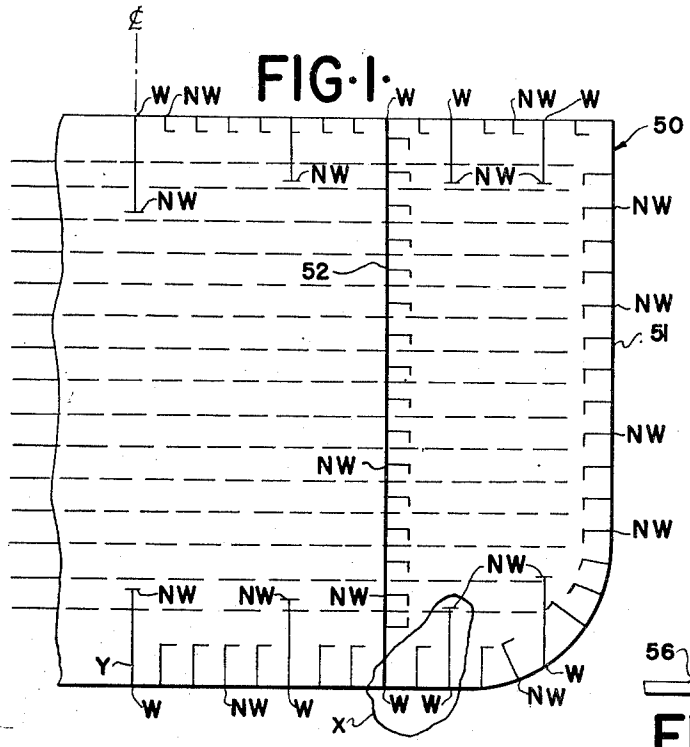
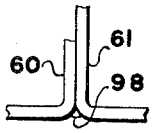
Jan. 29, 1957 J. CUPPLES 2,779,303

SHIP HULL BOTTOM PLATING HAVING INTEGRAL BENT BACK REINFORCEMENT

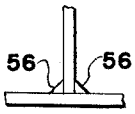
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FIG·1·

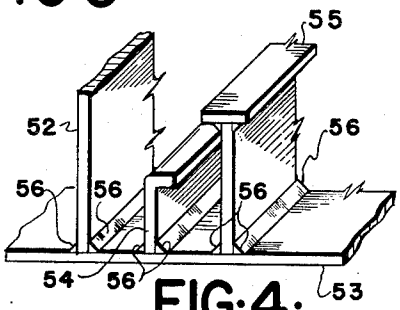




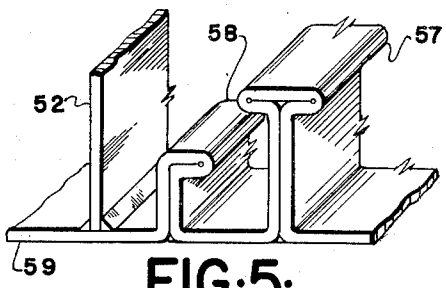
FIG·3·



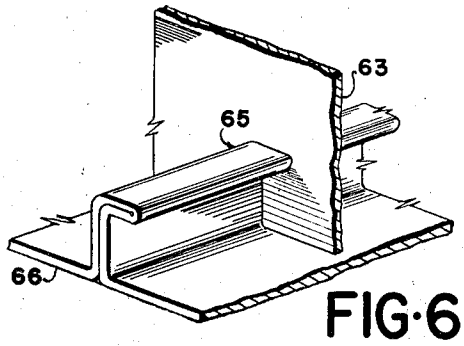
FIG·2·



FIG·4·

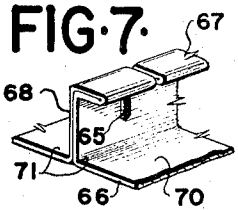


FIG·5·

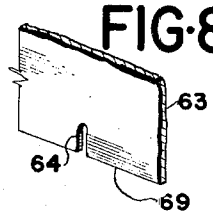


FIG·6·

FIG·7·



FIG·8·



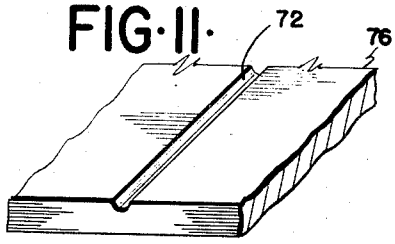
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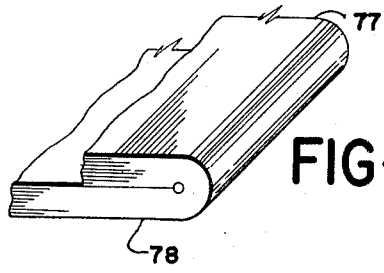
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SHIP HULL BOTTOM PLATING HAVING INTEGRAL BENT BACK REINFORCEMENT

