

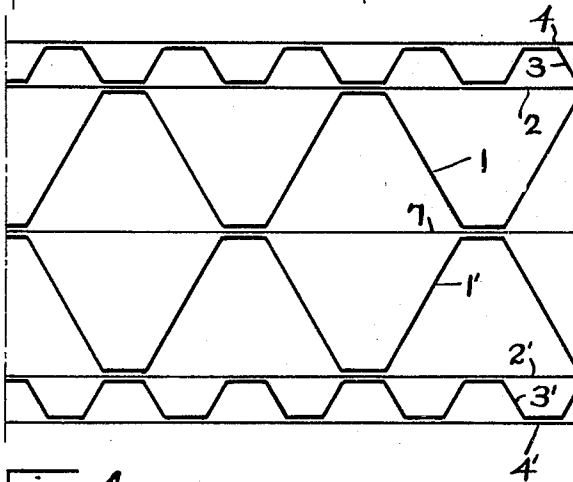
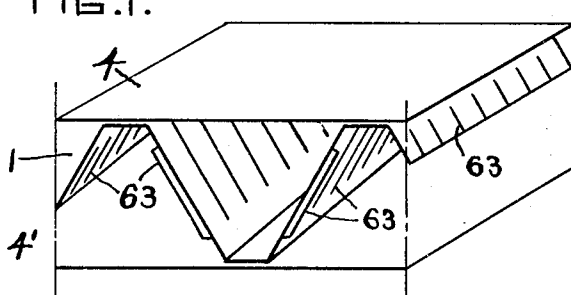
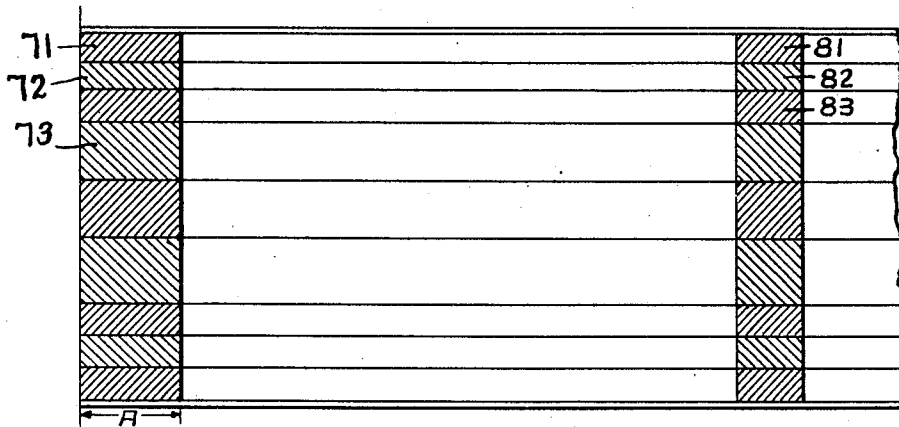
Nov. 2, 1943.

T. SENDZIMIR

2,333,343

METHOD OF MAKING STRUCTURAL MATERIALS

Original Filed April 22, 1937 2 Sheets-Sheet 1



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FIG. 6.

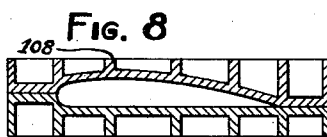
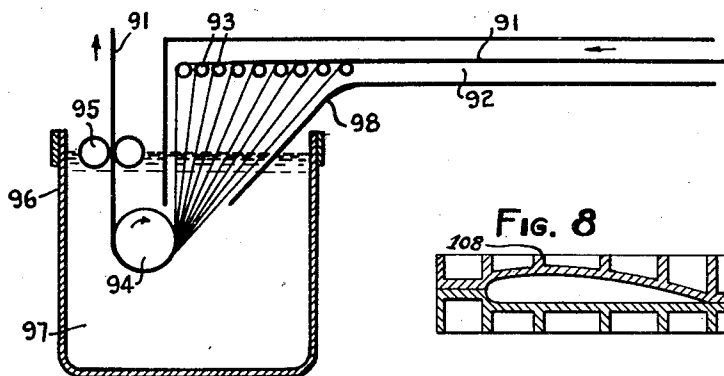


