July 15, 1941. R. K. HOPKINS 2,249,629

ARMORED ARTICLE

Original Filed March 2, 1938

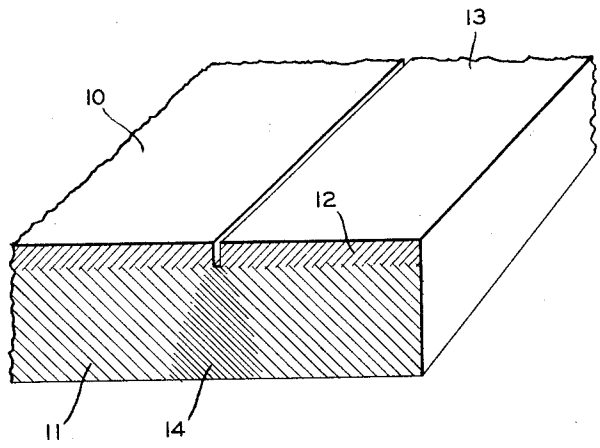


FIG. 1

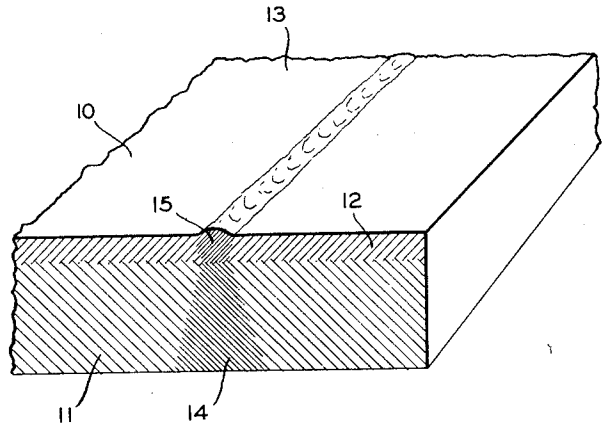


FIG. 2

INVENTOR
ROBERT K. HOPKINS

BY Virgil T. Davies
ATTORNEY

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ARMORED ARTICLE

Robert K. Hopkins, West New Brighton, Staten Island, N. Y., assignor to M. W. Kellogg Co., New York, N. Y., a corporation of Delaware

Original application March 2, 1938, Serial No. 193,411. Divided and this application April 11, 1939, Serial No. 267,233

1 Claim. (Cl. 148—31)

This invention relates in general to the manufacture of armored articles and in particular to the manufacture of weldable armored articles.

This application is a division of my copending application Serial No. 193,411 filed March 2, 1938.

It is the primary object of this invention to provide armor metal of such character that it may be fabricated into armored articles by welding.

It is a further object of this invention to provide armor metal of such nature that it can be worked with facility prior to the hardening treatment.

The further objects and advantages of the invention will be better appreciated from a consideration of the following description of embodiments of the invention and modes for producing them taken with the accompanying drawing in which,

Fig. 1 is a fragmentary isometric view, partly in section, of an assembled armored article, such as an armor plate, a gun shield, a gun turret and the like, showing edges thereof united by welding, and

Fig. 2 is a view, similar to that of Fig. 1 showing the edges joined in a somewhat different manner.

Armor metal in accordance with my invention may be made in the form of flat or shaped slabs, plates or sheets of the usual range of thicknesses which may be used as such or fabricated into armored articles such as ships armor belts, shields, turrets, bodies of armored vehicles etc. The armor metal 10 includes a backing zone 11 and a hard zone 12. Backing zone 11 and hard zone 12 are integrally united throughout so that metal 10 is a one piece unitary structure. In general, zone 12 will be of less thickness than zone 11, however, the ratio of thicknesses will vary in accordance with service requirements. Zone 12 may be of substantially uniform analysis throughout or it may be of variable analysis. Thus, its content of a hardening element, such as carbon, may decrease from face 13 inwardly towards zone 11. Also, zone 12 may be made up of a plurality of superimposed united layers of different analysis, the hardest layer may define face 13 or a comparatively soft layer may define face 13 and the hardest layer interposed between zone 11 and the layer defining face 13.

Backing zone 11, will generally be of alloy steel. A number of alloy steels are suitable; the metal chosen should, however, be of such analysis that it exhibits the following properties and characteristics:

1. It must be weldable. 2. After final heat treatment it must have the strength and toughness necessary for the intended service and must exhibit a fine grain structure. 3. After final heat treatment it must exhibit a hardness such that it will prevent dishing of the armor metal upon heavy impacts and will not throw slivers when penetrated. Depending on the ratio of the hard zone thickness to the total thickness of the armor metal the hardness of the backing zone may range from 200 to 400 Brinell. 4. It must not suffer from appreciable grain growth as a result of the heat treatment used for developing the desired properties in the hard zone.