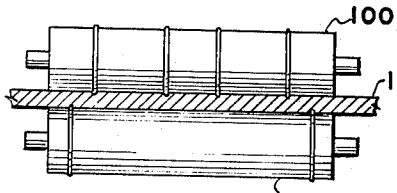
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FIG·11·

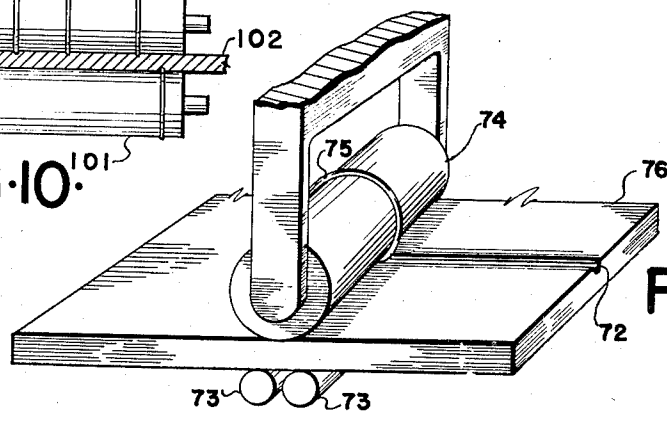




FIG·12·

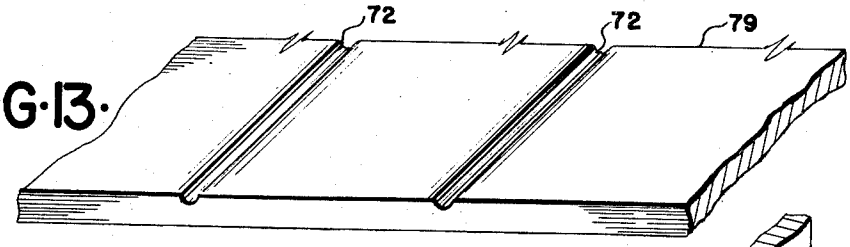


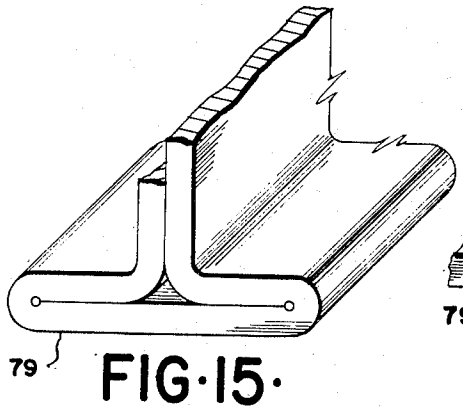
FIG·10·



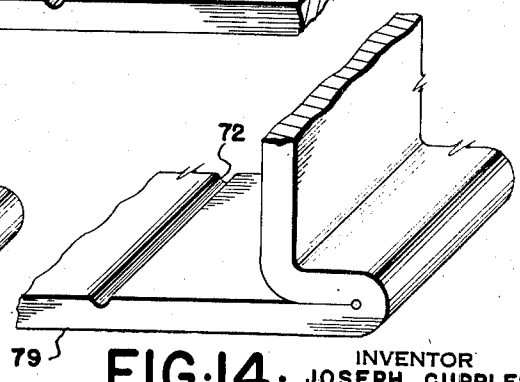
FIG·9·

FIG·13·





FIG·15·



FIG·14·

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United States Patent Office 2,779,303 Patented Jan. 29, 1957

2,779,303

SHIP HULL BOTTOM PLATING HAVING INTEGRAL BENT BACK REINFORCEMENT

Joseph Cupples, Brooklyn, N. Y.