FIG. 7

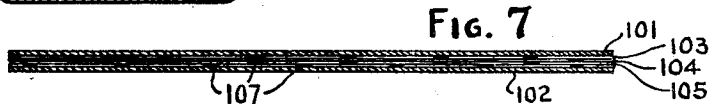


FIG. 5

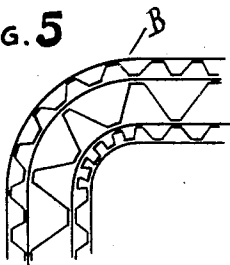
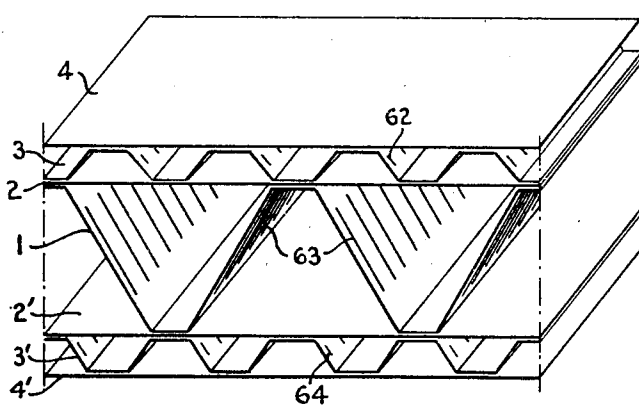


FIG. 3



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2,333,343

METHOD OF MAKING STRUCTURAL MATERIALS

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Original application April 22, 1937, Serial No. 138,431, now Patent No. 2,190,490, dated February 13, 1940. Divided and this application January 16, 1940, Serial No. 314,041

5 Claims. (Cl. 29—188)

This application is a division of my copending application Serial No. 138,431, filed April 22, 1937, and entitled "Structural Materials," now Patent 2,190,490 of Feb. 13, 1940.

My invention has to do with structural materials which will in most instances be made of metal, and will be so described in certain exemplary embodiments; but it will be understood that the aspect of the invention as hereinafter claimed is not so limited and is applicable to other materials, such as cellulose, paper, veneer, Bakelite, asbestos and other sheet-like materials.

An object of the invention is to provide a structural material of almost universal application, of light specific weight, and having a high mechanical resistance in all directions. Another object is to provide a material through which heat and sound penetrate only with difficulty, and which resists corrosion. A further object is to provide a material that can stand a very considerable deformation before breaking.

These and other objects of my invention which will be pointed out hereinafter or will be apparent to one skilled in the art upon reading these specifications, I accomplish by that certain construction and arrangement of parts, and in that process of which I shall now describe certain exemplary embodiments. Reference is made to the drawings wherein:

Figure 1 is a sectional view showing an assembly having cell closing elements.

Figure 2 shows another form of structural element.

Figure 3 shows yet another form of structural element in perspective.

Figure 4 shows the same structure in section.

Figure 5 shows a curved section formed in one of my elements.

Figure 6 is a diagrammatic illustration in a step of a process of manufacturing my elements.

Figure 7 is a diagrammatic sectional view of the immediate product of the step illustrated in Figure 6.

Figure 8 is a sectional view of a mould member.

The multicellular structural elements which are the subject of this application are assemblies of a plurality of preformed pieces of sheet-like material, dividing the space between the two outer surfaces of the element into a relatively great number of individually enclosed cells. The axes of such cells are usually parallel to the greater dimension of the plate and, in cases where resistance to corrosion for almost unlimited periods of time is of first importance, they are subdivided lengthwise each into a number of shorter

cells, by inserting or fixing blocking pieces at intervals, as will be more fully described.

In my sections, blocks of metal may be inserted and solidly welded at spaced intervals, into the individual cells, blocking each cell or subdividing it into a number of shorter cells, each hermetically sealed from the others, as shown at 71—73, 81—83 in Figure 4. Such blocks may be solid blocks of metal, or stampings, or may consist of another material which is simply pressed between the individual channels and adequately closes or seals each section of a cellule. Such sealing blocks also reenforce the whole section mechanically and wherever this is important, should be placed so that they always lie on the same cross section of the plate, and so that their stiffening effect is continuous, over the whole section.

