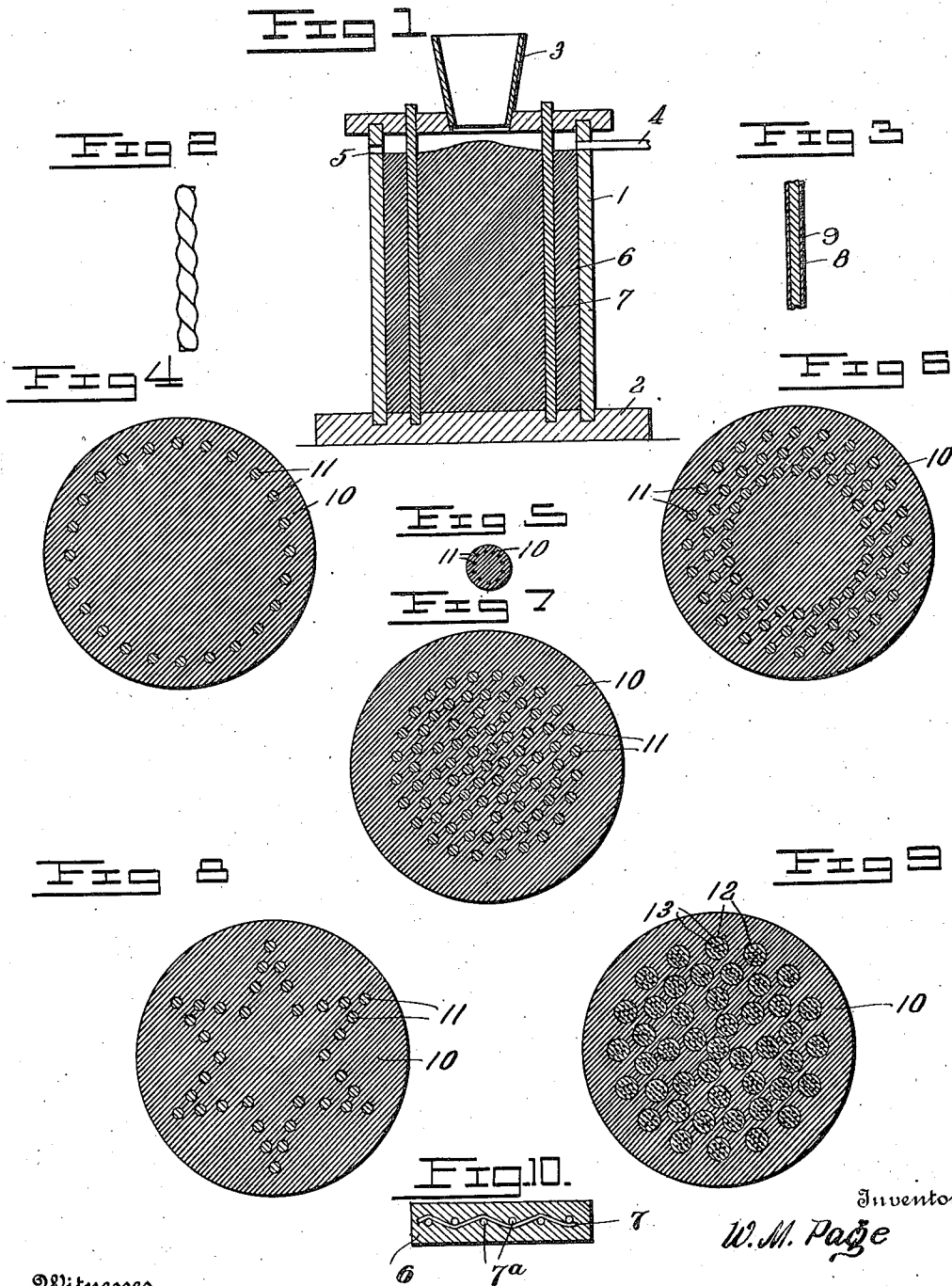


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 REINFORCED COPPER AND PROCESS OF MAKING SAME.
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Patented Jan. 19, 1915.



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REINFORCED COPPER AND PROCESS OF MAKING SAME.

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Specification of Letters Patent.

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To all whom it may concern:

Be it known that I, WILLIAM MARSHALL PAGE, a citizen of the United States, residing at Ridley Park, in the county of Delaware and State of Pennsylvania, have invented certain new and useful Improvements in Reinforced Copper and Processes of Making Same, of which the following is a specification.

