

PATENT SPECIFICATION

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DRAWINGS ATTACHED.

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COMPLETE SPECIFICATION.

Improvements in and relating to Welding.

We, UNION CARBIDE CORPORATION, of 270 Park Avenue, New York, State of New York, United States of America, a Corporation organised under the laws of the State of New York, United States of America, (Assignee of John Peter Sachs, Howard Edward Kasting and Alvin Ernest Ericson), do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a method and apparatus for welding a plurality of superimposed plies of thermoplastic film of relatively heavy cross-section under heat and pressure to obtain stronger and more uniform joints, and more particularly, to lap welding a selected number of plies of polyethylene film and/or sheet.

The primary object of the invention is to provide a method of and means for joining multiple layers of thermoplastic film with a uniformly strong, controlled lap weld of different total thicknesses in a single operation.

Strong, uniform heat seals are difficult to make in heavy gauge thermoplastic film, such as 4 mil to 11 mil polyethylene. Such film is considerably stiffer than 1 mil to 3 mil film material, commonly used for producing bags, garment bags, etc. A heat-seal joint between thermoplastic film plies is considered of optimum strength when the yield strength of the seal exceeds the yield strength of the individual parent film plies. Optimum heat-seal strength is obtained in an elongate welded lapped joint of thick polyolefin films such as polyethylene, when optimum temperature and sealing pressure are uniformly transmitted along the extent of the seal area and are maintained for an optimum sealing time interval.

Optimum sealing pressure is that which is sufficient to ensure intimate contact of the film plies at their interface, and which provides sufficient force to fuse the softened thermoplastic. Thus, according to the invention, the film plies are clamped flat before sealing. The sealing temperature and pressure are, at the same time, kept to optimum values to produce uniformly strong welds.

To obtain a uniformly strong weld or seal, we have found that a uniform pressure should be applied to the film plies adjacent the weld and maintained for a selected interval of time after removal of the weld heat, to prevent springback and permit the material in the weld to cool and consolidate the film plies.

In making a bottom closure in a shipping bag of heavy gauge thermoplastic film, the shipping bag bottom is preferably formed without creasing the flap folds, and the heat-seal joints are lapped and formed to transmit the filled bag stresses to the heat seal in shear.

Without hard creases defining the folds during the forming of the closure, the thick film plies tend to spring back, bulge and do not always lie completely flat at the fold edges. In such cases, the film plies may be locally separated at the interface of the desired weld or may be spaced from the welding backup surface. Thus, when a narrow elongated heat-sealing bar having transverse and/or branched surfaces is advanced toward the film flaps to make the desired lap weld joint in the bag bottom, the sealing surfaces initially contact those portions of the film surface which bulge upwardly and thus penetrate deeply into the top ply of film, resulting in localized weak and ineffective seal areas. Therefore, it is desirable to control springback as well as a flat co-

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planar condition of the thick film plies comprising the interfolded bag bottom, before the weld is made.

5 The present invention provides several steps for improving the efficiency of lap welding a pile of thermoplastic films. These steps are enumerated below for later references as follows:—

10 Positive pressure clamping of a plurality of film plies to flatten them against a flat resilient backup surface in an area immediately bordering welds to be made therein, and to ensure intimate contact of the individual film plies and uniform contact of the

15 sealing bar at the weld interface.
Gauging the average thickness of the pile of film plies from a clamping platen, and thereby accurately controlling the penetration of a welding member into a pile of film

20 plies.
Controlling or regulating heat-shrink effects by confining and thereby isolating tension and/or bending stresses in the film plies in the weld area.

25 Controlling the area of fusion zone in a plurality of extended, branched line lap welds made on a pile of thermoplastic films.

Individually controlling the depth of penetration of a plurality of welding surfaces into a pile composed of a different

30 number of film plies.
Accordingly, the present invention provides a method for welding a plurality of superimposed plies of thermoplastic film, which comprises positioning the plies on a supporting surface, compressing between

35 said supporting surface and a clamping surface the area of said plies surrounding the area of the weld, bringing a heat sealing surface into contact with said weld area and into the combined thickness of the plies to a predetermined depth, welding said

40 plies while simultaneously cooling the clamping surface, first withdrawing the hot sealing surface from the resulting weld and then releasing the compression by withdrawing the clamping surface from the plies.

