Feb. 2, 1960 M. MACCAFERRI 2,923,372

ACOUSTIC TILE

Original Filed April 22, 1952 4 Sheets-Sheet 1

Fig. 1.

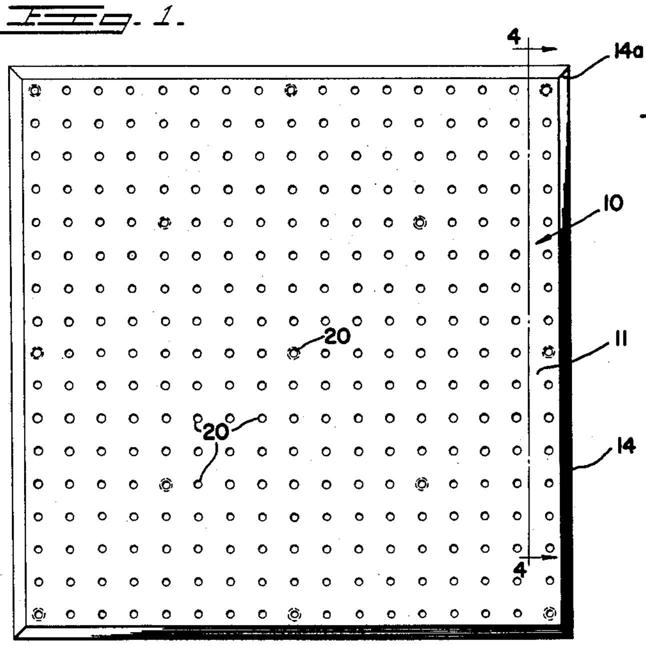

Fig. 2.

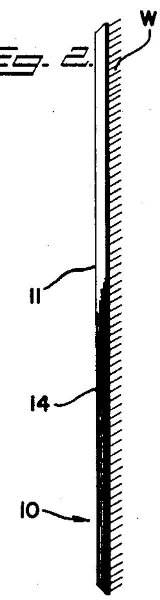

Fig. 3.

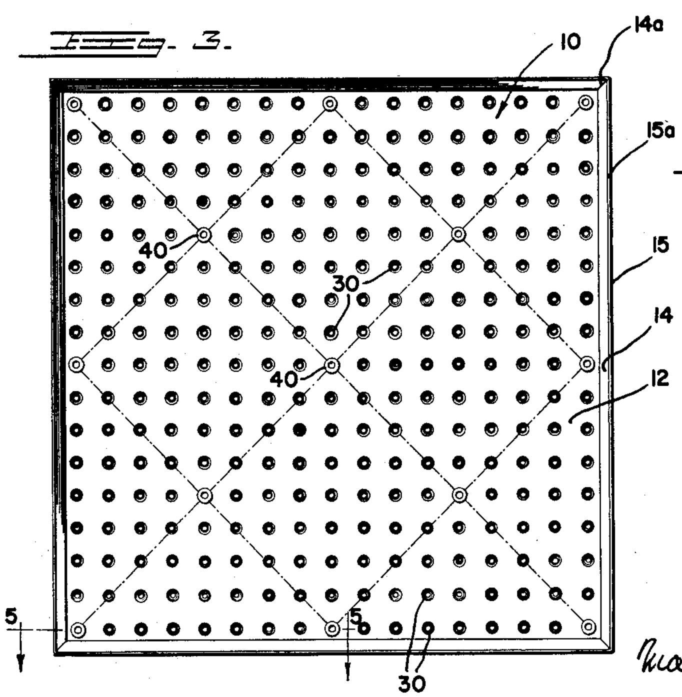

Fig. 4.

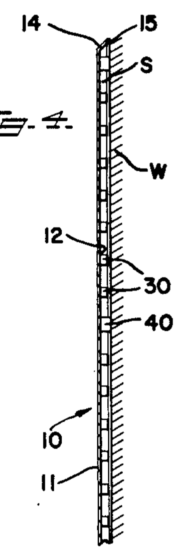

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Fig. 5.

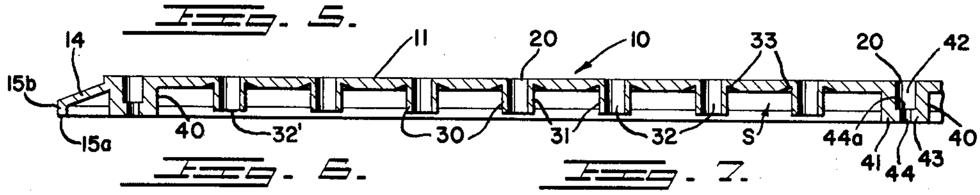


Fig. 6.

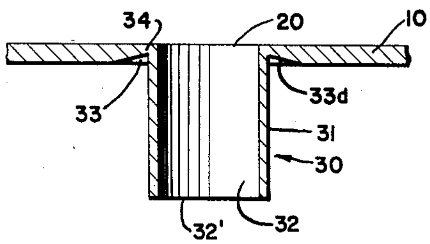


Fig. 7.

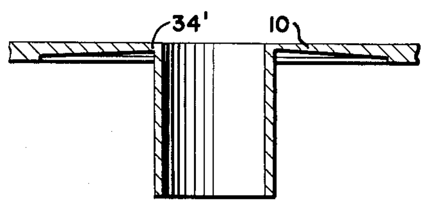


Fig. 8.

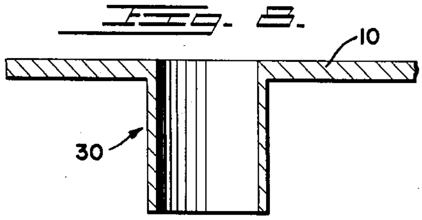


Fig. 9.

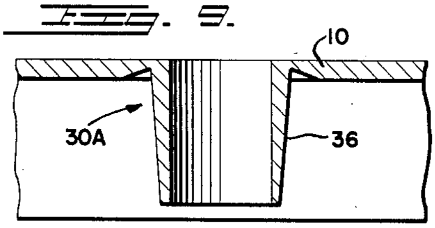


Fig. 10.

