may vary, it is desirable that one side of the panel be as rigid and resonate as possible. The wood used should be of the hard dense variety. The other shell or outer side 9*b* of the panel may be made up of 5-ply wood with a total thickness of one-fourth inch. The wood for this side of the panel

is preferably soft and porous. Airplane spruce has been found satisfactory.

The height of the panels may, of course, vary. Those illustrated herein are 14' high or long. They have a center thickness of 4" gradually tapering as they recede from their pivot point to a relatively blunt edge, with an overall blade width from edge to edge of approximately 2'5". The edges are preferably provided with resilient guards or bumpers 10 which may be made of rubber or analogous material.

The thickness of the panels, their curvature and other factors influence their frequency characteristics, and hence these factors are subject to variation in accordance with conditions desired for a given studio or enclosure. Each vane is also preferably provided with a sounding post 9c, and the position of the post also affects the frequency characteristics. This sounding post may consist of a dowel pin made up of a round piece of wood of say, for example, ½" in diameter, and is shown located approximately centrally of each panel.

By observing Fig. 2, it will be noted that the pivot points or axes of these vanes are spaced with respect to one another so that when their edges are brought into contact a wall having a serrated or undulating sound-diffusing contour is provided, such wall being indicated at 9' in Fig. 1. Thus, the spacing between the axes or pivot points of the respective vanes may be approximately 2'3", resulting, when the vanes are closed, in a serration having an approximate maximum depth of 6".

The vanes are pivotally mounted and may be arranged so that they are selectively adjustable or rotatable in groups; that is, a certain group of panels covering a certain wall area which may be independently adjustable with respect to another group. Any suitable means may be provided for adjusting or operating the panels.

Fig. 4 in conjunction with Fig. 2 illustrates a type of operating mechanism which may be used for operating the panels or vanes 9. Each panel is provided with end shafts or axes 11 and 11a, which are mounted for rotation in bearing brackets in the form of angle members 11b and 11c. The lower spindle or shaft 11a projects through the floor or base board and is provided with a sprocket 12 having a sprocket chain 13 in mesh therewith, the chain being trained over alternate sprockets as indicated in Fig. 2, so that one panel or base is turned clockwise and its adjacent panel counterclockwise. The sprocket chain 13 may be driven from a suitable electric motor M operating through a reduction unit. The controls for the motor, not shown, may be arrangd for operation from a central point, for example, from the control room indicated in Fig. 1, and which may be the desk of a monitoring engineer, a producer's desk or a sound effects engineer's control panel. The operating mechanism is shown housed in a wall compartment 14 accessible by means of a removable panel 14a.

In Fig. 3 an alternate form or type of panel is illustrated which may be used instead of, or in conjunction with the panels 9. These panels or vanes are each generally indicated at 15 and instead of being mounted on a central or center axis and gradually tapering toward opposite edges, they are mounted on vertical shafts or axes 16 and 16a located adjacent one edge thereof, or the thicker edge. As far as the actual construction of the panels is concerned, the shells or opposed walls thereof may be substantially similar to the walls of the panels 9, the inner shell 15a being rigid and resonate and therefore formed of relatively hard dense wood, for example 7-ply; and the opposite shell 15b of the panel being made of relatively soft and porous wood of 5-ply. The panels 15 at their thickest point may be approximately 3½" tapering to a relatively blunt edge having a bumper or guard 16 thereon; and the overall width of the blade of each vane may be approximately 3'9", with a spacing between pivot points of approximately 3'6" so that when the vanes are closed they will slightly overlap, providing a resonating or sound-reflecting wall having a substantially flat surface contour. With this type of vane, the serrated or undulating diffusion wall is less pronounced than with blades of the type used for the wall 9'. Thus, part of the studio may be equipped with vanes which provide a serrated or diffusion wall of the type indicated at 9' while other portions of the studio may be provided with vanes which when closed result in a wall such as that indicated at 15'.

In rear of the vanes 15 are sound-absorbing acoustical walls 8b, 8c such as the walls 8, 8a used in the rear of the vanes 9 of the compartment 5.

The type of operating mechanism illustrated for the vanes 15 is varied with respect to that used for the vanes 9, note Fig. 3 in connection with Fig. 5. The bottom pivot or shaft 16a for each of the vanes 15 is provided with a sprocket 17 having a sprocket chain 18 trained thereover. Any selected one of the shafts 16a may be provided with a drive connection, illustrated in the form of an arm 19, having pivotally connected thereto a link 20 which in turn connects with an arm 21 secured on a shaft 22 driven by a motor M'. In this instance, the drive is of the oscillating type, and hence the motor 23 may be of the reversing type.

As in the case of the drive mechanism for the vanes 9, the various drive units may be located in a compartment immediately above the floor level, the controls for the motor 23 being operable from a central point.