Application September 14, 1950, Serial No. 184,796

3 Claims. (Cl. 114—79)

This invention pertains to a new and useful improvement in the manufacture and production of structural shapes and it is an object of this invention to provide structural shapes fabricated in accordance with this invention which may be used in lieu of the currently employed standard rolled shapes, or may be employed as a structural shape forming an integral part of a plate used in construction work, and in particular where structural shapes are employed in conjunction with metallic flat plates or sheets. The invention also pertains to providing a series of sections supplementary to rolled sections now in use.

Throughout the invention the expression "formed sections" will be used for structural shapes, made in accordance with the invention, in contradistinction to the standard structural rolled shapes. Further, the expression "integral reinforcements" will be used throughout the specification where the stiffening members of a structure, now commonly secured to the plating either by riveting or by welding, can be formed as an integral part of the plating itself, thus eliminating the extra weight due to riveting, or the extra weight of welding metal, either or both or which means may be used for the conformal securing of the plate to the structural shape.

One of the advantages of the invention is that by employing structural shapes as either formed sections, or integral reinforcements, there will be a greater degree of accuracy in the ultimate product since there is a complete elimination of the variations in the thickness of the metal when formed in accordance with the teachings of the present invention.

Among the advantages of the present invention are the following:

To provide a method for executing a 180 deg. "back-upon-itself" bend in plate structures.

To provide an additional series of sections, supplementary to the rolled structural sections at present in use, and having engineering properties of an intermediate nature, thereby providing a more comprehensive and selective choice for engineers and designers.

To reduce weight in metal structures by either eliminating entirely or reducing considerably the necessity for welding and/or riveting.

To eliminate the dangers coincident with objectionable stresses which are induced in steel structures by excessive use of welding.

To eliminate the necessity for stress-relieving in large welded steel structures by reducing the necessity for welding.

To facilitate the sub-assembly phase of construction by making reinforcement members integral parts of the structure, thereby saving time and costs during shipping and at final assembly.

Engineers employing structural shapes fully recognize that variations indesigning and detailing must be kept in mind when employing conventional rolled structural shapes since, in production of the structural shapes, the

roll passes are modified in the wear of the rolls, and the actual dimensions do not always conform to the theoretical, even in the case of minimum weight sections. By using flat plates in forming sections any variation in dimensions of the section can be contained within the rolling limits of the plate.

By employng flat plates or sheets of metal in fabricating the formed sections and integral reinforcements, there is no necessity to be concerned with the thickness of the metal conforming to the theoretical, since flat plates and sheets are made to conform to a thickness of the plate or sheet. This is different than the conformance which would be necessary, for example, in the thickness of the various cross sectional portions of a rolled shape such as an I-beam or a channel.

While the present invention will find application in practically every field where structural shapes are now used, one example of a specific application will be in the construction of ships which will have at least a two-fold purpose, namely, in that in the construction of ships employing partially prefabricated sections, one or more structural shapes which may be alike or dissimilar, can be preformed as an integral part of the flat plate or sheet all of which can be handled at the forming mill where adequate facilities are available instead of trying to use "make shift" methods at the location of assembly of the ships. Further, not only will there be the elimination in engineering over the concern of variation in dimensions of the structural shape for possible reinforcement, but there will be the desired security obtained by practicing the present invention due to the elimination of the vast amount of riveting and welding.

In the practice of naval architecture, and particularly in the design of tanker vessels, any savings in cargo tonnage is a great commercial advantage. The difference between a light ship and a loaded ship, is the cargo capacity of the vessel. The load-water line is always assigned to a vessel and cannot under any circumstances be exceeded without breaching the safety regulations for vessels at sea. However, the light-load line should be as low as possible in order to leave a maximum volume for cargo-carrying capacity. Therefore, whatever is saved in light ship tonnage is gained in cargo tonnage and the economy and profit of this saving is continuously repeated whenever the particular vessel makes a voyage.

By using the present invention with the example of ships, there can be a saving in eliminating the necessity for welding any structural members and a further advantage of elimination of many of the distortions due to stresses within the structure by reason of the intense concentration of the high temperatures required by arc welding.

It will be seen from the specification by comparison between the teaching of the present invention, and the conventional rolled shapes, that much less time will be required at the steel mill to fabricate the formed sections whether individually or as part of a plate, than would be required at the shipyard to weld a similar member to the plating plus the time required originally at the mill to roll the sections.

The invention further contemplates in many instances a means for securing the butt edges of the shaped plates to one another, thereby in certain instances affording a greater saving in weight due to the inherent design of the particular integral reinforcements.

