June 8, 1948. R. S. SMITH 2,443,170

REINFORCED SHEET METAL

Filed Aug. 29, 1942

FIG. 1.

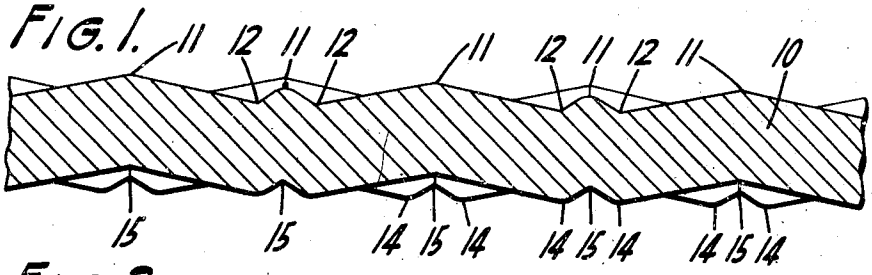


FIG. 2.

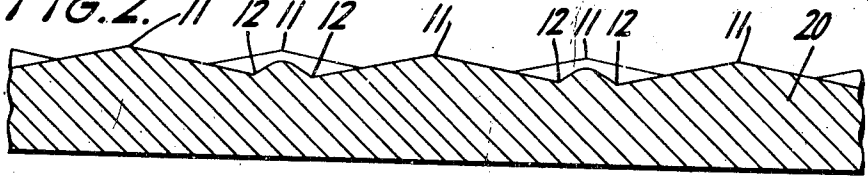
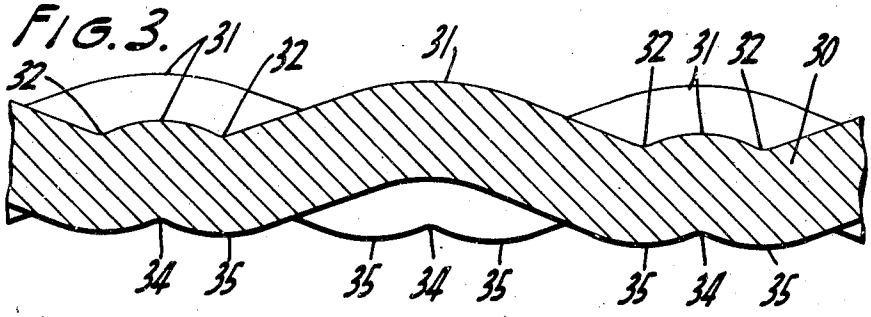


FIG. 3.



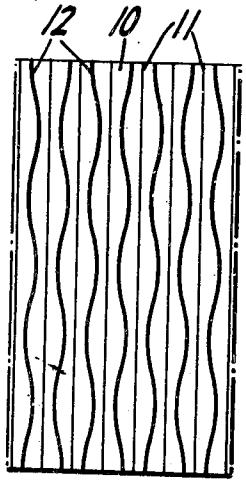


FIG. 4.

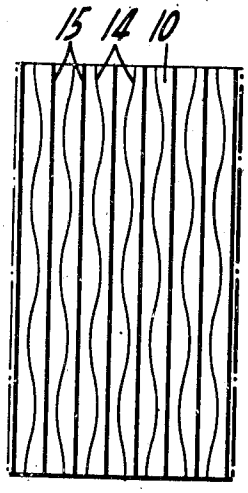


FIG. 5.

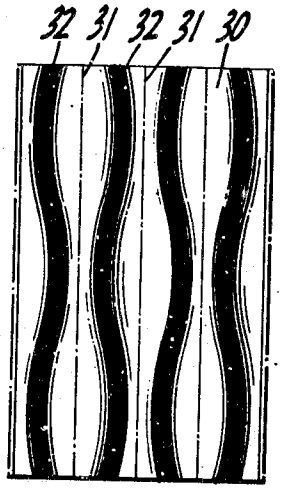


FIG. 6.

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REINFORCED SHEET METAL

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Application August 29, 1942, Serial No. 456,669

4 Claims. (Cl. 29—180)

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This invention relates to sheets of metal of various constituencies having improved characteristics of strength and stiffness when compared with flat sheets of the same material of equal unit weight.

