Feb. 13, 1945 F. H. RUPPEL 2,369,412

LATTICE MAT

Filed July 29, 1942 2 Sheets-Sheet 1

Fig. 1

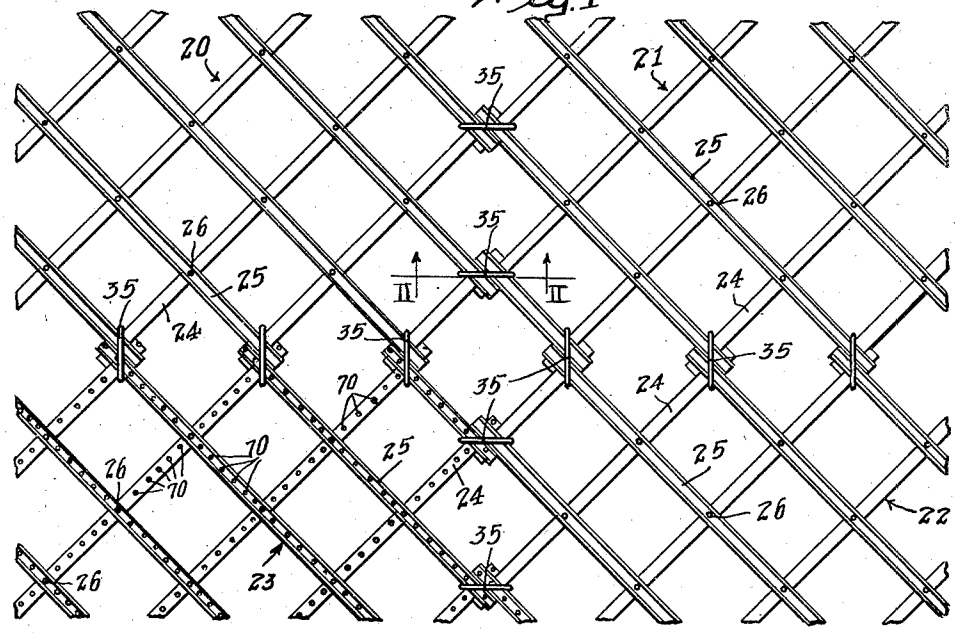


Fig. 2

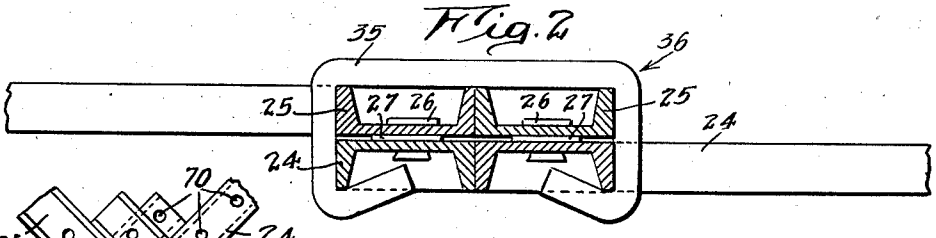


Fig. 3

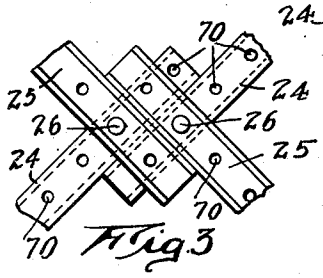


Fig. 4

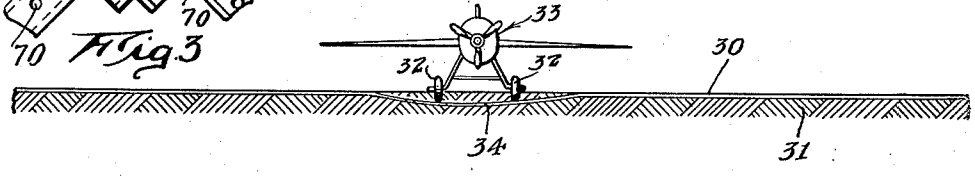
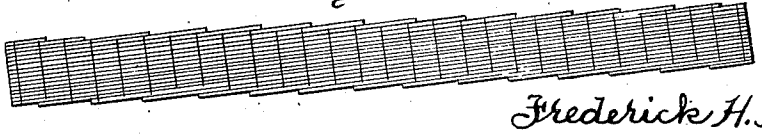