The resistance to bending, for a given weight per unit of surface, depends upon the thickness of the element and on the proportion of metal situated at or near the outside surfaces. From this point of view the present invention offers an almost ideal solution. Whenever the maximum resistance to bending is desired, the outside plates can be made thick. The inside structure can, in such cases, be made just strong enough to hold the outside portions rigidly and to prevent them from collapsing. For other prevalent combinations of forces, *i. e.* twisting, crushing, another distribution of metal across its thickness may be preferable, and the method lends itself always to the ready securing of the optimum conditions. It may be desirable, in some cases, to make the outside cellules smaller, and therefore stronger, than the inside ones. This has been shown in Figure 1, where the outside cellules are smaller than the inside cellules.

The cellular sections may or may not be symmetrical. The section shown in Figure 1 is symmetrical. Such disposition may lead to savings in weight. Take first a section like this subject to a bending movement alone. The outer fibres are in such case subject to tension and compression of equal magnitude and therefore should, theoretically speaking, be equally dimensioned. In case of the fibres subject to tension, however, a great safety factor is usually required than in those subject to compression, chiefly because possible cracks, non-metallic inclusions, etc. would weaken fibre subject to tension much more than fibre subject to compression. The necessity of providing for this extra safety factor on tensioned fibres or cellules of the section only,

can be taken advantage of, with this invention, by making such sections non-symmetrical.

Depending on the purpose for which my structural element is to be used, its construction may be varied. Where heat insulation is the chief objective, it is better to use many small cellules of very fine gauge, right across the sections; and it would be wasteful to increase the depth of the middle ones, especially as the thickness of the plate is frequently limited.

Another example is where resistance to penetration of a foreign body, like a projectile, is the foremost objective. This construction is ideal for such purpose, if properly designed, and offers a resistance many times greater than a solid armour plate of the best alloy-steel. For high muzzle velocities, inner sheets of extremely light gauge are preferred, as their inertia is small and they yield before being punched through. In fact, the action of such plate may be likened to the way a thin wire net fencing behaves, under the force of a bull; it yields but does not break. With a suitable distribution of gauges and sizes of the individual cellules which, in this case, may preferably have a wavy and not a rectilinear contour but in either case a foreign body trying to penetrate into the section will be deforming not only the cellules which are in its way, but a relatively large adjacent area of cellules. Consequently the kinetic or other energy of such foreign body or projectile is quickly used up and its speed of penetration brought to zero before it has penetrated the element.

The factor of utmost importance is the light gauge of the individual sections which with projectiles of high velocity, do not become pierced directly and individually, as the projectile moves through the element, but begin to bend or yield or elongate and involve a large mass of cellules in such deformation. This consumes a great deal of energy and therefore has a superior braking effect on such foreign body.

The great value of my structural elements, as far as resistance to corrosion is concerned, lies in the fact that, behind an outside plate which either is corrosion-resisting or can easily be made so (as by painting or metal spraying), lies a web of little cellules each of which is hermetically sealed in itself. There can be no corrosion where there is no access of air and moisture. Should, however, the outside surface be damaged, for instance the outside wall of a house, should someone drill a hole in it, corrosion can only affect one cell, namely, the one that has been opened up; and not until this one has been destroyed can corrosion proceed any further. This means that there would be many years before any serious damage could be done to a building, if such hole is left unprotected. If the hole is noticed, it can simply be patched up by cement or any suitable means and corrosion immediately stops.

It has been mentioned above that the blocks used for hermetically sealing the sections of a cellule, reinforce it mechanically. If such blocks are suitably disposed, in the neighbouring cellules, so as to lie all in one cross section of the plate, then the whole element is reinforced across this section. The blocks can be made use of still for another purpose: Figure 1 represents a longitudinal section through such plate. 71, 72, 73, etc., are end sealing blocks and 81, 82, 83, etc., are inside sealing blocks. They may be made of metal, wood, cement, Bakelite or any suitable material. If metallic, they may be solid blocks of metal, or stampings, and they may either

be welded on one side, when assembling the plate (depending upon the assembly pressure to make the joint sufficiently air-tight), or they may be soldered or brazed or suitable non-metallic filling media or cements may be applied to make the joint absolutely airtight, or other preferably plastic materials may be employed to fill up the pores. One such way is to use a filler which, when heated, vulcanizes or polymerizes and joins with both the sheets of the section and the material of the sealing block, like ebonite or some of the synthetic resin compounds. An ordinary cement, in suitable combinations may also be used.