10. This invention relates to reinforced copper and processes of making same; and it comprises a body of copper reinforced by interiorly incorporated relatively fine threads of steel in substantially parallel arrangement, said steel threads being in locked engagement with said copper and each of said threads being of very small or minute diameter as compared with the cross-sectional diameter of said body of copper; 15 and it also comprises a method of making such reinforced copper wherein a plurality of rods, of the like, of steel are placed in a mold in a spaced and isolated substantially parallel arrangement, this arrangement being such as to leave a comparatively wide unobstructed space around the inner periphery of the mold, copper is cast into the mold filling the spaces between the spaced rods and the space between the rods and 20 mold walls, and the compound ingot so formed is worked down to rods or the like in such a manner as to keep the copper shrunk down on the steel during the working operations; and it further comprises an extension of said invention wherein compound metal rods obtained in the manner just described are in their turn used as cores in a molding operation, copper is cast about them to form a secondary billet, and this 35 billet is worked down, the operation being repeated as many times as may be desirable to form tertiary, quaternary, etc. billets; all as more fully hereinafter set forth and as claimed.

45 It has long been a desideratum in the art to obtain compound or joined bodies of copper and steel which would unite the merits of the two metals, having the non-corrosive properties, the color and surface appearance (where the copper exists as a facing or sheath), and conductivity of the copper and the high strength of the steel, the idea ordinarily being to produce an article which is 50 mainly steel but is faced or sheathed with

the weaker and more expensive but more 55 conductive and more ornamental metal. These efforts until recently have not been crowned with success for reasons depending on the nature of the two metals, which do not readily unite together. It is impracticable to produce a rolled union between substantial bodies of copper and of steel, as by rolling down relatively thick hot juxtaposed plates of the two metals. Relatively thin 60 plates of either metal cannot well be used since they would be consumed by oxidation. Both metals readily oxidize when hot and air cannot in practice be excluded during heating and rolling. The two metals also roll differently and expand and contract 65 differently, while under steel rolling conditions their surfaces exhibit little or no tendency to unite with an integral union which would compel uniform extension on working down together. Furthermore with comparatively heavy plates of both metals, and it is not worth while trying to work with thin sheets of either in rolling mill practice, the plates are too thick to be sufficiently yielding to allow forcing of absolute contact at all points between abutting surfaces, 80 so there is in plate-uniting processes usually not even a good friction fit. The same considerations apply in most ways to the production of round-coated material by rolling 85 a core and an annular sheath together.

Recently material composed of copper and steel united by a true weld union has become commercially available (Patent 893,932); and this material may be rolled, 90 drawn, struck, etc., as if of unitary metal while it does not readily corrode, there being no seam or line of disunion between the metals or pore or crevice in the coating into which moisture can penetrate and set up a 95 galvanic couple. This material is however rather copper-coated steel than reinforced copper since under the most feasible methods of making it substantial bodies of steel are employed. A substantial body of steel 100 may be dipped in very highly heated molten copper, or supermolten copper (Patent 853,716), to produce a clinging film of alloy, withdrawn into a protective atmosphere and more copper cast on with the production of 105 a thick coated billet which can be rolled and drawn to any extent desired. It is however difficult to handle small or thin

bodies of steel in this way because of the dissolving action of the highly heated copper; so in practice large thick steel billets are ordinarily employed and these are given a heavy coat of copper, (40 per cent. copper and 60 per cent. steel being a frequent ratio) and are rolled and drawn down to the dimensions desired for the finished articles, such as wire, rod, sheets, etc.

In the present invention I desire to produce a reinforced copper rather than a coated steel and to this end I produce a material which is for the major part composed of copper, being advantageously as high as 90 per cent. copper, and instead of having the steel reinforcement occur as a unitary body or single core, I employ the steel as a plurality of relatively fine embodied spaced and isolated threads having the characteristics of worked down metal. This gives me a double advantage in that the steel of the threads is made much stronger, which means that I can secure higher tensile strength with less steel, and in that the compound material is much more flexible than is possible with all the steel occurring as a single stiff core, which is a desideratum in many cases, and particularly where the compound material is to be used for hung and strung wires. For many purposes, such as wire, it is desirable that the compound material shall have, as nearly as possible, all the properties of copper save that it shall have a high tensile strength and high elastic limit. Pure copper in wires tends to sag and neck under strains and temperature changes; and while it may be hardened and strengthened to some extent by various alloying treatments, these alloyings run down its most valuable property, its high conductivity for the electric current.