By comparison with the present standards and methods, formed sections and integral reinforcements as set forth herein, are cheaper to manufacture, can be produced faster, are stronger in physical properties, and are better suited for welded and riveted construction than the standard rolled sections.

The present showing are preferred embodiments of the invention but it is to be understood that variations,

changes and modifications may be made without departing from the spirit of the appended claims.

In the drawings:

Fig. 1 is an athwartship elevation of a symmetrical half of a transverse bulkhead of a representative vessel looking aft.

Fig. 2 is a representative section of a conventional welded method of double welding a vertical to a horizontal structural member.

Fig. 3 shows the method employed in the present invention for reproducing a condition similar to that shown in the conventional method shown in Fig. 2.

Fig. 4 is an enlarged view of the section outlined in Fig. 1, indicated by the character X, according to conventional methods.

Fig. 5 is an enlarged view of a section outlined in Fig. 1, indicated by the character X, according to the present invention employing integral reinforcements.

Fig. 6 shows the method of securing the transverse bulkhead to the bottom shell plating.

Fig. 7 is an isolated view of the bottom shell plating shown in Fig. 6.

Fig. 8 is an isolated view of the transverse bulkhead shown in Fig. 6.

Fig. 9 is a view showing a representative method of groove forming in a plate preparatory to bending.

Fig. 10 shows a representative method of multiple grooving a plate.

Fig. 11—the portion of the plate shown in Fig. 9 after the groove forming operation is completed.

Fig. 12 shows the plate presented in Fig. 11 after the 180° bending operation is completed.

Fig. 13 is a plate grooved for double 180° bends.

Figure 14 is the plate shown in Fig. 13 with one of the bends formed at a groove.

Fig. 15 is the plate shown in Fig. 13 with both of the bends completed.

Referring to the drawings, and more particularly to Fig. 1, there is shown a representative athwartship elevation of a symmetrical half of a transverse bulkhead of a representative vessel looking aft wherein the ship **50** has a shell **51** with a longitudinal bulkhead **52** positioned in the ship.

Figs. 4 and 5 are comparative sections, respectively, of the conventional method and the method in accordance with the invention as outlined by the area X of Fig. 1. There is shown the longitudinal bulkhead **52** welded to the bottom shell plating **53** alongside a longitudinal stiffener **54** and a girder **55** all of which are secured to the bottom shell plating **53** by welds **56**.

A comparative structure set up in Fig. 5 shows that the girder portion **57** and the stiffener portion **58** are formed as an integral reinforcement and are part of the bottom shell plating **59**.

Figs. 2 and 3 are fragmentary comparative representations, respectively, of the conventional welded method of double welding a vertical to a horizontal structural member with the similar condition produced in conjunction with the teaching of the present invention wherein portions **60** and **61** abut each other, thereby eliminating the double welds shown at **56** in Fig. 2. The joining seam may be caulked, to prevent corrosion, shown as **98** in Fig. 3.

Figs. 6, 7, and 8 show the transverse bulkhead **63** having a notch or slot **64** formed therein so that said transverse bulkhead slot may be fitted into the slot **65** formed in the integral reinforcement bottom shell plating **66**, with the slot **65** being formed the full width of the flange **67** and partially in the web **68** so that the edge **69** may come flush on the inner surface of the bottom shell plating **70** since the open corners where the slot **64** engages the edge **69** are rounded to fit the curved area **71** of the bottom shell plating.

In Figs. 11 to 15 inclusive, there is shown the progressive steps in making the formed sections and integral reinforcements whereby longitudinal grooves such as **72** are formed on either one or both sides of the plate, in separate steps, or in compound operation depending on the necessary requirements of the particular formed section or integral reinforcements in process of fabrication.

Opposing rollers **73** may be rotatably mounted in the groove forming machine with the groove roller **74** having a pre-shaped annular flange **75**, as part thereof, to form a groove **72**. The plate **76** may have the area to be grooved preheated, or the plate **76** may be rolled cold depending on the dimensions and physical properties of the plate **76**

By utilizing the grooves **72** as set forth herein, a 180° bend may be formed in a plate as shown in Fig. 11, resulting from the groove being formed in the plate **102** of Fig. 10. The reduction of metal by the grooving process, whether the groove be formed by rolling as shown in Fig. 9, or by a cutter wherein the metal is actually removed rather than deformed, permits the 180° bend to be made by a rolling operation so that the surfaces **77** and **78** may be substantially parallel, which would not be the case if the groove were not formed in the plate or sheet **76**.