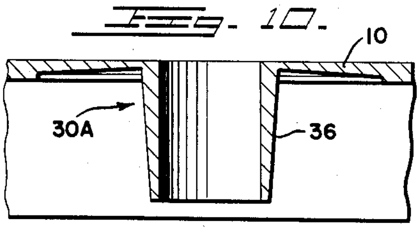
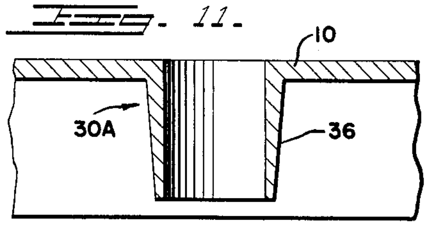


Fig. 11.



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Feb. 2, 1960 M. MACCAFERRI 2,923,372

ACOUSTIC TILE

Original Filed April 22, 1952 4 Sheets-Sheet 3

Fig. 12.

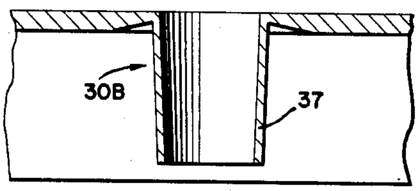

Fig. 13.

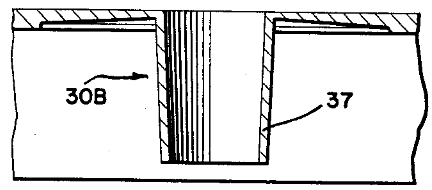

Fig. 14.

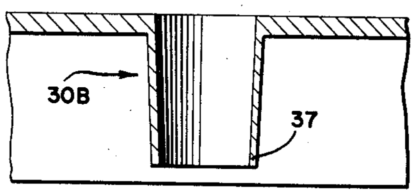

Fig. 15.

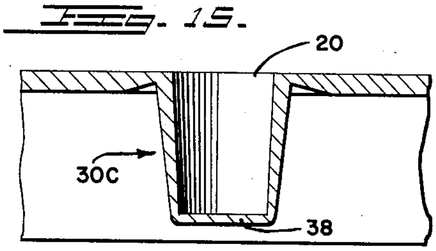

Fig. 16.

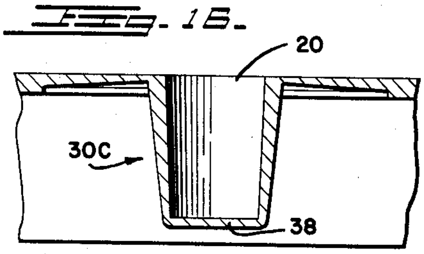

Fig. 17.

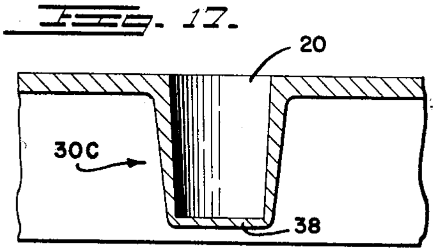

Fig. 18.

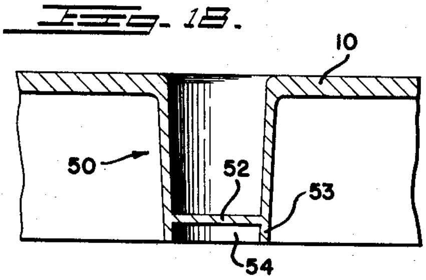

Fig. 19.

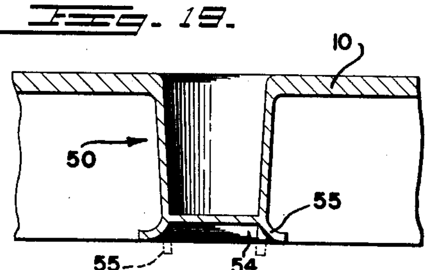

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FIG. 20.

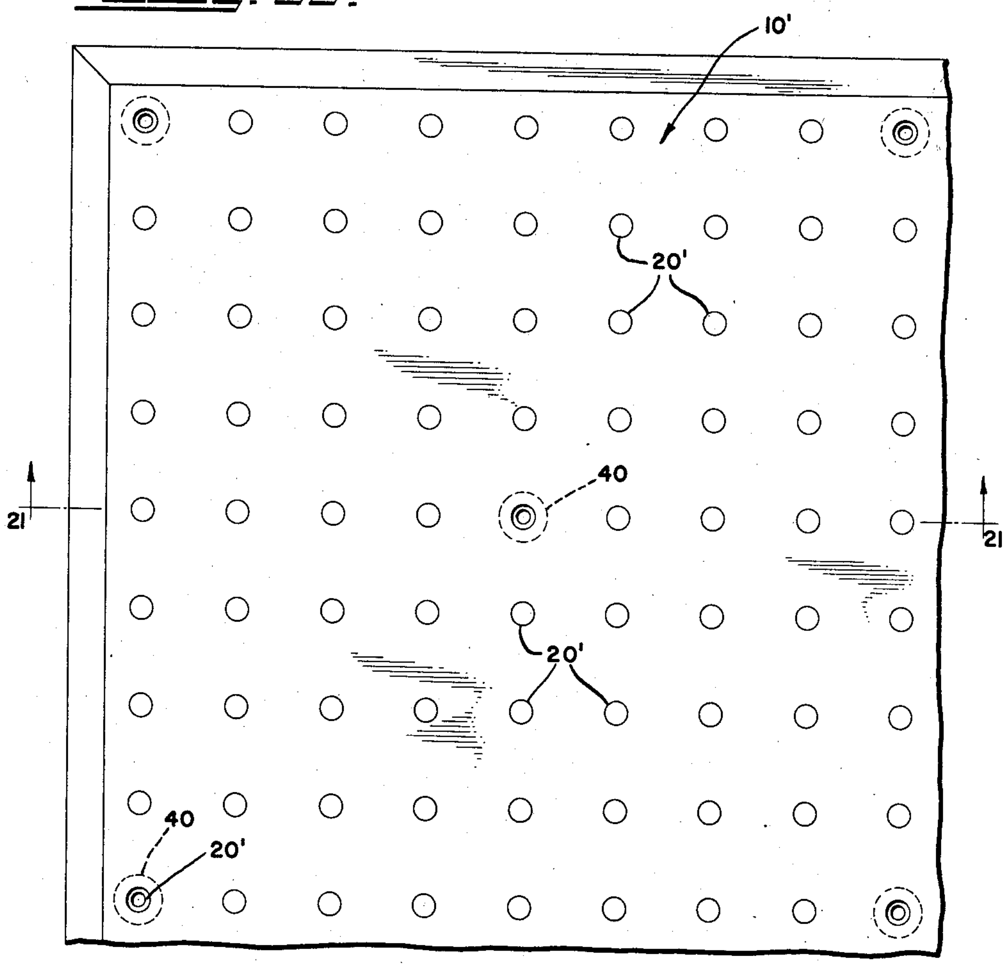
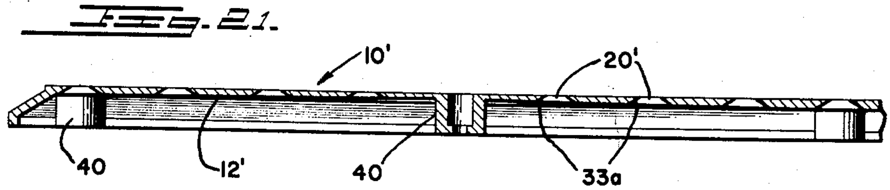