While as stated it is difficult to roll and otherwise work conjointly copper and steel which are not welded together, I have discovered that this may be done to an extent sufficient for my present purposes provided certain expedients are adopted. With a substantial body of steel and a substantial sheath or layer of copper if the two be unwelded the copper tends to flow faster than the steel under the roll pressure and, since the copper expands more than the steel, in reheating the metals tend to break away; and in working hot after reheating this is particularly apt to happen. Rolling of juxtaposed unwelded thick bodies of steel, whether as plates or as core and sheath, is quite difficult. But this tendency of the metals to part does not happen to such an extent where the steel body is relatively thin and of small diameter since the smaller it is of course the greater the friction, proportionately, tending to resist mechanical parting of the two metal surfaces. But such a

thin body of steel must be surrounded or included by the copper since otherwise it would perish in rolling. By using a relatively large number of relatively small steel rods in a mold, and casting copper around the rods to form a relatively large ingot or billet, the rods being spaced from each other by substantial areas or layers of copper and from the inner margin of the mold, a primary compound billet can be produced which will withstand the strain and stresses of rolling to an extent sufficient for my purposes. If, for example, say 54 rods of $\frac{3}{8}$ inch steel be placed in a mold of a diameter appropriate for making, say, a $6\frac{3}{8}$ billet, copper cast about them and the billet thus made rolled down to $\frac{3}{8}$ rod, each of the 54 rods will have suffered a concomitant reduction and will be in the form of fine threads contained within the rod so produced so that such rod may be readily drawn down to wire in a way in which a similar rod having a single unitary unwelded comparatively large steel core could not. In the preliminary stages of the rolling down of the rod-reinforced primary billet care must be taken to avoid parting while the steel cores are still of some substantial diameter; and for this purpose it is desirable to resort to an expedient.

As stated, expansion and contraction are greater with copper than with steel and this may be utilized in the rolling. If the hot compound billet be allowed to cool superficially before introducing to the rolls, the copper shrinks down on the steel rods binding on them tightly. After entering the rolls the temperature of the whole mass under the roll pressure equalizes again, and the shrinkage is relieved; but prior to equalization considerable extension may be effected. If now the coextended metals be allowed to cool again superficially to shrink on the copper shell, rolling can be again resorted to, and so on till the diameter of the contained steel threads is sufficiently reduced to allow friction to hold the metals together in the wire drawing. After a steel reinforcement in a comparatively massive body of copper becomes threadlike in diameter friction will hold it. It is not possible to roll down a thin unwelded copper sheath on a steel core; that is, to start with a steel core and an unwelded copper shell of small diameter and roll down to a point where the shell will become film-like. But it is possible to roll down relatively small steel rods included in a relatively large and massive copper body, even if they be unwelded thereto. For some reasons it is desirable to weld such rods to the main body of the copper, but for other reasons it is desirable that they shall not be welded. And, as stated, with proper precautions included isolated comparatively small steel rods can

be rolled down together with a substantial body of copper unwelded thereto if the rolling operation be carefully conducted; and particularly if the recited expedient be adopted.

Where the wire to be produced is to be used as a conductor, it is highly desirable that the copper shall not be contaminated with iron as iron runs down the conductivity of copper very much. By placing naked steel rods of small diameter in a mold and casting around copper of a temperature appropriate to attack the surfaces to the steel rods to form a weld union, the body of the copper necessarily becomes much contaminated with dissolved iron. The small rods of course expose a relatively large surface to contact with inflowing metal. But by using low-temperature molten copper, that is copper at a temperature at which it will not readily unite with steel, the copper cast in does not become contaminated and retains its full conductivity. The molds should be of a character permitting quick solidification.