The center compartment 6 may have a conventional wall structure and is so illustrated, although it will be obvious that any portion or all of the walls of this compartment could also be provided with adjustable acoustical vanes 9 or 15 having a sound absorbing wall in rear thereof.

The walls of the studio are preferably constructed in a manner such that opposite surfaces are non-parallel, thereby avoiding concentration of sound at any one spot and preventing either dead spots or flutters. The letters S. L. in Fig. 1 of the drawings are an abbreviation for the words "sound lock," a term used to designate a vestibule between the studio and a public space which is given acoustical treatment to prevent leakage of sound. The space or compartment marked "control" indicates the room where the control desk, panels or like parts are located.

As far as the operation of the apparatus is concerned, it will be obvious that such may vary in accordance with the acoustical results desired. For example, let it be assumed that a program is to be broadcast simulating a choral group advancing along a street and into a cathedral. When the choral group starts singing, the panels would be open, providing maximum exposure of the acoustical walls 8, 8a, 8b to the sound waves and creating the deadest possible condition in the studio. The panels would be gradually adjusted

toward closed position, and when the program reaches the point where the choral group is supposed to be moving over the threshold of the cathedral, the panels would be completely or almost completely closed, thereby giving maximum sound resonance and reflection and creating a sense of proximity of the singers to the radio audience, due to the fact that the studio has been changed from say, for example, .5 seconds reverberation time (a dead studio) to say 1.2 seconds reverberation time (a very live studio for the volume concerned in this particular instance).

When the panels are in their normal or closed position, the less resonant side (**9***b* or **15***b*) is preferably exposed to the sound chamber. However, the panels may be readily operated to expose the more resonant side (**9***a* or **15***a*) during a program, the full or wide range and flexibility of adjustment being one of the features of the present invention.

The natural frequencies of the vanes or panels will change when they are moved out of edge-to-edge contact with one another. Thus, the natural resonance or vibratory characteristics of each panel is increased as it moves out of contact with its adjacent panel, the panels having different absorption characteristics when open than when in contact. The result is that the reverberation times at the various frequencies change when the panels are opened and closed, the extent of the change depending upon the number of panels moved and the volume of the room, as well as the type of absorbing treatment of material in rear of the panels.

Another important feature of advantage is that a studio constructed as disclosed herein may be used for an entire program which would ordinarily require a plurality of studios. For example, where a program which heretofore required a studio for the cast, an adjoining studio or compartment for musical accompaniment, and a still further area or compartment for sound effects, the entire program could be put on in the present studio by creating a relatively live or reverberate condition in one end of the studio and a relatively dead or non-reverberate condition in the other end thereof.

A further feature of advantage is that the acoustical vanes disclosed in the present invention may be utilized to bring out tones of a frequency which would otherwise be obscure. For example, with studios as heretofore constructed, considerable difficulty has been experienced in bringing out tones having certain frequencies, a first violin being typical. An orchestral program in which there were around twelve first violins ofttimes sounded as though there were say, for example, only four first violins. The construction of the panels **9** and **15** is such as to bring out tone frequencies such as those emanating from a first violin in their natural state, while at the same time modulating frequencies in lower or higher ranges. Thus, assuming that during a test the sound or tone of a given frequency in a given studio was first measured and indicated 100 units with a decay period of 1.00 seconds, and panels of the type disclosed herein having a similar resonance frequency were then placed in the studio, the decay period would be approximately 1.25; whereas if the sound had a frequency below or above a frequency of 100 cycles, this reflecting action would be lessened and equalized. Thus the tones of the first violins would be rendered natural and distinct while at the same time tones emanating from other instruments would be, in effect, modulated and harmonized with the tones of the violins. Actual experience has demonstrated that violins of the Stradivarius type,—whose tone values run into five figures and are fully appreciated in concert halls but lose their character, quality and mellowness over the radio,—have their tones more fully brought out in their natural state when broadcast from a studio equipped with my improved acoustical apparatus.

No attempt has been made herein to list all the advantages of the improved acoustical apparatus, nor have the various methods of installing and utilizing the same been stated in detail. For example, it may be desired to install the vanes on the side walls and ceiling, and even on the floor, or adjacent the latter. Ordinarily, only a certain portion of the walls of the studio need be equipped with the improved acoustical vanes and sound-absorbing or deadening wall in rear thereof and the remaining walls constructed to obviate undue resonance and reverberation.

It will be obvious that the foregoing and other changes in construction and design may be adopted without departing from the spirit or scope of the invention as defined by the appended claims.

What is claimed is:

1. Acoustical apparatus including a plurality of acoustical vanes for use in an acoustic chamber, each of said vanes consisting of a hollow elongated body having opposed panels joined at their longitudinal edges and convexly outwardly curved with respect to a longitudinal axis of said vane, one of said panels being formed of rigid, thin dense sound-reflecting, resonant material and the other of said panels being formed of relatively soft sound-absorbent material.