Fig. 5



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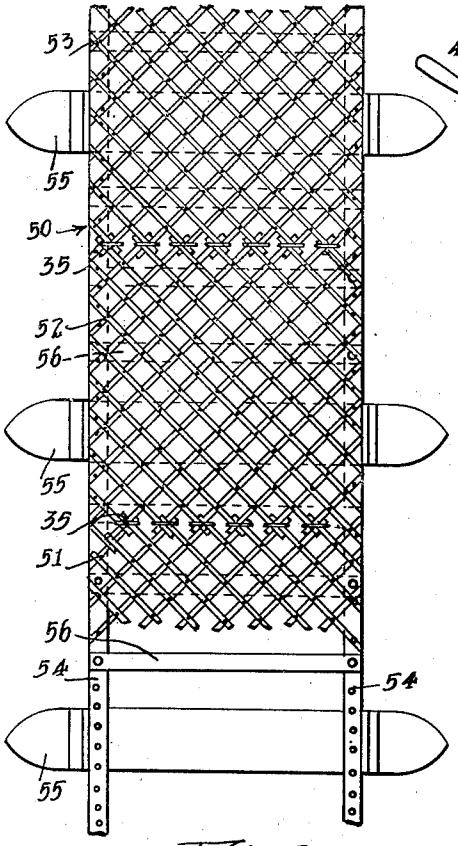


Fig. 9

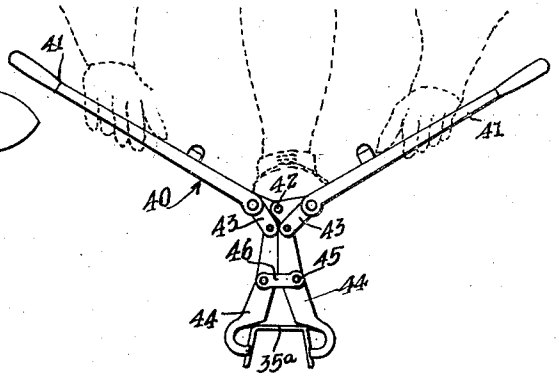


Fig. 6

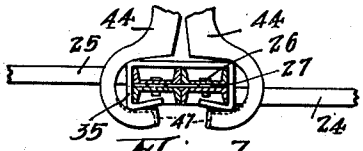


Fig. 7

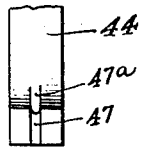


Fig. 8

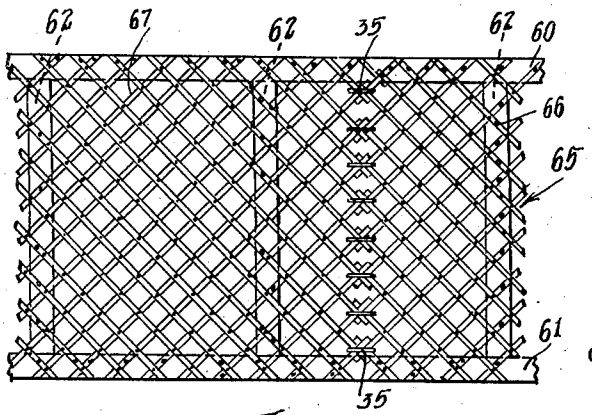


Fig. 10

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Patented Feb. 13, 1945 2,369,412

UNITED STATES PATENT OFFICE

2,369,412

LATTICE MAT

Frederick H. Ruppel, Pasadena, Calif.

Application July 29, 1942, Serial No. 452,681

4 Claims. (Cl. 94—13)

This invention relates to uniplanar metal mats of open lattice type, and more particularly to composite mats formed from a large number of small mats of convenient size for handling.

The invention is particularly applicable to the construction of foundation mats to be laid on the ground for forming airplane runways, roads, gun foundations, and similar purposes.

An object of the invention is to provide a reticulated mat as a foundation to be laid on the ground, which has relatively great load-supporting capacity with minimum weight of metal.