In order to hold the reduction in area of section through the bending plane to an absolute minimum it is suggested that the radius of the semi-circular area removed from the plate before bending be as small as possible and still permit the desired result. Since the neutral axis of the plate lies somewhere within the inner half-thickness of the material, the radius of the semi-circular section should not exceed one-half of this half-thickness. If radius equals the distance from the inner surface to the neutral axis then all of the fibers subjected to the forces of compression in the critical area will have been removed in the process and the intended purpose will have been entirely exceeded. In conclusion, then, the radius of groove **72** should in no case be greater than 25% of the thickness of the plate.

Figs. 13 and 14 are representative of progressive steps in forming opposing 180° bends in a plate **79** after the pair of grooves **72** are formed in the plate shown in Fig. 10 by using a dual groove forming roller, or by using a similar groove forming roller with two passes through the grooving machine as set forth in Fig. 9.

It is to be understood that according to the basic teaching presented in the invention of groove forming to provide integral reinforcements and formed sections, the groove forming machine may have any desired number of groove forming portions on a single roller or separate rollers may be provided which may be deposited for the particular section to be formed on either or both sides of a particular metallic plate or sheet.

In all instances, of both the formed sections and integral reinforcements, the 180° back-upon-itself bend can be provided by a simple or compound rolling operation whereby any apparent distortion which would prevent parallel surfaces such as **77** and **78** of Fig. 12, will be eliminated.

In Fig. 10 the rollers **100** and **101** show the multiple annular portions for simultaneously forming a multiplicity of grooves in a plate **102**.

The bend test specimens for bars and shapes is quite well standardized and include that the bars and shapes shall stand being bent cold through 180° without cracking on the outside of the bent portion. Ordinarily for material ¾" or under it shall be bent back upon itself without cracking while material from ¾" to and including 1½" in thickness shall be bent around a pin the diameter of which is equal to the thickness of the specimen. Since the bend test mentioned above refers to bending cold the material through 180° without fracture, then certainly a preheated plate can be bent back upon itself without any adverse effects.

When a metal is subjected to heat its molecular struc-

ture is thereby rendered sufficiently fluid to permit the shape to be easily altered. Referring to the "back upon itself" bend shown in Fig. 12, it may be said that while the fibers on the outside of the bend may be in tension those on the inside will be in compression. The physical interference of these elements coming to bear upon each other can be overcome by removing some of them entirely from the critical area thereby providing space in which other fibers can re-align themselves and thus relieve the induced forces of compression. If a semi-circular area of ⅛ inch radius is removed from one surface of the plate at the bending plane the reduction in area of section will only be 0.025 sq. inch. This is, for material of 1¼" thickness, a negligible amount which is of very little importance to the strength of the member. If now the plate is bent "back upon itself" this open area of 0.025 sq. inch will, theoretically, be distributed throughout a small complete circle of radius equal to 0.09 inch. In effect this provides a circle of approximately 3/16 of an inch diameter in which the compressed fibers can redistribute themselves and thus relieve the most severe compressive forces.

In view of the foregoing, it will be seen that by following the teachings of the present invention not only is it possible to make formed sections comparable to the conventional rolled sections but that many other derivatives are possible in structural shapes, regardless of whether they are formed sections or integral reinforcements.

There exists at present an enormous capital investment in machinery and methods for manufacturing rolled sections and it is not the intention to wish to eliminate this by substituting formed sections. The intention is rather to supplement rolled sections by offering to industry a form more easily and more economically manufactured from standard flat plates or sheets. This new form contains many advantages in physical properties, as we shall see, and its addition to the list of standard rolled sections will afford a much wider selective choice for engineers and designers.

During the recent war years when precious time and material were being allocated to effect maximum results the office of production management, in the interests of maximum steel mill production and the conservation of available steel supply, suspended the manufacture of many rolled steel sections as being non-essential and wisely diverted the materials to other uses. Formed sections manufactured out of standard rolled plate could have been an ideal substitute in such an emergency.