The process just described results in the formation of a primary reinforced billet; a billet of cast copper containing a multiplicity of incorporated steel rods, which on reduction of the primary billet give a primary rod or wire having distributed through its mass thread-like linear bodies of steel. These thread-like bodies having been worked down hot while shielded from actual contact with the air and with the working tool, have an exceptionally high strength. And the further this reduction can be carried, the greater becomes the tensile strength of the steel per unit of sectional area. It is therefore frequently desirable to carry the process further and make secondary, tertiary or quaternary billets, or even further. In so doing, the extension of the steel threads, and the consequent heightening of their tensile strength, is concomitant. For example, steel rods may be placed in a mold, copper cast around them to form a primary billet as described, and this primary billet drawn down to half inch or $\frac{3}{8}$ inch rods, and these rods in turn placed in a mold and used as the reinforcing elements in forming a new or secondary reinforced compound billet which, in turn, can be reduced to $\frac{3}{8}$ rod wire. The $\frac{3}{8}$ rod resulting from the secondary billet can be used to make a tertiary billet; the $\frac{3}{8}$ rod therefrom in turn used to produce a quaternary billet, and so on indefinitely. This process can be carried on till the incorporated steel threads become indefinitely fine. If, for example, there be 50 steel rods in the primary billet, each $\frac{3}{8}$ rod from it will contain 50 steel threads. If now 50 of these rods be used in making a secondary billet, such secondary billet will contain 50×50 or 2500 steel threads. A ter-

tiary billet made with the aid of 50 of the secondary $\frac{3}{8}$ rods will in turn, contain 50×2500 threads or 125,000; and a quaternary billet will contain $50 \times 125,000$ or 6,250,000 threads, and so on. Wire drawn from a quaternary billet will contain, under the stated circumstances, 6,250,000 steel threads and this wire may be very fine; the fineness to which the contained steel threads must be reduced will be readily evident.

While as stated it is not practicable to roll-weld substantial bodies of steel and of copper, and particularly where there is any possibility of air gaining access to the line of intended union, with a comparatively fine, flexible and yielding thread of steel in a comparatively massive body of copper, with absolutely no possibility of access of air to the abutting bounding surfaces and with such surfaces constantly pulled out and extended by the working operation in such manner as to constantly expose new and, very likely, molecularly reactive faces in forced contact, there occurs some sort of union, possibly mechanical but possibly also an alloying in the sense of a molecular interpenetration. The new surfaces constantly being produced are in absolute contact and, so to speak, within molecular reach of each other.

It is advantageous to make a secondary material in the way described because the steel threads in the duplicated reduction become so very fine that they have little stiffness while their tensile strength is very great. The secondary material therefore behaves, so far as flexibility is concerned, very much like copper, while it has a much higher tensile strength. With a secondary billet, contamination of the cast copper in making the primary billet, is not so important since there is no chance for contamination of the main body of the copper in making the secondary billet, the steel reinforcing rods being of course protected by the copper jacket coming from the primary billet.

By using low temperature copper in the casting operation in making the primary billet, however, contamination can be readily avoided. Since it is not necessary to make a weld union in the present invention, the casting copper can be at such a low temperature as not to unite with, alloy with, or dissolve the steel against which it is cast. If desired, the casting may be in a water-cooled mold, or a mold having thick, heat conductive walls, so that the copper cast in shall solidify at once; *i. e.*, shall not remain in contact with the steel cores in a fluid state for an appreciable time. An iron or steel mold having a thick cast-on rim of copper may be used. It is a useful expedient, using these heat removing molds, to cast the molten copper in such a manner that a ring of pure copper solidifies against the walls prior

to the solidification of the copper forming the central portion of the billet. With annularly clustered rods the vacant space in the middle may also be cast full of quickly solidifying copper. Or preformed copper castings may be used as part of the assemblage. The steel rods used in making the primary billet need not have metallic surfaces; they may be rusted or otherwise oxidized, thereby retarding or preventing the contact of fluid copper with the actual surface of the steel.

No weld union being contemplated in the present invention, the presence of a spacing layer of oxid between the steel and the copper is not always disadvantageous. For some electrical purposes, indeed, it is desirable to have such a spacing layer. However, it is usually more advantageous to have the rods metallic surfaced, as by previously pickling or sandblasting them, as this gives the surface a sort of tooth which is useful later in producing the desired friction fit. Where pickling is done by hydrochloric acid, a little chlorid of iron may adhere to the steel and proves useful in the subsequent casting operation, as it is volatile and displaces air. The rods may be given a twist or bend in order to promote locking union with the billet of copper in the preliminary stages of drawing down. The arrangement of the rods in the mold is best substantially parallel; that is, they should all have the same general direction. They may be grouped or clustered or spaced in any arrangement desired. In the ultimate wire the rods will reappear as linear thread-like bodies of steel and it is desirable that these thread-like incorporated reinforcing members be spaced away from each other the same distance throughout the wire so that each part of the wire will be like each other part; and this is best done by making a parallel arrangement of the rods in the original primary billet. Where it is desired to obtain very fine threads of steel in the wire from a primary billet, of course fine rods or even wires of steel may be employed in making the primary billet. Even with relatively fine wire employed as cores in making the primary billet, with the use of low temperature casting copper no contamination of the main copper body need be feared.