FIG. 21.



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United States Patent Office

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ACOUSTIC TILE

Mario Maccaferri, Rye, N.Y.

Original application April 22, 1952, Serial No. 283,707, now Patent No. 2,755,882, dated July 24, 1956. Divided and this application April 4, 1956, Serial No. 576,077

5 Claims. (Cl. 181—33)

The invention is concerned broadly with the acoustic treatment of wall structures and more specifically is directed to the tile forms of acoustic treatment for application to or to form the sound receiving surfaces for such wall structures; and the nature and objects of the invention will be readily recognized and understood by those skilled in the arts involved in the light of the following explanation and detailed description of the accompanying drawings illustrating what I at present consider to be the preferred embodiments or structural and acoustical expressions of the invention and the various features thereof, from among other forms, expressions, embodiments, modifications, constructions and combinations of which the invention is capable within the broad spirit and scope thereof as defined by the claims hereto appended.

This application is filed as a division of my copending application Serial No. 283,707, now Patent No. 2,755,882, filed April 22, 1952 for Acoustic Tiles.

The various types and forms of acoustic tiles which have been proposed by the art fall generally into two broad types or classes, namely, the type in which the tiles are formed of materials which are inherently sound absorptive, and the type in which the tiles are formed of materials which are inherently non-absorptive. Usually in the practical applications of both general types the tiles are formed with openings or passages therein for the passage of sound waves therethrough to space at the rear of the tile in which there is usually placed some form of loose sound absorbing material, either in bulk or in the form of mats or pads.

The numerous disadvantages of both the sound absorptive and the non-absorptive material tiles are well known to the art and need not here be recited at length. However, specific attention is directed to the fact that with both the sound absorptive and non-absorptive material tiles it is generally impractical and unsatisfactory to coat, as by painting, because of thereby closing or partially blocking the openings or apertures through the tile, so that, it is not practical to color the exposed surfaces of the tiles and the decorative harmonizing of these acoustical tiles and hence the wide application and use thereof, is limited. The cleaning of the exposed surfaces of the tiles is difficult, whether or not coated, because of the apertures and the passage of moisture and foreign matter therethrough with resulting undesirable collections at the rear of the tile on and in the sound absorbing material positioned back of these tiles. Cleaning difficulties are aggravated with the sound absorptive material tiles because of the inherently porous, absorptive characteristics of such materials. As the non-absorptive material tiles are generally formed of metal or such like hard surfaced, dense material, it becomes essential to color the exposed surfaces as by painting, and even if the coating is so applied as to minimize blocking of the tile apertures such coating must be refinished or redone after a certain period of time with the tiles installed.

2

One of the general objects of my invention is to overcome the color limitations of and the necessity for coating or otherwise finishing and treating the various acoustic tiles of the art before or after installation, by providing acoustic tiles of materials which may have any desired permanent color or color variations and which provide finished surfaces requiring no treatment of any character before or after installation, with the faces or exposed surfaces of the tiles capable of ready cleaning by mere dry wiping or dusting of the exposed surfaces thereof.

In carrying out the above general object, I have provided acoustic tiles of the dense, hard surfaced class formed of materials having no inherent sound absorbing characteristics; and a further important object is to so design and construct such a tile as to cause the tile to itself function to damp out and dissipate a substantial percentage of the sound energy or waves striking against the exposed surface thereof by damping out the striking sound waves.

Another object is to provide an acoustic tile having vibratory damping tubes projected from the inner side of the tile with sound receiving passages through the tubes opening through the outer, sound wave receiving surface of the tiled body.

I have discovered that certain thermoplastic synthetic resins, such as a polystyrene, have when molded the requisite structural and vibratory or resonance response characteristics from which to efficiently form an acoustic tile having the foregoing features in construction and functioning; and a further object is to provide a design and construction for such a thermoplastic acoustic tile which will permit of the tiles being efficiently manufactured on a quantity production basis with standard types of molding equipment at relatively low production costs per tile.

A further object is to provide a thermoplastic material acoustic tile which can be readily and cheaply installed in attached position on a wall or other structure without the use of special tools or equipment by unskilled installers, and with a minimum of tile surface marring and of tile breakage.