In longitudinally framed vessels the longitudinal structural members secured to the shell-plating must increase in sectional area as we proceed from the deck-edge down past the bilge-turn and along the bottom shell to the docking girder. Present practice is to use standard rolled angle progressively up to 8" x 8" which is the largest size rolled. Where greater sections are required flat plate is cut and bent in a flanging machine to a 90 deg. right angle shape. In short, rolled angle sections are supplemented with flanged plate sections. The intention in these notes is to supplement all rolled sections, I beam, H beams, channels, angles, T's, bulb angles, Z's, with formed sections.

Although steel plate is used as the basis for all calculations contained here the idea is much broader than this and must include other metals and alloys as well as other materials such as plastic products, etc.

The present-day practice of welded structural members has effected a considerable saving in weight over riveted structural members. The use of integral reinforcements can effect a further saving by eliminating the necessity for welding many structural members. Not only will the weight of weld metal be saved but a further advantage will be elimination of many of the distortions due to stresses set up within the structure by reason of the intense concentration of the high temperatures required by arc welding. A further advantage is that this is an

important step in the trend toward prefabrication of assemblies and as such will be the means of effecting a considerable saving of time. Much less time will be required at the steel mill to form the reinforcement within the plate than would be required at the shipyard to weld a similar member to the plating plus the time required originally at the mill to roll the section.

The following situation should be readily visualized: A vessel is in the process of design. The naval architects make up their drawings as at present showing welded stiffening members. As the structural drawings are completed they are submitted to the steel-mill for the purpose of ordering material. The engineers at the mill can easily substitute for the welded members shown on the drawings suitable and equivalent integral reinforcements. The plates are prepared at the mill and shipped to the building site ready for immediately assembly; the only additional requirement being to secure the butt edges of the prepared plates to each other.

The idea can no doubt be extended to other fields, particularly in the mass production of similar units. For example, in automobile body work and chassis fabrication where a saving in weight would mean greater economy in fuel consumption.

From the foregoing it will be observed that in accordance with the present invention it is possible to provide all of the existing structural shapes as part of integral reinforcements. Further, many variations are possible with the present invention so that structural shapes may be provided in accordance with the engineering design as it advances in demand.

Not only does the present invention provide equivalent shapes to those presently used but permits a great saving in labor at the mill and in labor of assembly and construction in the field.

By employing the teachings set forth herein prefabrication of many designs will be possible, and as was previously pointed out by way of example, will have a special application in relation to ship construction. In this latter field, the integral reinforcements may be provided from large plates and may not only include the structural shapes, but may also take advantage of the fact that the plate itself may be curved, angled or bent in any shape or conformation depending on the requirement of the engineer.

An extremely wide latitude in fabricating formed sections and integral reinforcements is possible by the teachings of the present invention.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. In a ship hull construction, a bottom shell plating having an integral longitudinal-extending structural stiffening portion formed of the plating bent back upon itself interior of the hull and providing vertical abutting surfaces lying in the outer side of the plating, said structural portion being further bent to provide a web and flange running coextensively of the plating, said structural portion having a slot through the flange and extending partially down through the web transversely thereof, and a bulkhead extending transversely through the structural portion and having a slot in its lower edge fitted in said slot in the structural portion and receiving the remainder of the web.

2. In a ship hull construction as defined in claim 1, and said web affording curved areas at the inward bends of the structural portion and said open edge slot in the bulkhead being rounded at the opposite sides to fit the curved areas whereby the lower edge of the bulkhead may be bottomed flush upon the shell plating.

3. In a ship hull construction as defined in claim 1, and said structural portion having opposing outer curved areas below the abutting surfaces thereof, and closure material extending therebetween.

(References on following page)

References Cited in the file of this patent

UNITED STATES PATENTS

496,465	White	May 2, 1893
739,650	Clutter	Sept. 22, 1903
831,755	Vietor et al.	Sept. 25, 1906
1,429,400	Bloedow et al.	Sept. 19, 1922
1,508,743	Polis	Sept. 16, 1924
1,578,416	Frease	Mar. 30, 1926
1,605,513	Connery	Nov. 2, 1926
1,760,332	Wibault	May 27, 1930
1,772,694	White	Aug. 12, 1930
1,940,830	Weyerbacher	Dec. 26, 1933
2,007,354	Vass	July 9, 1935
2,244,847	Oeckl et al.	June 10, 1941
2,245,690	Krueger	June 17, 1941

FOREIGN PATENTS

548,572	Great Britain	Oct. 15, 1942
932,743	France	Dec. 1, 1947
932,820	France	Dec. 1, 1947