For some purposes, the copper used in forming the primary billet may be replaced by bronze, thereby producing a reinforced bronze primary billet and primary wire. The bronze coated primary rods may be used in reinforcing a secondary copper billet or secondary bronze billet as may be desired.

An expedient which is sometimes useful in reducing the possibility of contamination of the cast copper in making a primary billet is to electroplate the rods or wires employed with a coating of copper. It is less useful to

brass coat, zinc coat or tin coat the cores used in making the primary billet since the low melting metal is apt to diffuse through the cast copper, running down its conductivity and other properties. The melting point of tin and zinc is, of course, very far below the temperature of even low temperature casting copper.

For some purposes rods of aluminum, nickel, cobalt, etc. may be used in lieu of steel. It is not usually desirable to employ sections of stranded cables as reinforcing cores in making the primary billet. With low temperature casting copper, the copper does not penetrate a stranded core though subsequent working tends to close up cavities.

In compound wire and other material of reinforced copper made under the present invention, the steel threads are so very fine that even if not welded to the copper no substantial seam or avenue for moisture exists between any thread and the copper surrounding it; there is no substantial opportunity for the capillary penetration of corrosive fluids. And should by chance such corrosion occur around one thread, it does not affect the remaining threads. The amount of steel exposed at any one place in a cut face of a reinforced conductor under the present invention, is wholly negligible. Neither is there any possibility of the removal of the reinforcing threads of steel by pulling out from a cut face. Apart from the friction fit which exists, in rolling and drawing there is usually more or less twist given the thread which coöperates in locking it in place. The threads should always be incorporated in the body of copper at a substantial distance from the periphery or margin. It is always desirable that there shall be a relatively substantial shell or coating of pure copper outside the reinforced portion of the metal; and the rods should consequently always be clustered or located in the billet so as to leave an unobstructed space between the assemblage of rods and the inner periphery or margin of the mold used in making the compound billet. The rods or cores should be spaced apart sufficiently to allow the cast copper to enter between.

Since the main object of the present invention is to produce a reinforced copper, rather than a coated steel, it is usually desirable to restrict the amount of steel to a low proportion; say around 10 per cent. Material may be made with as high as 50 per cent. steel but such high-steel material is less and less like copper as the percentage of steel increases. High steel reinforced wire under the present invention has however certain unique properties which make it useful in some relations. A wire carrying, say, 50 per cent. of embodied steel in the

form of excessively thin, very strong isolated parallel linear threads of strong steel spaced by films of softer copper has mechanical properties quite different from other available materials. A stranded body of steel wires is stiffer and not so strong even when of the same diameter and so carrying much more steel. The individual steel threads in the present material are, or may be, much finer and stronger than wire can be commercially drawn. For conductor wires, of course, the conductivity of the copper is the main thing to be considered, and the more steel there is in the compound wire the less copper there can be. As 10 per cent. of steel in the form of a multiplicity of distributed thread-like linear bodies will give an ample strength for most conductor wire purposes, it is usually desirable not to use more steel. Such a compound material carrying 10 per cent. steel has a very high scrap value; it being possible to recover the scrap by simply melting up and burning out the iron.

In the accompanying illustration I have shown more or less diagrammatically certain embodiments of apparatus useful in the present invention.

In this showing Figure 1 is a vertical section of a mold containing copper and reinforcing rods in place; Fig. 2 is a vertical section of a twisted rod suitable for use in the present invention; Fig. 3 is a similar view of an electroplated rod; Fig. 4 is a transverse section of a reinforced billet under the present invention showing a single row of reinforcing bodies in annular arrangement; Fig. 5 is a similar section of a wire; Fig. 6 is a similar view of a billet having several annular rows of reinforcement; Fig. 7 is a similar view of a billet having the reinforcement in central clustered arrangement; Fig. 8 is a similar view of a billet having the reinforcement in star shaped arrangement; Fig. 9 is a similar view of a secondary billet having a reinforcement derived from a primary billet; and Fig. 10 is a transverse vertical section of a flat sheet bar containing reinforcements in right angled arrangement.