In any case, such a zone as is indicated at A in Figure 1, which has thus been reenforced, can be used for the purpose of obtaining a mechanically sound joint between one plate and another, as, in this zone, the plate presents practically a solid section and holes may be drilled in it, bolts put through or any suitable means of connection applied. Forces transmitted locally by such bolts or other means of connection are distributed uniformly to all of the plates and cellules forming parts of the element. The sides of the plates may be similarly reenforced, for this purpose, just the same as the ends.

If vulcanization, or another operation requiring a high temperature, is required to join the sealing blocks with the sheets, it is preferable to do it under conditions of elevated pressure, so that, upon cooling, there will be no partial vacuum within the plate which might impair its mechanical resistance.

Figures 2, 3 and 4 represent multicellular elements built on the same principle, with the corrugated sheet sections extending parallel to the surface of the elements. To make the drawings clearer, plates with a comparatively small number of cellules are shown; but many more may be used in practice, depending upon the purpose for which the plates are to be used. It will be noticed that this form of plate construction has a decided advantage when equally strong bending moments, both in the direction of the length of the elements as well as at right angles to it, are to be taken up.

Figure 2 shows such an element still further simplified and consisting only of two external plates and one corrugated sheet in between.

For the most economical use of the sheet metal, elements such as those shown in Figures 1 to 4 are preferably not made of sheets all of the same gauge. On the contrary, it is preferable to use heavier gauges for the outer sheets 4, 3, 2 and 2', 3', 4' and lighter for the inner sheets 1, 7 and 1'.

By suitably disposing the sheets, this method may also be used for producing curved or bent plates, as shown in Figure 5 at B.

Ordinary manufacturing methods for such elements will be clear to the skilled worker in the art and need not be described. There are, however, two developments which produce results unobtainable by ordinary methods:

Strip which is cold rolled or drawn in rolls of very small diameters and possesses a high tensile strength but is not too brittle may be employed. Such strip, whether of low or medium carbon content steel, can, for certain purposes, be used without annealing; and its structure resembles one of a steel rope. With the use of such material, it was found that a large number of spot welds of very small diameter give very good re-

sults, as such welds are close enough to one another to insure tight joints and the portions annealed through the welds are small enough not to impair the very high mechanical value of the element. Each individual weld does not need to be strong, as they hold only by their great number.

Another development is an economical method of producing elements of the type of Figures 5 and 6. This is done in conjunction with metal coating machines for strips according to applicant's copending application No. 31,699, filed July 16, 1935, now Patent No. 2,110,893, dated March 15, 1938. The exit side of such apparatus is represented in Figure 6. 98 is an airtight cooling compartment of an annealing furnace through which pass, while being partially cooled, a number of superimposed strips 91. The furnace has a reducing atmosphere. The strips have undergone a preliminary treatment before they enter the furnace, in that certain portions of them which are not to receive any metallic coating have been given a preventive coat of heat-resisting non-metallic substance such as lime, graphite, magnesia or other, alone or in combination, or containing a binding substance like sodium silicate, clay, etc.

While still within the cooling chamber 98, the strips are separated by being led over pulleys 93 and individually enter a bath of a coating metal, such as cadmium, zinc, bronze or other molten metal, that portion of the bath surface where the strips enter into the bath being protected from contact with the outside air by a suitably shaped exit portion of the cooling chamber, the edges of which are submerged into the metal coating bath.

The strips now travel a certain distance in the bath individually, both surfaces of each strip being in contact with the coating bath. Thus their surfaces obtain a metallic coating, continuous, excepting for the places which have on them the preventive coating above referred to.

The strips now go round the roll 94 while submerged in the coating bath where they are brought together, and move vertically through exit rolls 95 to cooling and shearing means.