Another object is to provide a modified form of the thermoplastic acoustic tile having the sound wave damping and energy dissipating features referred to hereinabove, which will be particularly efficient for those types of installations in which the tiles are to be positioned and secured by manually pressing the tiles into an unset mastic coating applied to the structure to be acoustically treated with the tiles.

A further object is to provide a construction of such a mastic installable tile in which members are provided projected rearwardly from the rear side of the tile with the rear ends of such members formed into cups for engagement in the unset mastic onto which the tile is pressed so as to firmly secure the tile in position against displacement during and after setting of the mastic.

And a further object is to provide an acoustic tile formed of a thermoplastic synthetic resin capable of being pigmented prior to molding to give to the tile molded therefrom any desired permanent color, shade or color variation, and which aside from permanency of color will produce a tile requring no further finishing or conditioning after discharge from the mold and prior to the installation of the tile.

With the foregoing and various other objects, features and results in view which will be readily apparent from the following description and explanation, my invention consists in certain novel features in design, construction, materials and forms and in combination of elements, all as will be more fully and particularly referred to and described hereinafter.

Referring to the accompanying drawings in which similar reference characters refer to corresponding parts and elements throughout the several figures thereof.

Fig. 1 is a view in plan of the front or face side of an acoustic tile of my invention of a form thereof having the multiplicity of sound wave damping tubes projecting from the rear side thereof.

Fig. 2 is a view in edge elevation of an acoustic tile of Fig. 1 in installed position.

Fig. 3 is a view in plan of the rear side of the tile of Fig. 1 showing the multiplicity of damping tubes thereon.

Fig. 4 is a fragmentary view in transverse section taken as on the line 4—4 of Fig. 1.

Fig. 5 is a transverse sectional view taken as on the line 5—5 of Fig. 3.

Fig. 6 is an enlarged fragmentary view in longitudinal section through one of the integral damping tubes and the base construction thereof which joins the tube with the tile in the form of tile of Fig. 1.

Fig. 7 is a view in longitudinal section through a modified form of the recess formed in the rear side of the tile body around the base of a damping tube.

Fig. 8 is a view in longitudinal section through another modified construction in which the recess around the base of a damping tube is eliminated.

Figs. 9, 10 and 11 are sectional views of further modified forms of the damping tubes shown in Figs. 6, 7 and 8, respectively.

Figs. 12, 13 and 14 are sectional views of still further modifications of the damping tubes shown in Figs. 6, 7 and 8, respectively.

Figs. 15, 16 and 17 are sectional views of modifications of the damping tubes in which each tube has the rear end thereof closed by an end closing wall.

Fig. 18 is a sectional view through a form of the closed end damping tube of Fig. 17 having a cup at the inner, closed end of the tube.

Fig. 19 is a sectional view through a modified form of the cup tube of Fig. 18.

Fig. 20 is a view in plan of the face side of a modified form of tile in which the damping tubes at the rear side of the tile in the form of Fig. 1 have been eliminated with the tile having a multiplicity of sound wave receiving openings therethrough, a portion only of the tile being shown.

Fig. 21 is a view in transverse section through the portion of the modified tile of Fig. 20, taken as on the line 21—21 of Fig. 20.

I have selected examples of tiles of my invention in which the tile is square in plan and has maximum outside dimensions of 12" by 12", that is to say, each tile of the selected examples presents approximately one (1) square foot of wall covering when in installed position. A tile of this approximate size is generally considered by the art as a tile adapted primarily for ceiling installation but it is to be understood that with the plastic tile of my present invention due to the design and construction thereof and to the visual appearance of the tile when in installed position, these so-called larger area or "ceiling" tiles may be as readily effectively used, if desired, for installation for the acoustic treatment of side walls. Hence, there is no intention by the disclosed examples of larger area tile to in any way limit the intended use thereof, or the use for which such tile are or may be found to be adapted.

All of the tiles of the examples have the common characterisic of having been injection molded into the form of a thin, flat sheet or plate of a thermoplastic material forming the body of the tile and having a thickness within the range of the order of .05" to .10", that is to say, approximately 1/20" to 1/10". In the particular examples of polystyrene tiles hereof, the bodies of both the preferred and the modified forms of tile have a maximum thickness of approximately .06". Each of the example tile is formed with a continuous, narrow, shallow depth integral flange therearound which is comprised of an outwardly and rearwardly inclined wall or panel along each side of the tile and which terminates along its rear edge in a wall disposed normal to the plane of the front surface of the body of the tile, such rear wall of the flange having a straight, planar outer surface also normal to the plane of the tile body front surface or face. The inclined panel and inner or rear wall thereof along each side of the tile body are integrally joined at their opposite ends with the ends of the inclined panels and rear edge walls of the adjacent sides of the tile to form in effect the four corners of the tile unit. In the tile embodiments hereof the inclined panels and inner or rear edge walls making up the continuous flange of the tile are of uniform thickness throughout that is the same as the maximum thickness of the tile body, namely, .06". The outer side, planar surface of the inner edge wall of the flange along each outer side of the tile body is located in a plane spaced a distance of ½" from the inner, forward edge of an inclined wall along which such wall joins the front side or face of the tile body. Hence, the square face of the tile body has plan dimensions of 11½" x 11½" and a resulting area of 132.25 square inches. However, the various features of the invention are not limited or restricted to any particular size of tile or surface area of the face thereof, but may be embodied in larger, sheet-like sizes, or in smaller sizes, including the so-called "wall tile" sizes.