In Fig. 1, element 1 is a mold resting on base 2 and provided with pouring spout 3, gas inlet 4 and gas outlet 5. In the mold is shown a mass of cast copper 6 and reinforcing naked steel rods 7. As shown in Fig. 2 these rods may be twisted or otherwise shaped to give good frictional engagement. This however is not necessary though sometimes advantageous. In Fig. 3 is shown a rod 8 provided with a thin flash coating 9 of electrodeposited copper. In Figs. 4, 5, 6, 7 and 8, 10 represents the main body of copper and 11 the reinforcing naked steel bodies. In Fig. 9, 10 also represents the body of cast copper and 12 are reinforcing

bodies derived from a primary billet and composed of copper containing thread-like steel bodies 13.

Special steels, such as vanadium steel, chrome steel, tungsten steel, nickel steel, manganese steel, etc., can be used for reinforcement since in working they are protected against oxidation and change of composition by the protecting sheath of copper. The copper acts as a sort of lubricant and facilitates the drawing down of these hard and tenacious steels in a way which is hardly practicable with the naked steel. And their high tensile strength can be relied upon in the present invention without fear of the concomitant stiffness, since the reinforcing bodies are reduced, as stated, to excessively fine threads. A composite copper which contains from 10 to 15 per cent. of such very strong steel in threadlike linear bodies is still flexible and can be handled and hammered like pure copper. The included steel filaments yield readily to flexure, although displaying their high tensile strength on longitudinal pulling of the wire. Where a very soft metal is required, wrought iron and mild steels may also be used as reinforcements.

While my invention is particularly useful in making rods, wires, and the like, and particularly for conductor purposes, it is also applicable for the manufacture of sheets, tubes and other shapes. For many purposes for which copper is used in the arts, because of its non-corrodibility, such as evaporating devices and the like, it is desirable to have it of a somewhat stronger character. The size of a vacuum pan, for example, is limited by the structural strength of copper in available sizes. A vacuum pan must withstand atmospheric pressure and if the pan be over a given size, copper sheets cannot be relied upon to furnish the strength unless of undue thickness and weight. Metal sheets for such purposes however must be like copper, capable of being worked into shape under the hammer; the metal must be malleable and flow under the tool. By reinforcing copper with steel in the present invention sheets can be obtained which combine a high tensile strength with a flowability like that of copper; For this purpose instead of using only longitudinal reinforcing elements it is better to have reinforcing elements in two directions. That is, instead of merely clustering longitudinal rods in a mold and casting copper about them, it is better to use rods arranged in two directions. The rods may, and very usefully for many purposes, be interlaced in a sort of open fabric. Presuming that strengthening rods of material, such as described, be woven into a sort of loose or open fabric, that is in right-angled arrangement, copper cast about them to form a compound billet and then rolled

down into sheets, an article will be secured which is substantially copper so far as its hammering properties are concerned, but nevertheless has a greater degree of strength than copper alone can have. If the reinforcements be, as is preferable, each of relatively small diameter as regards the body of copper, on cutting the new reinforced sheet to sizes such as are desired, there will be merely spots of steel exposed; and these spots may, and usually will, be too small in diameter to allow corrosion to penetrate too far by capillary penetration. They may, of course, be touched with a soldering iron. The reinforced sheet may also be punched and drilled to receive rivets and the like without any substantial exposure of the reinforcing metal.

Reinforced bars or sheets such as described, which may have reinforcements distributed through the bar or sheet in one or more planes, may of course be converted into structural elements, such as T's, I's, channels, cross-sectioned elements, etc. For such material of course perforated plates of strong metal, "expanded metal", or electrically welded woven screen as well as ordinary woven screen material may be employed. But the product, using such materials, does not have the reinforcements spaced and isolated from each other at all points.

In Fig. 10 I have shown a section of a reinforced bar adapted for making sheets and other flat shapes and containing strengthening rods in a sort of loose or open angled arrangement. As shown, it has reinforcing rods 7 crossing the width of the bar reinforcement 7^a extending lengthwise of the bar, both being embodied and held in a mass of copper 6.

What I claim is:—

1. A reinforced metal article comprising an integral body of copper and a plurality of isolated linear reinforcing elements in substantially parallel alinement contained within said body of copper, said elements being spaced away from each other and comprising linear bodies of steel having the characteristics of preworked metal and having worked surfaces in contact with worked surfaces of copper.