It is evident that a partial cross section of such composite strip after cooling will appear as shown in Figure 7. Outside are the two thicker strips 101 and 102 which, in this process, have incidentally obtained a corrosion-proof outside coating. Inside are the thin sheets 103, 104, 105, 106 brazed to each other, or to the outside strips but only at places indicated at 107.

Such brazed elements can now easily be expanded to form a multicellular plate of the general type of Figure 3 by gripping one end of a sheared length and introducing a liquid or gas under pressure at the other.

Such treatment, for preventing certain parts of a strip from obtaining a metallic coating, can of course, also be used for other purposes, such as for sheets coated on one side only, etc.

In certain instances, I prefer statically to expand the elements while delimiting their outside contour, as by first placing them in a mould 108, Figure 8. This prevents buckling and allows enough pressure to be applied to iron out any wrinkles that may be produced on the outside surface of the element, especially when the outside sheets are not sufficiently heavy in proportion to the inside sheets. The expansion of the element in thickness necessitates a certain amount of drawing on the part of the inner

sheets which become lengthened in the direction of their cross section. Unless the outside sheets are sufficiently heavy to insure this, the whole element may become narrower with resulting wrinkles on the outside sheets. This can be corrected and the wrinkles ironed out during the final stage of expansion within a mould.

Such mould can also be used advantageously in order to produce multicellular plates which are not flat but are curved or varying in thickness etc. The elements have been found to be very plastic during such expansion and can be made to fill different shaped moulds, within certain limits, of course.

Modifications may be made in my invention without departing from the spirit of it. Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:

1. A process for the production of multicellular plates consisting in applying a coating-preventive layer on the surfaces of sheets where they will not be brazed together and where cellules are to be formed, then applying a metallic coating to each sheet individually, withdrawing them from the metallic coating bath and cooling them jointly whereby to braze them together along uninterrupted spaced lines and finally expanding the plate, to produce cellules.

2. A process for the production of multicellular plates consisting in applying a coating-preventive layer on the surfaces of sheets where they are not to be brazed together and where cellules are to be formed, then applying a metallic coating to each sheet individually by passing said sheets through a bath of molten coating metal, withdrawing them from the bath, superposing them and cooling them in superposition, whereby to braze them together along two opposed sides of the plate and in those areas to which the coating preventive layer was not applied, and finally expanding the plate so formed to produce cellules.

3. A process for the production of multicellular plates comprising applying a coating-preventive layer to sheet surfaces to prevent brazing where cellules are to be formed, then applying a metallic coating to sheets by passing them individually through a bath of molten coating metal, superposing the sheets before the coating thereon has hardened, and cooling them in superposition, whereby to braze them together in those areas not affected by the coating-preventive layer, and finally expanding the plate so formed to produce cellules.

4. A process for the production of multicellular plates comprising applying a coating-preventive layer to sheet surfaces to prevent brazing where cellules are to be formed, then applying a metallic coating to sheets by passing them individually through a bath of molten coating metal, superposing the sheets before the coating thereon has hardened, and cooling them in superposition, whereby to braze them together in those areas not affected by the coating-preventive layer, and finally expanding the plate so formed to produce cellules, the said plate comprising external sheets and at least one internal sheet, the said external sheets being of heavier gauge than the remainder, and effecting the expansion by subjecting the plate to internal fluid pressure insufficient substantially to stretch and deform the external sheets, whereby these sheets remain in substantially smooth and uncorrugated condition, but sufficient to stretch and deform

the remainder, whereby to produce a cellular product.

5. A process for the production of multi-cellular plates comprising applying a coating-preventive layer to sheet surfaces to prevent brazing where cellules are to be formed, then applying a metallic coating to sheets by passing them individually through a bath of molten coating metal, superposing the sheets before the coating thereon has hardened, and cooling them in superposition, whereby to braze them together in those areas not affected by the coating-preven-

tive layer, and finally expanding the plate so formed to produce cellules, the said plate comprising external sheets and at least one internal sheet, and the expanding operation comprising the steps of locating the plate in a mold and subjecting it to internal fluid pressure so as to cause the entire structure when in expanded form to fill substantially the entire mold cavity, whereby to produce a structure which is cellular within and has relatively smooth surfaces.

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