Another object is to provide a foundation mat to be laid on the ground as a support for moving loads in which the mat is of such construction as to have a very large frictional resistance to movement in a horizontal direction along the ground, whereby concentrated loads on the mat tending to depress it into the ground directly under the load, places the mat in horizontal tension so that the load is suspended from the ground on each side of the load for a substantial distance.

Another object is to provide a large area foundation mat composed of a large number of units sufficiently small to be conveniently handled, and of such construction as to be readily and strongly joined together.

Another object is to provide a mat capable of being contracted in one dimension and elongated in the direction at right angles thereto, for convenience in shipment and handling, and to adapt the structure for different purposes.

Another object is to provide a fastener and a fastener tool for rapidly and strongly interconnecting a plurality of unit mats in accordance with the invention.

The present invention represents a further development of the invention in my Patent No. 2,052,113, granted August 25, 1936, on a structural fabric, in which I disclose a reticulated metal fabric for use as a diagonal reinforcement in building. The fabric therein disclosed comprises two sets of bars crossing each other at an angle and pivotally connected at their crossing point by rivets or bolts. That construction can be expanded and contracted according to the principle of the wellknown lazy tongs for convenience in handling, and each mat is formed as a single unit of suitable size for use in structures such as walls of buildings.

In accordance with the present invention, I have discovered that with certain variations the reinforcing unit of my earlier patent can form an excellent support for vehicles on soft ground, by merely laying the unit on the ground. The bars dig into the ground in response to their own weight and the weight of the vehicles moving thereover, thereby providing great resistance to lateral movement along the ground surface. The bars of the mat function as supporting members in tension anchored between the bars imbedded in the earth on each side of the load. The invention is particularly useful for constructing landing fields for military aircraft, or for constructing military roads. Either use demands mats of very large horizontal dimensions at least in one direction. Hence an important part of the present invention resides in the fastener, and method of applying it, whereby a large number of small unit mats can be quickly assembled together.

The invention is also useful in the construction of military bridges by virtue of the fact that a large number of single units can be quickly assembled into a strip that can be laid directly on stringers supported on boats to form a pontoon bridge, or similar strips can be quickly secured between upper and lower side beams to form therewith a truss beam of any desired length.

The invention will now be more fully explained by describing certain specific embodiments thereof in connection with the drawings, in which

Fig. 1 is a plan view of a portion of a large lattice mat in accordance with the invention, showing the intersecting portions of four unit mats;

Fig. 2 is a greatly enlarged detail section of one of the joints, taken in the plane II—II of Fig. 1;

Fig. 3 is an enlarged plan view of one of the joint intersections, with the fastener removed;

Fig. 4 is an elevation view, partly in section, of a landing field in which a mat in accordance with the invention is laid on soft ground;

Fig. 5 is a plan view of a unit mat in accordance with the invention, in folded condition for transportation and handling;

Fig. 6 is an elevation view of a fastening element and a tool for applying it, the tool and fastener being shown in position just prior to application of the fastener to the mats;

Fig. 7 is a detail section, showing the fastener clamped onto the mats, with the tool;

Fig. 8 is a detail view, looking at one of the jaws of the fastening tool;

Fig. 9 is a plan view, showing a fabric strip in accordance with the invention, used in the construction of a pontoon bridge; and

Fig. 10 is an elevation view of a portion of a long truss, in accordance with the invention.

Referring, first, to the plan view of Fig. 1, there is shown a section of a mat in accordance with the invention, the view showing portions of four adjoining units **20**, **21**, **22** and **23**, respectively, all of which units are identical with each other. Each unit comprises a plurality of parallel lower bars **24** and parallel upper bars **25**, the latter extending across the lower bars at right angles thereto, and all the bars being interconnected at their points of crossing by rivets **26** which permit rotation between the upper and lower sets of bars, such as to swing the bars from positions normal to each other, as shown in Fig. 1, into positions in which all the upper bars lie against each other, the lower bars lie against each other, and the lower and upper bars are very nearly parallel to each other, as shown in Fig. 5. In this position the unit can be conveniently shipped and handled, and can be spread out into the open condition shown in Fig. 1 at the point of assembly.