The improved characteristics of stiffness and strength of the metal sheets of the present invention are attributable to a beneficial redistribution of the material with respect to neutral axes lying in a plane medially of the sheet. The particular application of the principles of the present invention which is set forth herein by way of example has reference to a metal sheet, and in general the formations are intended to be produced by the cold rolling of flat sheets. In the general field of metallic sheets the improvements of the present invention may be applied to both ferrous and non-ferrous metals. The successful attainment of the objects of the present invention has been demonstrated in the case of stainless, alloy and carbon steels, and various aluminum alloys.

The use of plain corrugated sheets of metal, chiefly steel, has been thoroughly explored and fairly widely used. This attempt at strengthening steel is ineffective in all excepting very special cases, since its only effect is to stiffen the sheet when it is loaded as a beam with the corrugations running parallel to the direction of the beam. If loaded at right angles to this direction a corrugated sheet has very much less stiffness than a plain sheet since the corrugations merely open up or flatten out. Likewise, a corrugated sheet has far less resistance to buckling under compressive loads at right angles to the corrugations and tensile forces in this direction do not meet substantial resistance until the sheet has been stretched to a substantially flat uncorrugated condition. Treating metal sheets by corrugation methods increases the weight per unit of area as compared with the flat sheet, while treatment of sheets according to the present invention, by actual displacement of metal, decreases the weight per unit of area.

According to the principles of the present invention surface formations are produced which redistribute the metal about the neutral axes of the cross-section of the material in such a way that increased strength and stiffness characteristics are imparted to the sheet, when compared with a flat sheet of the same unit weight and material, and this is true regardless of the direction of application of compressive buckling loads, tensile loads or flexural loads. Strengthening of a metal sheet in accordance with the principles of the present invention may be effected in a variety of ways, as is exemplified by the various alternative forms illustrated in the accompanying drawing, and described below. It is to be understood that surface formations other than those illustrated in detail will occur to those skilled in the art and the principles of the present invention are not to be limited otherwise than as defined in the appended claims.

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In the drawings:

Fig. 1 is a transverse cross-sectional view of a portion of a sheet having formations in its opposite faces;

Fig. 2 is a similar view of a sheet having formations in one face only;

Fig. 3 is a view similar to Fig. 1 but with variant formations in its opposite faces;

Fig. 4 is an elevational view of the upper surface of the sheet of Fig. 1;

Fig. 5 is an elevational view of the lower surface of the sheet of Fig. 1, and;

Fig. 6 is an elevational view of the upper surface of the sheet of Fig. 3.

Throughout the several figures of the drawing, like characters of reference denote like parts and in Figs. 1, 4 and 5 the numeral 10 designates generally a sheet metal body. The upper surface of the sheet metal body 10 is so formed that it has a series of parallel linear ridges 11. These ridges are demarcated by intermediate grooves or valleys 12 which extend sinuously along the sheet between the respective ridges. The grooves or valleys 12 are generally parallel to each other and disposed midway between adjacent ridges 10, excepting for their regularly recurring sinuosity.

The angles of the faces of the metal sheet between the ridges 11 and the grooves or valleys 12 are such that the height of each ridge 11 or its distance from the neutral axis of the cross-section of the sheet is a minimum when the adjacent sinuous grooves are closest thereto and reaches a maximum when adjacent sinuous grooves are most remote therefrom. Reference to Fig. 4 shows that the grooves or valleys 12 are so arranged that each adjacent pair either diverges or converges simultaneously.

Efficient production of a sheet having the surface formations of the present invention is facilitated, and in fact the desired strength and stiffness characteristics are augmented, by reversing the formations of the reverse side of the sheet, shown in Fig. 5, as compared with the obverse side shown in Fig. 4. Stated generally, the underside of the sheet of Fig. 1, as appears

from Fig. 5, has sinuous ridges designated 14 and linear parallel grooves or valleys 15.

By reason of the relationship of the two faces of the sheet of Fig. 1, a maximum redistribution of the material of the sheet body 10 is accomplished with a minimum of coining or cold-forging. The production of the desired surface formations cannot be effected by a mere bending of the sheet body; first, by reason of the sinuosity of the grooves on one face of the body and the ridges on the other, and second, by reason of the desired sharp definition of the crests of the ridges. This sharp definition contributes materially to the moment of inertia of the cross-section, which is a direct measure of the resistance of the cross-section to bending.