In the preferred acoustical form of the tile illustrated in Figs. 1 through 6, the tile body is constituted by the thin, sheet-like plate **10** having a maximum thickness of approximately 0.06", and providing the flat, planar front surface or face **11**, and the flat rear surface **12**. The tile body has the continuous integral flange therearound comprised by the outwardly and rearwardly inclined panel or wall **14** and rear edge wall **15** thereof along each of the four side edges of the body **10**. The rear wall **15** of each panel **14** is formed with a straight planar rear edge surface **15*a*** which is adapted to form an elongated seat to abut and seat against the surface of a wall W or other structure as schematically indicated in Fig. 2 of the drawings. The inclined panel **14** and rear edge wall **15** along each side of body **10** are integrally joined at their opposite ends with the ends of the panels along adjacent sides to thereby form the beveled corners **14*a*** of the tile unit. Thus, the rear edge walls **15** of the tile flange together form a hollow-square seating base for locating and positioning the tile in installed position on a structure to be acoustically treated. In the example tile, the rear edge surfaces **15*a*** of the tile flange lie in a plane spaced approximately ¼" from the plane of the front surface or face **11** of the body of the tile, so that with the tile in installed position on a wall, the tile body is spaced outwardly from the surface of the wall a distance to provide a space S which is enclosed within the tile flange between the tile body and the wall (see Fig. 4). Thus, the flange is narrow or of shallow depth rearwardly relative to the plane dimensions of the example tile. The outer side of each rear edge wall **15** of the continuous flange of the tile, is formed to provide a precisely planar surface **15*b*** normal to the front surface or face **11** of the tile, for accurate abutment against the corresponding surface **15*b*** of an adjacent tile in an installation of tile, so that a clean, visually satisfactory joint between adjacent tile may be had with the joint so formed in effect providing a seal against the passage of foreign material therebetween.

The tile unit comprised of the body **10** and the continuous integral flange **14—15** therearound is formed of an injection molded polystyrene in the example hereof, and, due to the physical and structural characteristics of injection molded polystyrene, the tile may be commercially produced with dimensional stability and dimensional precision. It is therefore possible with such thermoplastic to produce a tile of the form illustrated, with sharp, clear cut edges along and between the flange walls **14** and the front surface or face **11** of the tile and between such walls **14** and the rear edge forming walls **15** of the flange, with the inclined walls **14** being precisely planar and giving a clean, beveled appearance to the tile. And due to the characteristics of the material, the precision of the planar surfaces **15**a and **15**b may be attained by the injection molding of the tile, without requiring any machining, grinding, polishing or other finishing operations on the tile after the molding thereof.

The tile body **10** of the form of the tile of Figs. 1 through 6, is formed with a multiplicity of circular apertures, openings or holes **20** distributed over the entire area of the plate like body **10** of the tile and opening through the front, exposed surface of face **11** thereof. The area of the front surface or face **11**, in this example, is 132.25 square inches, and I have formed each circular aperture **20** of a diameter of 5/32″ at the surface **11**, and provided a total of 289 of such apertures of that particular diameter. These 289 apertures are arranged and located over the area of surface **11** of tile body **10**, in seventeen parallel rows spaced equal distances apart across the surface **11** with each row being comprised of seventeen (17) apertures spaced equidistant apart along the row formed thereby. Hence, there results a pattern of apertures through the surface **11** in an equal distribution over the area thereof, which is comprised of seventeen (17) rows of seventeen (17) apertures each across the tile parallel with opposite edges thereof in one direction, and seventeen (17) rows of seventeen (17) apertures each across the tile in a direction perpendicular to the first mentioned rows. By thus arranging and distributing the aperture **20**, each aperture of the 289 apertures is located with its center spaced 11/16″ from the center of the apertures of the pattern next adjacent thereto in either direction along either row in which an aperture is located. In the example pattern arrangement the outermost row of apertures **20** along and parallel with each straight side edge **14**b of the tile surface **11**, has the apertures located with their centers spaced a distance of 1/4″ from such adjacent edge **14**b.

With the tile thus apertured and comprised of the thin, plate-like body **10** and the flange **14—15**, formed of an injection molded thermoplastic, such as a polystyrene, I have provided as an important feature of my invention, both acoustically and structurally, a multiplicity of vibratory, sound damping tubes **30** integral with the tile body **10** and projecting rearwardly from the rear side **12** thereof at each location of an aperture **20** through the body. Referring to Figs. 5 and 6 in particular, each damping tube is formed of a wall **31** of cylindrical cross section and of a thickness less than the thickness of the tile body **10**, say of an approximate order of 0.03″. Each thin-walled damping tube **30** is molded as an integral part of the plate-like body **10**, and is disposed in position projected rearwardly from the rear wall **12** of the body with its axis normal to the plane of the body face **12** and coincident with the center of an aperture **20** through the body. Each tube provides a bore or cylindrical passages **32** therethrough having the same diameter as the diameter of an aperture **20**, namely 5/32″ in this instance, so that the aperture **20** at which a tube is located provides the sound wave inlet opening through the body **10** from the front exposed face **11** thereof into the body **10** from the front exposed face **11** thereof into the passage **32** of the tube. The length of each tube **30** is less than the distance between the outer surface or face **11** of the tile body **10** and the plane passing through the rear, seating edges **15**a of the tile flange **14—15**, that is to say, less than the distance between body **10** and the front surface of a wall W (see Fig. 4) with the tile in installed position on the wall. Thus, the tubes **30** are free at their inner ends with a tile installed on a wall as a component of

an acoustic treatment. The inner, free end of each of the vibratory damping tubes **30** is open to provide the sound wave discharge outlet or opening **32′** from the tube. In this preferred form of tube, the passage **32** therethrough is of constant diameter and the end discharge opening has the same diameter as the passage and as the inlet aperture **20** in the tube body **10**.