45 The present invention also provides an apparatus for carrying out the method of welding a plurality of superimposed plies of thermoplastic film, which comprises a

50 base member having a flat supporting surface for the plies, a vertically movable clamping platen co-operating with the base member for compressing the plies, said

55 platen having an elongated narrow aperture for passage therethrough of the heat sealing element of a vertically movable heat sealing member, said heat sealing member being provided with a heater element and with a

60 plurality of machined shoulders equidistant from the axis of said member and equally spaced from the heat-sealing element, while the platen is provided with passageways for

65 cooling fluid and with a plurality of tapped

holes for receiving a plurality of screws adjustable to engage and stop the shoulders of the heat-sealing member and so thereby limit the penetration of the heat-sealing surface into the plies.

Clamping a pile of film plies adjacent the desired weld areas flat against a resilient backup surface, and accurately limiting the depth of penetration of the heat-sealing surfaces, respectively, into a plurality of plies while the weld is made, permit using higher temperatures at the surfaces of the sealing bar and shorter seal cycle and more uniform welds. This method is particularly useful for heat-sealing bioriented thermoplastic films which have a high shrink factor at fusing temperature.

The present method of clamping, welding and cooling a varying number of plies of thermoplastic film to form a strong bag closure, employs an independently operated and sequenced flattening platen and a heat-sealing bar; and reciprocating means for applying pressure to the film plies interposed between them and a resilient pressure surface. A flat clamping-gauging platen is composed of metal of high heat conductivity, such as aluminium or brass, and is operated to advance and retract from the pile of film plies. Openings in the platen permit parts of an independently operated heat-seal bar to advance therethrough to the flattened film surfaces. The top of the platen is provided with adjustable stops to gauge and limit penetration of the welding surface into the film plies.

The clamping platen is also provided with circulating water passages to remove heat therefrom and thereby confine the fusion zone to a desired weld area and speed consolidation of the plies at the weld. The platen is retracted from the surface of the film plies after the sealing bar is removed therefrom to avoid springback as well as to provide the time lag and thermal capacity necessary to consolidate, i.e., weld the film plies together.

The sealing bar is of the heated type, composed of metal with a high heat conductivity, such as aluminium or brass. The clamping platen surface is preferably spaced as closely as possible to the heat-seal bar extremities to clamp the film plies about substantially the entire periphery of the weld area. However, where film tension effects are minimal, such as at the end portions of extremely elongate weld areas, the clamping means need not circumscribe the narrow portion of the weld area.

A pressure is applied to the surface of the film plies by the clamping platen that is at least sufficient to obtain desired flattening against the pressure surface. Strong uniform film welds are obtained when stops on the top of the platen are adjusted to

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limit the penetration of the co-operating seal bar surfaces to obtain the strongest possible weld.

The area of the weld is supported by a base surface which is covered with a resilient cushion material, such as rubber. Satisfactory welds, however, may be made through a different number of film plies supported on a nonresilient base surface by appropriately machining the co-operating surface areas of the platen to compensate for the difference in film thicknesses.

When an extended area of weld is made through a different number of film plies, the resilient surface may be appropriately elevated by an underlay at respective areas of lesser film thickness, and/or the respective heat-sealing surface areas may be machined to compensate for uniform weld penetration in the differing number of plies, as later described.

This invention is particularly useful for making strong, uniform welds in the end closure of polyethylene shipping bags. When forming the end closure of such shipping bags without using the method and apparatus of the present invention, it was difficult to control the plies, and the seal of the closure frequently puckered up. When the heat-seal bar was withdrawn, the seal weld was in a softened state for a greater time interval and was more sensitive to residual bulges in the film plies of the closure. This adversely affected the uniformity of the filled bag from shipping or handling stresses imposed on the closure.

However, when bag end closures are made according to the present invention, good uniformity in heat-seals are obtained even in the layers of film plies, such as polyethylene, which vary in total thickness from 8 to 34 mils. The clamping apparatus ensures flattening the plies against the resilient surface and maintains the plies flat, counteracting spring-back while the weld cools. The heat-absorbing capacity of the clamping platen also assists in compensating for any thermal inequality needed for welding a selected number of plies. This combination results in a stronger and more uniform heat-seal across the entire bag end closure.

The bag bottom is made in several steps. In a blanking operation, side flaps and end flaps are formed by slitting. The end flaps and side flaps are later interfolded and welded into an overlapped joint which is coextensive with the bag width. In such bottom closure, branch seals are angularly disposed to the coextensive joint to impart a siftproof quality to the closure. For operating efficiency, it is desirable that the coextensive seal and branch seals be made in a single operation against a backup

platen located in the interior of the bag bottom.

The sealing of the bottom closure in a polyethylene bag made of 4 to 11 mil film, formerly required five separate sealing operations. Each individual seal was made with an impulse sealer and required a sealing cycle of about 7 seconds. With the present new method, however, the heat-sealing bar when used with polyethylene film of a density of from 0.910 to 0.925 for example, is maintained at a constant temperature of from 575° to 775° F., and yields satisfactory welds in one operation for a total cycle time of less than 2 seconds.