2. A reinforced metal article comprising an integral body of copper and a plurality of isolated linear reinforcing elements in substantially parallel alinement contained within said body of copper, said elements being spaced away from each other and comprising frictionally held linear elements of steel having the characteristics of preworked metal and having worked surfaces in contact with worked surfaces of copper, each of said steel bodies being of a threadlike relatively minute cross-section.

3. A reinforced metal article comprising

an integral body of copper and a plurality of isolated linear reinforcing elements in substantially parallel alinement contained within said body of copper, said elements being spaced away from each other and comprising copper shells and threadlike steel cores and having the characteristics of preworked metals and the core being held to the shell by engagement between co-worked surfaces.

4. A reinforced metal article comprising an integral body of copper and a plurality of isolated linear reinforcing elements in substantially parallel alinement incorporated in and distributed through said body of copper, said elements comprising copper shells and contained threadlike steel cores and having the characteristics of preworked metals, each of said cores being of a threadlike relatively minute cross-section and the cores being held to the shells by engagement between co-worked surfaces.

5. A reinforced metal article comprising an integral body of cupriferous metal and a plurality of isolated linear reinforcing elements in substantially parallel alinement incorporated with and distributed through said body of cupriferous metal, said elements comprising linear bodies of steel having the characteristics of preworked metal, said steel being held to the cupriferous metal by engagement between co-worked surfaces.

6. A reinforced metal article comprising an integral body of cupriferous metal and a plurality of isolated linear reinforcing elements in substantially parallel alinement incorporated with and distributed through said body of cupriferous metal, said elements comprising linear elements of steel having the characteristics of preworked metal, each of said steel elements being of a threadlike relatively minute cross-section and held by engagement with a co-worked surface of cupriferous metal.

7. A reinforced metal article comprising an integral body of cupriferous metal and a plurality of isolated linear reinforcing elements in substantially parallel alinement incorporated with and distributed through said body of cupriferous metal, said elements comprising cupriferous shells and threadlike steel cores and having the characteristics of preworked metals, said cores being held in said shells by engagement between co-worked surfaces.

8. A reinforced metal article comprising an integral body of cupriferous metal and a plurality of isolated linear reinforcing elements in substantially parallel alinement incorporated with and distributed through said body of cupriferous metal, said elements comprising cupriferous shells and threadlike steel cores and having the characteristics of preworked metals, each of said

elements being of a threadlike relatively minute cross-section and the cores being held in said shells by engagement between co-worked surfaces.

5 9. In the manufacture of reinforced cupriferous articles, the process which comprises assembling a plurality of relatively small steel rods in a mold in an isolated arrangement as regards each other and as regards the mold walls, casting a body of low temperature cupriferous metal thereamong and therearound to form a body of such cupriferous metal inclosing such rods and then working down the cupriferous metal in such way as to give uniform extension of such body and of such included rods.

10. In the manufacture of reinforced cupriferous articles, the process which comprises assembling a plurality of relatively small steel rods in a mold in an isolated arrangement as regards each other and as regards the mold walls, casting a body of low temperature copper thereamong and therearound to form a body of such copper inclosing such rods and then working down the copper in such way as to give uniform extension of such body and of such included rods.

11. The process of producing a reinforced cupriferous metal which comprises spacing a plurality of rods of steel in a mold in isolated arrangement and casting low temperature copper thereabout and thereamong in contact with said steel and working down the composite casting to a final shape in a

plurality of hot rolling operations, the material being superficially cooled prior to each hot rolling operation.

12. The process of producing a reinforced cupriferous metal which comprises spacing a plurality of rods of steel in a mold in isolated arrangement, casting low temperature copper thereabout and thereamong in contact with said steel, working down the composite casting to rod form in a plurality of hot rolling operations, the material being superficially cooled prior to each hot rolling operation, placing the rods obtained in a mold and casting copper about them to form a secondary billet.

13. The process of producing a reinforced cupriferous metal which comprises spacing a plurality of rods of steel in a mold in isolated arrangement, casting low temperature copper thereabout and thereamong in contact with said steel, working down the composite casting to rod form in a plurality of hot rolling operations, the material being superficially cooled prior to each hot rolling operation, placing the rods obtained in a mold, casting copper about them to form a secondary billet and working down said secondary billet.

In testimony whereof, I affix my signature in the presence of two subscribing witnesses.

WILLIAM MARSHALL PAGE.

Witnesses:

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