As a further feature of the preferred form of damping tube, and as a factor contributing to the vibratory response of the tube to sound waves entering into and passing through the passage **32** of the tube, I have provided a construction at the base of each tube where the tube integrally joins with the body **10**, by which the tube base is of reduced thickness relative to the thickness of the body **10**. I have in the preferred expression of such a reduced depth for the base of a tube **30**, referring now to the enlarged detail view of Fig. 6 in connection with Fig. 4, provided an annular recess **33** in the rear side **12** of the tile body **10** around each damping tube **30**, with each recess being tapered or inclined radially outwardly from and around the inner or base end of the tube to the rear surface **12** of body **10**. A recess **33** thus has its greatest depth at and around the outer surface of the thin wall **31** at the inner end of the tube at the line of integral joindure of the inner end of the tube with body **10**. By this construction the thickness of body **10** is reduced around the aperture **20** which forms the inlet end of the tube to provide a reduced thickness mounting base **34** which integrally joins the tube with the tile body, as will be clear by reference to Fig. 6. The forward wall **33**d of the recess **33** may be flat to form a radially outwardly and rearwardly sloping planar surface, or may be formed concave or even convex while retaining the essential function of reducing the thickness of the body around and immediately adjacent the inner end of a tube **30** and the aperture **20** thereof, to provide a base portion **34** having a more sensitive vibratory response.

With the tile unit of this vibratory tube form secured in mounted position installed on and over a wall surface, such as the surface W as indicated in Fig. 4 of the drawings, the tile is positioned by the flange rear edge surfaces **15**a seated against the wall surface with the multiplicity of tubes **30** projecting rearwardly from the rear side **12** of the tile body **10**, into the space enclosed within the tiles. As the tubes **30** have a length less than the depth of the space S, the rear ends of the tubes are positioned spaced from and out of contact with the wall W, and are thus free to vibrate without interference with or constraint by either the tile or the wall structure. The polystyrene thermoplastic of which the tile is preferably formed, has when injection molded the characteristics of density and of surface hardness, and may be considered non-absorptive of sound waves striking against the hard front surface or exposed face **11** of the body **10** of the tile. However, with the great multiplicity of apertures **20** evenly distributed in a relatively closely spaced relationship over the entire area of face **11**, a substantial percentage of the sound waves striking against surface **11** will enter into and be absorbed by these apertures, so that the striking waves will be effectively broken up as well as absorbed in the apertures with a resulting initial sound wave deadening effect. The effectiveness of the tile acoustically is substantially increased by the entry of the percentage of waves into the apertures **20** and the passage thereof through the tubes **30** and discharge from the inner ends of the tubes into the space S at the rear of the tile. Passage of sound waves into and through tubes **30** induces or sets up vibration of the tubes, so that the sound energy is substantially expended and dissipated in effecting such vibration of tubes. In this manner a sufficient proportion or percentage of sound waves striking the tile body will be dissipated and destroyed to effect a substantial sound absorption with a minimum of reflected or induced waves being thrown back or projected from the tile body **10**, notwithstanding the fact the tile body is formed of a substantially non-absorptive material having a relatively high inherent resonance response characteristic when in the thin plate form of the body 10. Any sound waves which are not effectively damped out and expended in effecting vibrations of the tubes 30, or any of them, will be discharged from the free inner ends of the tubes into the space S at the rear side of the tile and there dissipated and absorbed within such space.

In order to buttress the acoustic tile of the form of the preferred example, and to provide additional, rigid seats against which the tile may be firmly attached in installed position, I have provided a plurality of integral, cylindrical bosses 40 located at strategic positions on and projecting rearwardly from the rear side 12 of the tile body 10. Referring to Fig. 5 in particular, each of these bosses has a flat, planar seating surface 41 across the rear side or end thereof which lies in the plane passing through the continuous seating edge 15*a* provided by the rear edge of the tile flange 14—15. In the arrangement of this example such bosses 40 are distributed and located as follows: One at each corner of the rear side 12 of the tile body; one midway along each edge of the tile body; one at the center of the rear side of the body; and one at the center of each quarter section of the tile rear surface. Thus, with the relatively large area of the very thin tile body 10, when the tile is attached in installed position on a wall, the rear ends 41 of the bosses 40 are engaged against the surface of the wall and support the tile body 10 against bending or flexing inwardly toward the wall to thereby maintain the front side or face 11 of the tile body as a substantially true, flat, planar surface. Obviously any other suitable or desired arrangement of locations may be utilized for the bosses 40, and any number thereof may be used, as my invention is in no sense limited to the number or arrangement of the bosses provided on the example tile.

As the tile of the example form of Figs. 1 through 6, is of the type to be secured in installed position on a wall by mechanical fastening means, such as nails, I have devised a design and location of the bosses 40 by which they provide the members for nailing attachment to a wall or other structure and by which they utilize apertures 20 of the tile body for receiving the nails to be driven therethrough. For example, each boss is of tubular form and is formed on the rear side 12 of the tile in position with the bore 42 of the boss axially alined with an aperture 20 which aperture thus provides the front, nail receiving opening of the boss. The rear end of each nail receiving boss 40 is formed with the end wall 43 which provides across its outer side the seating surface 41, as referred to hereinabove. This rear end wall 43 is formed with an axial bore or opening 44 therethrough in axial alignment with the bore 42 and the aperture 20 through the face of the tile body, with the opening 44 having a diameter less than the diameter of bore 42. There is thus formed an annular seat 44*a* around the opening 44 within the boss 40 against which the head of a nail is driven and seated. In this manner a countersunk nailing opening through the tile body and each integral boss 40, is provided as clearly shown in Fig. 5 in particular, so that, the tile may be nailed into attached, installed position by driving the nails through the boss bores 42 and rear nail openings 44 into tile securing position with the nail heads engaged against the seats 44*a* in position "countersunk" within the bosses.

With the preferred form of the tile of Figs. 1 through 6, having the plan dimensions and the thickness for the tile body 10 as heretofore stated, the ratio of the aggregate area of all of the 289 apertures 20 each having a diameter of $\frac{5}{32}$", to the total surface area of 132.25 square inches of the tile face 11, is considered to be effective in sound absorption or deadening. However, this ratio may be varied not only in the size tile of the example, but in tiles of different face areas, although it is considered that the ratio may be effectively used for resulting acoustical efficiency with tiles of both smaller or larger sizes and face areas. But such ratio of aggregate sound opening area to tile face surface may be varied in accordance with the acoustic treatment desired.