2. Acoustical apparatus including a plurality of acoustical vanes for use in an acoustic chamber, each of said vanes consisting of a hollow elongated body having opposed panels at least one of which is convexly outwardly curved with respect to a longitudinal axis of said vane, one of said panels being formed of rigid, dense sound-reflecting, resonant material and the other of said panels being formed of relatively soft, less rigid and less resonant material, said panels being joined at their longitudinal edges.

3. Acoustical apparatus including a plurality of acoustical vanes for use in an acoustic chamber, said vanes each including a pair of concave panels arranged in opposed relation to provide a hollow elongated body, one of said panels being of rigid, thin, dense material to impart resonating and sound-reflecting properties to the vane and the other of said panels being of relatively soft material capable of absorbing sound.

4. Acoustical apparatus including a plurality of acoustical vanes for use in an acoustic chamber, said vanes each comprising a pair of concave panels arranged in opposed edge-to-edge relation to provide a hollow elongated body, one of said panels being of rigid, thin, dense material to impart resonating and sound-reflecting properties to the vane and the other of said panels being of relatively soft material capable of absorbing sound, and means pivotally mounting said vanes whereby they may be rotated to varying degrees of exposure to sound waves.

5. Acoustical apparatus including a plurality of acoustical vanes for use in an acoustic chamber, said vanes each comprising a pair of concave panels arranged in opposed relation to provide a hollow elongated body, one of said panels being

of rigid, thin, dense material to impart resonating and sound-reflecting properties to the vane and the other of said panels being of relatively soft material capable of absorbing sound, means pivotally mounting said vanes whereby they may be adjusted to varying degrees of exposure to sound waves, the pivotal spacing of said vanes being such that when they are adjusted to closed position their edges are brought into contact providing a surface of serrated or undulating sound diffusing contour.

6. Acoustical apparatus including a plurality of acoustical vanes for use in an acoustic chamber, said vanes each including a pair of concave panels arranged in opposed relation and joined at their longitudinal edges to provide a hollow elongated body, one of said panels being of rigid, thin, dense material to impart sound-resonating and sound-reflecting properties to the vane and the other of said panels being formed of relatively soft material capable of absorbing sound, means pivotally mounting said vanes whereby they may be adjusted to varying degrees of exposure to sound waves, the pivotal axes of said vanes being spaced apart a distance less than the width of the vane so that when the vanes are adjusted to closed position their edges contact one another varying the natural resonance or vibratory characteristics of the vanes, said vanes having the edges thereof provided with a resilient bumper to ensure quiet operation.

7. Acoustical apparatus including a plurality of acoustical vanes for use in an acoustic chamber, said vanes each comprising a pair of concave panels arranged in opposed relation and joined along their longitudinal edges to provide a hollow elongated body, one of said panels being of rigid, dense, sound-reflecting and resonant material and the other of said panels being of relatively soft, less rigid and less resonant material, means pivotally mounting said vanes, and a sound-absorbing surface in the rear of said vanes.

8. Acoustical apparatus including a plurality of acoustical vanes for use in an acoustic chamber, each of said vanes consisting of a hollow elongated body having opposed panels joined at their longitudinal edges and convexly outwardly curved with respect to a longitudinal axis of said vane, one of said panels being of rigid, dense, sound-reflecting and resonant material and the other of said panels being formed of relatively soft, less rigid and less resonant material, and a sounding post disposed between said panels and in contact therewith, the frequency characteristics of the vane being rendered variable by changing the position of the sound post.

9. Acoustical apparatus including a plurality of acoustical vanes for use in an acoustic chamber, said vanes each comprising an elongated hollow body having opposed walls of convexly curved contour, said walls being in part formed of hard, rigid, resonant material and in part of less rigid and less resonant material capable of absorbing sound, and means rotatably mounting said vanes.

10. Acoustical apparatus including a plurality of acoustical vanes for use in an acoustic chamber, said vanes each comprising an elongated hollow body having opposed convexly curved vibratory walls, one of said walls being of hard, rigid, resonant material and the other of said walls being of less rigid and less resonant material, and means rotatably mounting said vanes.

11. Acoustical apparatus including a plurality of acoustical vanes for use in an acoustic chamber, said vanes each comprising a hollow elongated body with walls shaped to provide a sound box of elliptical shape in cross section, said walls being of varying degrees of rigidity and hardness to thereby vary the sound-reflecting and sound-absorbing qualities of the vane while at the same time imparting resonance to the vane as a whole, and means rotatably mounting said vanes for varying degrees of exposure to sound vanes.

12. Acoustical apparatus including a plurality of acoustical vanes for use in an acoustic chamber, said vanes each comprising a hollow elongated body functioning in the nature of a sound box and having walls of varying degrees of rigidity and hardness circumferentially of the body to thereby vary the sound-reflecting and sound-absorbing qualities of the vane while at the same time imparting resonance to the vane as a whole, and means rotatably mounting said vanes for varying degrees of exposure to sound waves.

CLARENCE R. JACOBS.