The method of the present invention is especially useful in the welding of highly oriented or bioriented polyethylene films and other oriented or bioriented polyolefin films including polyethylene copolymers, polypropylene, copolymers of ethylene and propylene and mixtures of polyethylene and polypropylene which are extremely difficult to weld because of heat shrink effects in the parent film immediately adjacent to the weld area.

The new method also makes possible the production of uniform welds that are continuous or discontinuous, and of complex shape, and in one operation forms a closure even in a relatively heavy wall plastic bag.

In the accompanying drawings:—

Fig. 1 is a fragmentary perspective view of an apparatus embodying the invention;

Fig. 2 is an enlarged fragmentary view in cross-section taken on line 2—2 of Fig. 1;

Fig. 3 is an enlarged fragmentary view in cross-section of the sealing bar and platen contacting the film plies on a resilient surface;

Fig. 4 is a schematic cross-sectional view of one arrangement of heat-seal surfaces welding varying numbers and thicknesses of film plies;

Fig. 5 is a fragmentary cross-sectional view of another arrangement of heat-seal surfaces welding varying numbers and thicknesses of film plies;

Fig. 6 is a bottom view of a heat-seal bar of an embodiment having two parallel and one or more branched sealing surfaces;

Fig. 7 is a fragmentary perspective view of the clamping platen;

Fig. 8 is a fragmentary perspective view of an inverted portion of another embodiment of the heat-seal bar having separately operable sections;

Referring to Fig. 1, a heat-seal bar 12 is mounted on blocks 14 connected by shafts 16 to pneumatic cylinders (not shown) that advance and retract bar 12 toward a bag bottom 10 to be sealed. Bar 12 is provided with a longitudinal hole 17 to receive an electrical resistance heater element 18. The upper part of the bar 12 has a plurality of

deep grooves 20 therein. The bar shape acts to distribute and balance heat energy from heater element 18 conducted through the metal of the bar to sealing surfaces 26, 26¹. Sealing bar 12 has a plurality of machined shoulders 28, equidistant from the centerline of the bar 12 and accurately and equally spaced from sealing surfaces 26, 26¹.

Clamping platen 30, Fig. 1 and 2, is advanced and retracted toward the backup surface of base 32 of the machine by shafts 33 connected to additional pneumatic cylinders (not shown). A resilient member or cushion 34 is mounted on such surface which is flat. Such member 34 is composed of solid rubber of 20° to 30° Shore Durometer, which in turn, supports the thermoplastic film bag bottom 10 in position for the clamping and sealing operation.

In the sealing operation, the folded bottom of the bag is positioned under platen 30 which is then advanced to engage the film upper ply 38, flatten it against lower film ply 36 and the surface of resilient member 34, thereby clamping and compressing it on the surface of machine base 32. Clamping platen 30 has slots 40, 40¹ which provide a passage for sealing surfaces 26, 26¹ of sealing bar 12 centrally through each slot. Platen 30 also has grooves 42 equally spaced from slots 40, 40¹ to retain water-circulating tubing 44, which is pressed therein and provides cooling means for said platen.

Platen 30 is provided with a plurality of tapped holes 46 adjacent slots 40, 40¹ to receive adjustment screws 48. Adjustment screws 48 are adjusted and locked to stop shoulders 28 to limit the advance of sealing surfaces 26, 26¹ with respect to the under surface of platen 30, and thereby control melt penetration into the surface of film ply 38. The depth of sealing surface penetration in combination with the cooling effect of the walls of slots 40, 40¹, controls and limits the fused film zones 50 of film plies 38 and 36. The sealing bar 12 is retracted from the weld surface while clamping platen 30 continues to clamp the plies of film and chill the fused film zones 50, thus permitting a clean stripping of the sealing surfaces 26, 26¹ from the film weld.

Using the method of the present invention, it has been possible to weld two- and three-ply thicknesses of 10 mil polyethylene film into lap joints having satisfactory seal strength in 1-½ seconds.

Referring now to Fig. 3, which shows an embodiment of a preferred relationship of clamping platen 30, sealing surface 26 and resilient pressure member 34, "X" represents the combined thickness of polyethylene film plies to be welded. Width of sealing surface 26 is greater than "4X" and the

space 76 between the side walls of surface 26 and slot 40 of clamping platen 30 is less than "3X". Resilient cushion 34 is rubber of 25° to 35° Shore Durometer and of a thickness "Z", such as 0.2 to 6 "X". Sealing surface 26 is maintained at a temperature of the order of 725° F. heat by resistance heater 18, and depth of penetration into the film plies is set to ¼ to ¾ "X" by adjusting stop screws 48 mounted in platen 30 when clamping pressure on the film plies is set at 2 to 4 p.s.i.