The lower and upper bars **24** and **25**, respectively, can be of a variety of cross sectional shapes. However, I find it desirable to employ channel bars as shown in Fig. 2, the upper bars being laid with their channels facing upward and the lower bars with their channels facing downward. In other words, the upper and lower channels are laid back to back. This places the flat backs of the bars close together, reduces the length of the rivets **26** necessary to secure them together, and substantially increases the effective strength of the rivets. As shown in Fig. 2, it is sometimes desirable to position a washer **27** on the rivets between each pair of connected upper and lower members to facilitate free opening and closing movement of the mat.

When used as a roadway or landing base, another advantage of employing channel members positioned back to back as shown in Fig. 2, is that the exposed flanges of the lower back members sink into the ground and anchor themselves against horizontal movement normal to their length. The flanges of the upper channels provide additional traction with respect to the wheels of the road vehicles or air vehicles moving thereover.

Referring to Fig. 4, there is shown an airplane runway formed by laying a large mat **30**, in accordance with the present invention, on soft or boggy ground **31**. The ground may be so soft that if the mat **30** were not employed the wheels **32** of an airplane **33** would be hopelessly mired. However, when the mat, in accordance with the present invention, is laid on the soft ground and the airplane runs thereover, the weight of the airplane causes the mat to belly down below a short distance below the surface of the soft ground, the ground immediately below the airplane affording very little resistance to the settling of the mat therethrough. However, the deflection of the mat from its normal flat shape to the arcuate shape, indicated at **34**, places the mat in tension so that it can be depressed only a very short distance without either stretching or pulling in from the sides. The bars **24** and **25** which are placed in tension, are made of sufficiently heavy stock, and placed sufficiently close together, so that they will not stretch materially in response to the forces applied to them. Hence the mat cannot sink into the ground very far in response to the load of the airplane unless the mat pulls in from the sides. Such pulling in from the sides is prevented by virtue of the fact that the bars are imbedded in the ground and afford great resistance to horizontal dragging movement through the surface earth. As a result of these inherent anchoring properties of my mat, it is capable of supporting relatively enormously heavy vehicles for movement over ground so soft that the vehicles would be hopelessly mired without the mat.

As is apparent from an inspection of Fig. 1, the bars **24** and **25** of each unit **20**, **21**, **22** and **23** extend diagonally of that unit. It is possible to connect the individual units together in any desired manner so that in a large roadway or runway the individual bars **24** and **25** may run either parallel and normal respectively to the direction of traffic, or diagonally with respect to the direction of traffic. The latter arrangement is preferable for several reasons. One reason is that it permits straight edges on the composite mat, which saves material, particularly in the case of a relatively narrow roadway. Another reason is that the tensile stresses extending across the runway, as described in connection with Fig. 4, are distributed over both the lower bars **24** and the upper bars **25**. It is also of interest to note that when the tensile stresses are applied to the mat diagonally with respect to the bars **24** and **25** they tend to deform the openings defined by the bars from square to diamond-shape. Such movement of the bars is resisted by the compression of earth therebetween. It is well known that woven fabric will yield more when stretched on the bias than when stretched in the direction of either the warp or woof. This is likewise true of my mat and when it is laid with the bars **24** and **25** extending diagonally to the direction of traffic movement a certain amount of local yielding is permitted under the weight of the vehicle, which reduces the maximum stresses applied to the bars and permits the mat to sustain a larger load without breakage.

An important feature of the present invention is the aggregation of a large number of small unit mats, of a size convenient for handling, into a large mat having the same strength as it would if made in one piece. It is essential not only that the joints between the individual mats be strong, but that they be of such a nature as to permit rapid assembling of the individual mats into a composite mat in the field.

In accordance with the present invention, I satisfy these requirements by employing clamps **35** which are pressed around overlapping bars **24** and **25** of the adjacent individual mats. Thus referring to the individual joint **36** between the individual mats **20** and **21**, the upper bars **25**, **25** of the two mats lap each other for a length equivalent to about twice their width and the lower bars **24**, **24** likewise lap each other for substantially the same distance. The clamp **35** passes across the two upper members **25**, **25** down between the bars **24**, **25** of one mat at one end, and down between the two bars **24** and **25** of the other mat at the other end, the lower ends of the clamp being clinched against the undersides of the lower bars **24**, **24**. This produces a strong joint because the clamp **35** has to resist movement only along its length. Thus vertical movement of mat **20** with respect to mat **21** is prevented by engagement of the underbars **24** of mat **20** against the upper bars **25** of mat **21**, and downward movement of mat **20** with respect to mat **21** is similarly prevented by engagement of the bars **25** of mat **20** against bars **24** of mat **21**. Relative

horizontal movement of the two mats in a direction at right angles to the plane of the clamp **35** is prevented in one direction by contact of the upper bars **25, 25** of the two mats with each other, and in the other direction by contact of the lower bars **24, 24** of the two mats with each other.