Many alloy steels satisfy the above requirements the following will give good results when used for the metal of the backing zone:

1.25%	chromium	0.5%	molybdenum	0.25%	carbon steel
7.5%	chromium	0.5%	molybdenum	0.10%	carbon steel
4.0%	nickel	1.50%	chromium	0.15%	carbon steel
1.5%	manganese	0.60%	molybdenum	0.30%	carbon steel

The metal for the hard zone 12 may also be chosen from a considerable group of steels. The requirements for the metal of the hard zone are:

1. That it be capable of developing the required hardness, 400 to 650 Brinell, when air or oil cooled, but preferably air cooled, from the necessary hardening temperatures. 2. That it will not, after the hardening heat treatment, lose a detrimental amount of hardness or toughness when heated to temperatures suitable for stress relieving welds, these temperatures will usually range in the neighborhood of 1000° F. 3. That it be preferably, though not necessarily, weldable. 4. That it be of a sufficiently sluggish nature to undergo changes, due to the application of heat, slowly so as not to be susceptible to material softening when heated for comparatively short periods to elevated temperatures, temperatures above 1000° F. 5. That it be of extremely fine grain in the final hardened condition. 6. That it be workable before the hardening heat treatment.

The most satisfactory steels for the purposes will be found in the class of pronounced air hardening steels that can be hardened to the range above given, after heating to the neighborhood of 1800° F., by cooling in air or oil. Those that develop the hardness by air cooling will generally be preferable.

The following steels meet all of the requirements:

7.5%	chromium	0.50%	molybdenum	0.70%	carbon steel
12.0%	chromium	0.7%	molybdenum	0.50%	carbon steel

While two specific analyses have been given,

a great deal of variation in analysis is possible, thus, the chromium content may vary from 3% to 20%, the molybdenum content may vary from 0 to 3%; and the carbon content may vary from 0.25% to 1.5%. Also, vanadium, tungsten and similar elements may be included in the alloy steels in various percentages. Furthermore, vanadium, tungsten and similar elements, alone or in combination with each other, may be used as the only alloying elements of the steel.

The novel armor metal may be produced by fusing, by electric energy discharge under a blanket of protective flux, the metal of the hard zone 12 on the metal of the backing up zone 11. The method preferably employed is disclosed in detail in my prior Patent No. 2,191,469 issued February 27, 1940. The metal of backing zone 11 to which the metal of zone 12 is united by fusion may be in the form of the desired article but in the usual case it will be in the form of a thick slab, or other intermediate form, from which the desired article may be produced by working operations such as rolling, forging, etc.

The metal of the hard zone may be deposited as a single layer or as a plurality of superimposed integrally bonded layers. The layers may all be of substantially the same composition or they may be of somewhat different composition so that the change of characteristics from the metal of zone 11 to the hardest metal of zone 12 may be gradual or sharp as desired. In any of these cases the armor metal will include a zone 11 of backing metal to which is integrally united throughout a zone of hard metal which may include one or more united layers. Also, if desired, a layer of comparatively soft metal may form the outside layer of the metal of zone 12.

The armor metal after it is produced by either of the procedures above described, may be in its final form or it may be in such form that the desired articles or the component parts of the desired articles may be formed from it by suitable working operations. When working is necessary the armor metal is worked in a properly heated condition as by forging, rolling, etc. When the armor metal is worked the working operations, aside from reducing the thickness of the metal, refine the metal and thus improve it. The working operations will convert the deposited metal of zone 12, which approximates cast metal in character, as well as the metal of zone 11, which may be in the cast or partly worked condition, into fine grained work refined metal.

The armor metal whether worked or unworked is then annealed preparatory to the machining, shaping, forming and other operations necessary to produce it in the form of the finished article or its component parts. At this time, all necessary welding grooves are formed in the edges of the article or its component parts that are to be united by welding. The welding grooves, in the cases where the metal of zone 12 is not weldable, or it is not desired to weld it will be formed in the metal of zone 11 only, in all other cases the grooves may be formed in both of the zones.

The armored article, or its component parts, is then subjected to the hardening treatment. The hardening treatment consists of a heat treatment in which the article, or its component parts, is heated preferably uniformly to the temperature and for the time interval necessary to place the metal in such condition that when cooled at the proper rate the required hardnesses and other characteristics are developed in the hard zone 12 and backing zone 11. When the metal of zone 12 is of the pronounced air hardening type, the hardening treatment will include heating to a selected temperature within the range of 1700° F. to 2200° F. and cooling in air at the proper rate to develop the desired hardnesses in zones 11 and 12. When the metal of zone 12 is not of the pronounced air hardening type the hardening treatment will include heating to a selected temperature within the range of 1500° F. to 2000° F. and quenching in oil of the proper characteristics to develop the desired hardness in zones 11 and 12.