The construction of the base 34, through the medium of the recess 33 at the inner end of a thin-walled damping tube may be varied to the construction of Fig. 7, in which a recess 33 of greater area and flatter slope to the wall formed thereby is provided. By the construction of Fig. 7, a reduced thickness base 34' is formed for a tube 30 than the base 34, to form in effect a relatively thin base disc for and with which a tube is integrally joined.

And while constructions of the base of the vibratory tube as shown in Figs. 6 and 7, offer certain advantages in vibration sensitivity and response for a tube, a construction such as shown in Fig. 8 may be employed with effective results with a tile of the form of Fig. 1. With the construction of Fig. 8, the recesses, such as 33 or 33' at the rear side 12 of the tile body 10 are eliminated, and substantially the full thickness of the tile body is maintained to and integrally joins with a tube 30. Such construction makes for a stiffer and more rigid tube base but still retains the free end, vibration responsive, thin-walled tube for effective sound wave damping.

In Figs. 9, 10 and 11, I have shown a variation of the damping tube wall construction for tubes having the types of bases of Figs. 6, 7 and 8, respectively. In the illustrated variation the damping tube 30A has in each instance a wall of slightly greater thickness than the very thin wall 31 of a tube 30, with the bore through the tube being of constant diameter but with the outer surface 36 of the tube wall being progressively tapered inwardly from the base to the rear, free end of the tube. There is thus provided a damping tube having a wall thickness which progressively decreases from base to the rear, free end thereof.

A further variation of the damping tube is disclosed in Figs. 12, 13 and 14, by a tube 30B having a thin wall 37 of approximately the thickness of the wall 31 of a tube 30, but with the wall 37 of uniform thickness throughout its length and being progressively tapering from the base to the rear, free end of the tube. Such form of tube provides the bore therethrough as being of progressively decreasing diameter from the base to the free rear end of the tube. The tube 30B is shown in Figs. 12, 13 and 14 as having bases of the types shown for the tube 30 in Figs. 6, 7 and 8, respectively.

If desired or found expedient the damping tubes of any of the forms and constructions may be provided with the rear free ends thereof closed by an end wall formed integral with the tube side wall. As an example I have illustrated such a closed end tube 30C in Figs. 15, 16 and 17 as applied to the tube of the form shown in Figs. 9, 10 and 11. A tube of the form of tube 30C has a flat end wall 38 molded integrally with the tube to extend completely across and close to the rear end of the tube. The tubes 30C of Figs. 15, 16 and 17 are shown integrally joined with the tile body 10, by bases of the types shown in Figs. 6, 7 and 8, respectively. While the closing of the rear free ends of the damping tubes may decrease the acoustic efficiency thereof and of a tile on which used, yet the closed chambers thereby formed having the sound inlet apertures 20 through the face of the tile body will have a substantial sound wave absorbing effect, particularly with a distribution of such tubes with the sound absorbing chambers therewithin, in great multiplicity over the face of the tile body in an arrangement such as shown in Figs. 1 and 3 of the drawings.

A thermoplastic tile of my invention in accordance with a modified form thereof illustrated in Figs. 20 and 21, may eliminate the damping tubes of the forms of Figs. 1 through 6 and the several disclosed variations thereof, and provide the tile body 10' as solely a thin plate having only the mounting and nailing bosses **40** provided in any desired arrangement on the rear side thereof. In Fig. 20, a quarter section of the front side of such a tile is shown having a number and distribution of apertures **20'** therethrough similar to that provided for the preferred form of tile of Fig. 1. The rear side **12'** of the tile body **10'** is formed with an annular rearwardly and outwardly tapered recess **33a** therein surrounding and concentric with each aperture **20'**. Each recess **33a** extends into the body **10'** of the tile to its face aperture **20'** with the latter forming the smaller diameter sound wave inlet opening of a rearwardly tapering passage having its large diameter discharge opening through the rear surface **12'** of the tile body.

This modified form of tile of Figs. 20 and 21, will without the damping tubes of the preferred form, give an effective performance acoustically for certain characters and conditions of installation. Due to the distribution and number of the apertures **20'**, which apertures may be taken to each be of the diameter of an aperture **20** of the preferred form, a substantial and effective percentage of the sound waves striking the face of the tile body **10'** will enter and will enter and pass through the apertures **20'** and the rearwardly tapering passages provided by the annular recesses **33a**, into the space at the rear of the tile. Such sound waves will thus be dissipated and absorbed.

The modified form of tile of Figs. 20 and 21, lends itself to the mounting of sound absorbing material in the space at the rear of the tile, where in any installation it may be found desirable to do so.

Instead of providing the recesses **33a** as of a progressive taper to the front surface or face **11'** to form and define each aperture **20'** by a short, thin circular edge, as in the example illustrated, the aperture may be formed of greater depth by a constant diameter passage which joins and opens into the recess at an intermediate location within the tile body.

The preferred form of the tile of Fig. 1 and the modified form of Fig. 20, are both shown as being of the nail attachment type, but by a further feature of my invention I have provided a form of the tile having the multiplicity of sound wave receiving tubes so designed as to render the tile capable of efficient installation by means of a mastic and without the necessity of mechanical fastening means.

In order to increase the holding effect of the closed end tubes when engaged in the still unset mastic, I have devised a form and construction by which a cup is provided at the rear closed end of the tube. Referring to Figs. 18 and 19, I mold the tile with the closed end tubes **50** thereof provided with a rearwardly extended flange or skirt **53** therearound in continuation of the tube wall. Thus, flange **53** provides at the rear end of the tube a cup **54** which is closed at its inner or bottom side by wall **52** and at its outer side by flange **53**, with its rear side open. In one form of such tube and cup as exemplified by Fig. 18, I may make the overall length of the tube **50** and the flange **53** such that the rear edge of the flange lies in the plane of the rear edges **15a** of the tile flange.