To speedily install the clamps **35**, I provide a special tool **40** (Fig. 6) which is similar to a conventional bolt cutter, except that the jaws are different. Thus it comprises a pair of long handles **41** pivotally connected together by a pivot **42** and having short arms **43** pivotally connected to the upper ends of a pair of jaw members **44** which are fulcrumed to each other by pivots **45** interconnected by yokes **46**. The lower, or working, ends of the jaws **44** are shaped to fit around the bar members **24** and **25**, as indicated in Fig. 7, when the jaws are forced together. In their open position, as shown in Fig. 6, the lower ends of the jaws are separated a sufficient distance to receive and frictionally retain U-shaped clips **35***a* from which the clamps **35** are formed. The sides of the U-shaped clips **35***a* are preferably slightly spread apart at their tips, so that the clips can be readily entered between the jaws **44** and be frictionally retained thereby. As shown in Fig. 8, the tips of the jaws have grooves **47** therein into which the clips fit.

After a clip **35***a* has been positioned between the jaws of the tool, as shown in Fig. 6, it is forced down over the overlapping bars of the two mats at a joint until the cross bar of the clip seats against the flanges of the upper bars **25**. Such seating may be positively effected by the operator placing his foot between the handles **41**, as shown in Fig. 6, while supporting the handles, one on each hand. As soon as the cross bar of the clip is seated, as described, the clip is converted into the clamp **35**, as shown in Fig. 2, by simply bringing the handles **41, 41** of the tool **40** together, which forces the jaws of the tool into the position shown in Fig. 7. The ends of the clip are guided as they are bent under the bars **24, 24** by extensions **47***a* of the grooves **47** into the inner portion of the jaws. After the clamp has been set, as described, the handles **41** of the tool **40** are spread to open the jaws, whereupon the tool is lifted away from the mat and loaded with another clip **35***a* for the making of another clamp. The work of joining the mats together proceeds very rapidly for the reason that there are no holes to align, as there would be if attempt were made to bolt, or rivet, or pin the mats to each other.

There is an additional advantage to having the tips of the clips spread slightly, as shown in Fig. 6, at the time they are forced down into place. The advantage is that it facilitates the placing of the clip when the bars to be fastened are not already in close contact with each other. Then as the clip is forced down into place the titled arms of the clip function to force the bars of the two mats tightly against each other.

When a mat is to be broken up into individual mats for removal, the upper bars of the clamps **35** can be quickly cut with a conventional bolt cutter. This work is facilitated by the use of channels as the upper bars **25**, since the tips of the jaws of the bolt cutter can be extended well past the clamp on each side thereof and down into the channel of one of the adjacent bars **25**.

Heretofore my mat has been described in detail only with reference to its use as an airplane runway or roadway on soft ground. However, there are other uses for long sections of lattice work interconnected in the particular manner herein disclosed. Two such uses are disclosed in Figs. 9 and 10, respectively. In Fig. 9 a strip **50** of lattice work is formed by interconnecting a plurality of unit mats **51, 52** and **53**, in accordance with the invention, and is used as a base or roadway for a pontoon bridge, the strip being laid upon stringers **54** extending between pontoons **55**. The stringers **54** are spaced apart by cross beams **56**, and the lattice work **50** is secured to the stringers **54** where each bar **24** and **25** of the mat overlies the stringer. Attachment between the bars and the stringers may be effected by bolts extending through apertures provided in the bars **24** and **25**. Such apertures are shown at **70** in the mat unit **23** of Fig. 1.