Fig. 2 shows a sheet body 20 having in its upper surface formations identical with those of the upper surface of Fig. 1 and accordingly like characters of reference have been applied thereto. The underside of the sheet body 20, designated 21, is flat. The ratios of strength and stiffness to unit weight will not be as high in the sheet of Fig. 2 as in the sheet of Fig. 1 but they will be substantially higher than in the case of a plain sheet. Sheets of the kind shown in Fig. 2 may be desirably employed in the formation of airfoils or other skin surfacing of aircraft. In such cases, obviously, the plain uninterrupted surface of the sheet will be exposed to the air stream to render the airfoil or other aircraft part aerodynamically efficient. The production of a sheet with one plain surface may likewise be desired for purely aesthetic reasons, or to facilitate decoration.

In Fig. 3 I have illustrated a form of surface treatment similar to that of Fig. 1 but characterized chiefly by the fact that the ridges are less sharply defined. I have found the cross-section of Fig. 3 to be more satisfactory, from various standpoints, when applying the principles of my invention to heavier gauge metals. In the upper or obverse face of the sheet of Fig. 3, the body of which is designated 30, the crests are lineal and parallel and are designated 31. Despite this parallelism and lineality, the crests 31 undulate in a vertical direction along their lengths. This is evidenced by the two elevations of the crests 31 appearing at the left and right sides of the cross-section, Fig. 3.

In Fig. 6 the dot and dash construction lines indicate the crests 31 and the shaded sinuous portions therebetween designate grooves or valleys 32. Note that as shown in Fig. 3 the sinuous grooves or valleys shown in Fig. 6 are at a condition of maximum divergence with respect to the central crests 31 and are at a position of minimum spacing with respect to the ridges 31 lying on each side of the central ridge of Fig. 3.

As in the case of Fig. 1, the under surface of sheet body 30 of Fig. 3 is to some extent complementary to the upper surface. At its under side the sheet body 30 has lineal parallel grooves or valleys 34 and sinuous ridges 35. The effect of this arrangement in the production of the variation in height of the crests 31 and the variation in the depths in the grooves or the valleys 34 is the same in principle as in the case of Fig. 1. It is by virtue of this variation in crest and groove amplitude that a cross-section of any of the sheets, Figs. 1, 2 or 3, taken at right angles to those cross-sections, will similarly produce an undulating cross-section. It is this fact that gives the sheet increased flexural strength with respect to cross-sections taken along the direction of the general extent of the ridges and grooves.

Referring to preferred proportion of the formation, I have successfully demonstrated the benefits of the invention in cases where the distance between respective crests along a single ridge bore ratios varying between 4 to 1 and 8 to 1 with respect to the lateral pitch of adjacent ridges.

What is claimed is:

1. A reinforced structural sheet having longitudinal corrugations presenting ridges at opposite sides thereof, the crests of the ridges at one side extending along straight parallel lines and the crests of the ridges at the opposite sides being generally parallel but pursuing a predetermined regularly recurring sinuous course as viewed perpendicularly to said side of the sheet.

2. A structurally reinforced metallic sheet having a plurality of adjacent longitudinal corrugations, the ridge of each corrugation comprising an undulating line as viewed in longitudinal cross-section, the crests of the undulating corrugations being staggered with respect to the crests of adjacent longitudinal corrugations, said corrugations having portions of maximum width at said crests and portions of minimum width at their nodes with adjacent staggered corrugations interfitting laterally.

3. A reinforced structural sheet having a plurality of longitudinal, generally parallel ridges therein, said ridges having predetermined regularly recurring variations in amplitude along their lengths, the variations in amplitude being staggered with respect to the variations in amplitude of ridges next adjacent thereto with the ridges interfitting laterally and all longitudinal cross sections through said sheet produce undulating contours and the sheet is thus reinforced against flexure both transversely and longitudinally.

4. A reinforced structural sheet having a plurality of longitudinal, generally parallel ridges therein, said ridges having predetermined regularly recurring variations in width along their lengths, the variations in width being staggered with respect to the variations in width of ridges next adjacent thereto with the ridges interfitting laterally and all longitudinal cross sections through said sheet produce undulating contours and the sheet is thus reinforced against flexure both transversely and longitudinally.

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