The hardening treatment will usually be followed by a toughening or tempering treatment to reduce the brittleness and increase the toughness of the metal of zones 11 and 12. The toughening treatment may comprise the heating of the metal to a temperature as high as 1200° F. followed by slow cooling, but a temperature of 1000° F. is generally not exceeded. The temperature chosen will be determined by the characteristics of the metals of zones 11 and 12 and the hardness required in zone 12.

The hardened article, or its component parts, after being assembled is then welded and preferably by means of the electric arc. The weld metal deposited to join the edges may be of substantially the same composition as the metal defining the grooves in which it is deposited, or it may be of a different composition. Thus, the weld metal may be of austenitic character. Since the heat generated by the welding operation can have a softening effect on the metal of the hard zone 12 if it is allowed to reach high enough temperatures and remain at such high temperatures for long time intervals, the welding is conducted at high travel rates even if by so doing a greater number of passes is necessary to fill the grooves. By means of this expedient deleterious softening of the metal of zone 12 can effectively be prevented as the welding heat is applied only for short time intervals over any area of the metal and is dissipated before it is again applied.

The welding may be performed in grooves formed only in the metal of zone 11 to produce the welded joint shown in Fig. 1 wherein the weld metal 14 unites the edges of the metal of zone 11, or the welding may be performed in grooves formed in the metal of zone 12 as well as the metal of zone 11 to form the joint shown in Fig. 2 wherein weld metal 14 unites the edges of zone 11 and weld metal 15 unites the edges of zone 12.

As a specific example, armor metal is made having a backing zone 11 composed of 1.25% chromium, 0.5% molybdenum, 0.25% carbon steel and a hard zone 12 composed of 7.5% chromium, 0.5% molybdenum, 0.70% carbon steel. The metal of the hard zone 12 is deposited by the electrical fusion method described above, on the metal of zone 11 which may be in the form of the finished article but is preferably in the form of a thick slab from which the final article may be formed by working operations. When the latter is the case zones 11 and 12 are each made to such thickness that when worked they will be of the required thickness.

After the deposition of the metal of zone 12 the armor metal may be annealed. Annealing is especially desirable as it will prevent cracking and other imperfections from developing when there is a sufficiently long delay between the deposition

of the metal of zone 12 and the working operation, to fully cool the metal. The metal is annealed by heating to a temperature in the range of from 1550° F. to 1600° F. and cooling in the furnace.

The armor metal thus produced, when in the form of a thick billet or slab is ready for conversion, by working operations such as rolling, forging and the like, into metal of the proper thickness for the final article or its component parts. Preparatory to the working operations the metal is heated uniformly to a temperature of about 2150° F. and soaked at this temperature for a time interval, which depends on the thickness of the metal, to render the whole of the metal sufficiently plastic for rolling, forging etc. After the working operation, the worked metal is annealed by heating to a temperature in the range of 1550° to 1600° F. and furnace cooling to ordinary temperatures.

The armor metal worked as just stated, or the armor metal as annealed that does not require working, is then formed into the final article, or its component parts, by machining, roll shaping and like operations. At this time all welding grooves will be formed in the edges to be welded.

The article, or its component parts, is then ready for the hardening heat treatment. This will include a controlled uniform heating to 1800° F. and a holding at this temperature for a sufficient time interval to assure full conversion of the metal of zone 12 to the condition for hardening to the desired degree. This is followed by cooling in air to ordinary temperatures. A holding time of one hour for each inch of thickness of the hard zone will usually be sufficient. After this hardening treatment the article or its component parts may be tempered as found necessary. The tempering temperature will usually be under 1200° F. and preferably in the neighborhood of 1000° F.

The hardened article, or its component parts, is then assembled for welding. The deposition of the weld metal is preferably accomplished by the electric arc, using small electrodes and traversing them at high rates through the grooves so as to minimize the softening effect of the welding heat on the metal of zone 12. The welding may be followed by a stress relief heat treatment. This treatment includes heating to 1000° F. and slow cooling to ordinary temperatures.

The hard face of the article thus produced will have a Brinell hardness of about 550 Brinell; the backing zone 11 will have a hardness of about 275 Brinell. By choosing the proper hardening temperature and cooling rate the hardnesses of zones 11 and 12 may be varied over the range above given, i. e., 400 to 650 Brinell for zone 12 and 200 to 400 Brinell for zone 11.

I claim:

As an article of manufacture a composite steel body including a plurality of superimposed zones united into the integral structure by fusion, one of said zones being of an alloy steel containing from 3% to 20% chromium, molybdenum in effective amounts not exceeding 3%, carbon in effective amounts not exceeding 1.5% and the remainder substantially all iron, another of said zones being of an alloy steel containing about 4.0% nickel, about 1.5% chromium, about 0.15% carbon and the remainder substantially all iron.

ROBERT K. HOPKINS.