When a load is run across the bridge of Fig. 9, the cross bars of the lattice work are placed in tension and are capable of supporting substantial loads. Furthermore the mats provide the important function of providing diagonal bracing between the stringers **54, 54** so that the composite structure consisting of the stringers **54, 54** and the mat **50** constitutes a horizontal truss beam. This is important in a pontoon bridge since it prevents lateral bending or deflection of the bridge as the result of strong currents, and the like.

Obviously the same principle last described in connection with the pontoon bridge **50** may be utilized for producing vertically disposed truss beams for use on such members as long-span bridges, and the like. Such an arrangement is shown in Fig. 10, consisting of an upper beam member **60** and a lower beam member **61**, which are maintained separated by vertical members **62** at frequent intervals and are maintained against sagging by a web of lattice work **65** consisting of a plurality of unit mats **66, 67** interconnected together by clamps **35**, as previously described. The individual bars of the mat **65** are secured to the upper and lower beams **60** and **61** in any desired manner, as by bolts or nails.

All the structures shown and described are particularly useful for military purposes, because the individual mats can be readily transported and handled in the collapsed form shown in Fig. 5, and can be quickly expanded and connected together with the clamps **35** at the point where they are to be used.

Obviously, the bars **25** and **26** may be made of various sizes. A suitable size of channel that has been employed is ¾" wide by ⅜" deep. The upper and lower bars may be joined together by $\frac{3}{16}$" x ⅜" rivets, and the clamps **35** may be of $\frac{3}{16}$" pencil rod. Individual mats may be conveniently dimensioned 10' x 12' fully extended size (when the upper and lower bars are normal to each other). Such a mat, when collapsed to the condition shown in Fig. 5, will be approximately 14' x 3" long and 15⅛" wide. With the rods spaced to define squares 6" on a side, such a mat will have a total weight of approximately 200 pounds and can be handled by two men. It will weigh approximately 1.62 pounds per square foot of area and is capable of supporting 20-ton trucks, having conventional tires, even on very soft soil or sand.

Although for the purpose of explaining the invention certain specific embodiments thereof have been disclosed and described in detail, it is to be understood that various departures from the exact construction shown can be made with-

out departing from the invention, which is to be limited only to the extent set forth in the appended claims.

I claim:

1. A composite mat of the type described, consisting of a plurality of similar unit lattice-work mats connected together, in which each unit mat comprises a lattice-work consisting of a lower set of parallel spaced apart bars, and an upper set of parallel spaced-apart bars overlying said lower set, the bars of the upper set crossing the bars of the lower set at an angle, and each bar of one set being pivotally secured to each bar of the other set at its intersections therewith, all said bars extending diagonally with respect to the boundaries of the unit mat, and each adjoining pair of unit mats having the adjacent ends of their upper bars in side overlapping relation with each other and having the adjacent ends of their lower bars in side overlapping relation with each other, and diagonal tie means for securing each set of overlapping bars together, said diagonal tie means extending around the overlapping bars in the direction of a diagonal of the parallelograms formed thereby.

2. A composite mat as described in claim 1, in which said tie means for securing each set of overlapping bars together comprises a rod member extending diagonally across the top of said overlapping portions of said two upper bars, thence downwardly at one end in the angle between the upper and lower bars of one mat and downwardly at the other end in the angle between the upper and lower bars of the other mat, the ends of the downwardly extending portions being clinched under the lower bars of the respective mats.

3. A composite mat as described in claim 1, in which the end of each bar in each unit mat extends a short distance beyond the last intersecting bar of the same mat, whereby it overlaps the bar in the opposite set in the adjoining unit mat.

4. A composite webbing consisting of a plurality of similar lattice-work units connected together in which each unit comprises a lattice-work consisting of a lower set of parallel spaced-apart bars and an upper set of parallel spaced-apart bars overlying said lower set, the bars of the upper set crossing the bars of the lower set at an angle and each bar of one set being pivotally secured to each bar of the other set at its intersection therewith, all said bars extending diagonally with respect to the boundaries of the unit, and each adjoining pair of units having the adjacent ends of their upper bars in side overlapping relation with each other and having the adjacent ends of the lower bars in side overlapping relation, the said bars being substantially in side to side contact, and a diagonal tie means for securing each set of overlapping bars together, said tie means extending in the direction of a diagonal of a parallelogram formed by said bars whereby overlapping bars are held in face to face and edge contact.

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