In another form of such tube and cup as shown in Fig. 19, I form the flange **55** as of greater length than the flange **53** of Fig. 18, and then bend or form the flange to flare or extend radially outwardly from and around the tube to thereby provide a key or anchor for engagement in the mastic. With the form of Fig. 19, the cup **54** will function primarily to hold the tile in position while the mastic is setting. After the mastic is set the key or anchor flange **55** then firmly and rigidly holds the tile in installed position. I may curl or press the flange **55** into final form by molding it straight as indicated in Fig. 19, and then pressing or forcing the flange against a hot plate to soften the thermoplastic and cause the flange to be pressed outwardly into its radially flared, anchor forming shape.

My invention contemplates and includes tiles which are provided with the majority of the damping tubes having open, sound wave discharging rear ends, such as the tube forms of Figs. 6 through 14, together with a sufficient number of closed end tubes, with or without end cups, such as shown in Figs. 18 or 19, for anchoring or keying in a mastic to permit of the mastic installation of the tile.

The invention provides as a new article of manufacture an acoustic tile in several forms and types, injection molded of a thermoplastic material, such for example as a polystyrene and the designs and constructions of such tile as to certain of the essential features thereof utilize certain of the physical characteristics of an injection molded thermoplastic material to attain increased acoustical and structural efficiency, and to make it possible to produce a complete tile structurally and in finished form by a single injection molding cycle with standard injection molding equipment. However, the invention is capable of expression in other thermoplastic materials than a polystyrene, and as to certain features thereof in other materials than thermoplastics. Hence, it is not intended to restrict the invention and the several features thereof to use only in a polystyrene tile. Similarly while the thermoplastic material tile may be preferably formed by injection molding, it is not intended to so restrict the invention as it includes the formation of the tile by other molding methods.

It will also be evident that various other modifications, embodiments, combinations, substitutions, eliminations, as well as various composite arrangements of the several forms and variations shown, might be resorted to without departing from the broad spirit and scope of my invention, and hence I do not desire to limit the invention in all respects to the exact and specific disclosures of the several examples hereof, intended specific limitation thereto appearing in any of the claims hereto appended.

What I claim is:

1. As a new article of manufacture, an all-plastic acoustic tile formed of plastic material comprising, in combination, a thin plastic material body of plate form; a rearwardly extending edge flange of plastic material around said body integral therewith; said edge flange having a narrow, shallow depth relative to the plan dimensions of said body; said thin body having a front side providing a face surface thereover and an opposite rear side providing a rear surface thereover surrounded by said shallow depth edge flange; said body having a multiplicity of small diameter apertures closely spaced over the area of said face surface extending through said body from and opening through said face surface to and opening through said rear surface of said body over the entire area of said rear surface; a multiplicity of vibratory sound wave damping tubes of plastic material integral with said body projecting rearwardly from the rear side thereof; each of said plastic material damping tubes having a passage axially therethrough and being located on the rear side of said body in positions with said axial passages aligned with and opening into said body apertures, respectively, with the latter forming the inlets to said tube passages through said tile body; each of said plastic material sound wave damping tubes being relatively thin walled with the thickness of the wall thereof being less than the thickness of said thin plastic material body for vibration response by said damping tubes to sound waves to which subjected; said multiplicity of thin walled, vibratory plastic material damping tubes extending in uniformly closely spaced relation rearwardly from and over the entire area of said rear surface of said tile body; and said vibratory plastic material damping tubes extending rearwardly throughout substantially the full depth of said narrow, shallow depth edge flange

with the rear ends thereof located at the rear edge of said edge flange in a plane in immediate proximity to the plane in which the rear edge of said edge flange is located for free vibration of said plastic material damping tubes.

2. As a new article of manufacture, an all-plastic acoustic tile formed of a molded plastic material, comprising, a plate-like body having a rearwardly extended edge flange therearound integral therewith; said body being formed to provide the front side thereof as a flat, planar face and having a multiplicity of apertures therethrough from said front face to and opening through the rear side of the body; sound wave damping tubes molded integrally with said body projecting rearwardly from the rear side thereof; each of said damping tubes having a passage therethrough open at the rear end thereof; each of said damping tubes being located on the rear side of said body in position with a body aperture opening into and forming the inlet to said passage of said damping tube; and said body having the rear side thereof formed with an annular recess therein around each of said damping tubes providing a reduced thickness base portion of the body with which the tube is integrally joined.

3. As a new article of manufacture, an all-plastic acoustic tile formed of a molded plastic material, said acoustic tile comprising, a plate-like body having a rearwardly extending edge flange therearound integral therewith; said body having a front face side and a rear side surrounded by said edge flange; said body being provided with a multiplicity of apertures therethrough from said front face side to and opening through said rear side thereof; sound wave damping tubes integral with said body projecting rearwardly from the rear side of said body; each of said damping tubes having a passage therethrough open at the rear end of the damping tube; each of said damping tubes being located on the rear side of said body in position with a body aperture opening into and forming the inlet to said passage in the damping tube; said body having the rear side thereof formed with an annular recess therein around each tube and through which each tube extends; and said recesses having their greatest depth at their respective tubes and progressively decreasing in depth radially outwardly from the tubes along the rear surface of said tile body.

4. As a new article of manufacture, an acoustic tile formed entirely of plastic material, comprising, in combination, a thin body of plate form having a narrow, shallow depth, rearwardly extending edge flange therearound integral therewith; said body having a front face side and an opposite rear side surrounded by said edge flange; said body having a multiplicity of apertures therethrough spaced apart over substantially the entire area of said front face side; said apertures opening through said front face side and extending through said body to and opening through said rear side thereof; sound wave damping tubes integral with said body projecting rearwardly from said rear side thereof throughout substantially the depth of said shallow depth edge flange; each of said damping tubes being located in position on the rear side of said body with one of said apertures opening into and forming the inlet into the forward end of each such damping tube; and the portion of said body of said tile around and adjoining each of said damping tubes being of reduced thickness relative to the thickness of said body in the remaining areas thereof between said damping tubes and said portions of said body of reduced thickness.

5. An acoustic tile in accordance with claim 4, in which each of said sound wave damping tubes has the rear end thereof closed by an end wall.

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