When it is desirable that a zone 50 of a composite weld, Fig. 4, be heat-sealed through a greater number of film plies than another zone 50¹ of said weld, the heat-sealing surface 26 of zone 50 may be machined an amount "D" equal to ¼ to ¾ the difference in thickness between the greater and lesser number of plies, so that heat-sealing surface 26, when limited by flat platen 30 clamping the pile of plies, will still penetrate into the plies a depth of from ¼ to ¾ of the combined thickness of said plies.

In an alternate method, shown in Fig. 5, when a zone 50 of a composite weld is to be heat-sealed through a greater number of film plies than another zone 50¹ of said weld, zone 50¹ may be elevated by underlaying it with ply(s) 39 of a thickness "D" equal to ¼ to ¾ of the difference in thickness between the greater and lesser number of plies.

Fig. 6 shows a composite branched, parallel line heat-sealing member comprising separately mounted middle section 12 and end sections 13 and 13¹ that may be used to make the closure for a bag bottom. Such a bag closure may require a welding construction made up of as many as 10 separate heat-sealing surfaces. In this embodiment, heat-sealing surfaces 60, 60¹ are disposed in section 12 to make parallel welds in *two plies* of film. Heat-sealing surfaces 62, 62¹ and 66, 66¹ are disposed in sections 13 and 13¹, respectively, to make parallel welds in *three plies* of film. Heat-sealing surfaces 64, 64¹ and 68, 68¹ are disposed as branches at the extremities of section 12, respectively, to make branched welds in *two plies* of film and thereby to provide a sift-proof bag bottom.

Fig. 7 shows a portion of clamping platen 30 that is slotted to co-operate with the heat-sealing member of Fig. 6. Parallel slots 40, 40¹ are respectively spaced to provide a passage for sealing surfaces 60, 60¹ and 62, 62¹ of Fig. 6, centrally therethrough. Likewise, branched slots 72, 72¹ are positioned to provide a passage for sealing surfaces 64, 64¹ centrally therethrough.

Fig. 8 shows, upside down, a portion of an embodiment of the composite branched, parallel line heat-sealing member shown in Fig. 6 with separately mounted middle section 12 and end section 13. Sections 12 and 130

13 of the composite heat-sealing member are advanced to the film surface by resilient reciprocating means. When sections 12, 13 are advanced, adjustable stop pins mounted on each section engage the top surface of platen 30 and thereby independently regulate the respective penetration of each sealing section into the film plies.

Section 12 is provided with parallel sealing surfaces 60, 60¹ and branched sealing surfaces 64, 64¹ that are regulated to penetrate *two film plies* by engagement of adjustable pins 80, 82 with the top surface of clamping platen 30. Section 13 is provided with parallel sealing surfaces 62, 62¹ that are regulated to penetrate *three film plies* by engagement of adjustable pins 84, 86 with the top surface of clamping platen 30.

The embodiment of the heat-sealing member shown in Fig. 4, is preferred for making a uniform strength weld construction in a single operation in an extended bag closure, having in its length a varying number of film plies, by providing regulated penetration of the sealing surfaces according to the number of plies under the respective surface area.

While the present invention is highly advantageous in the sealing of heavy gauge films, it is not restricted thereto being also suitable for thinner as well as thicker material.

WHAT WE CLAIM IS:—

1. A method for welding a plurality of superimposed plies of thermoplastic film, which comprises positioning the plies on a supporting surface, compressing between said supporting surface and a clamping surface the area of said plies surrounding the area of the weld, bringing a heat-sealing surface into contact with said weld area and into the combined thickness of the plies to a predetermined depth, welding said plies while simultaneously cooling the clamping surface, first withdrawing the hot sealing surface from the resulting weld and then releasing the compression by withdrawing the clamping surface from the plies.

2. A method as claimed in Claim 1, in which the heat-sealing surface penetrates into the plies to a depth of from one-third to two-thirds of the combined thickness of the plies to be welded.

3. A method as claimed in Claims 1 or 2, in which two superimposed plies of thermoplastic film are welded.

4. A method as claimed in Claims 1 or 2, in which three superimposed plies of thermoplastic film are welded.

5. A method as claimed in Claims 1 to 4, in which a plurality of welds are made simultaneously by a plurality of hot sealing surfaces.

6. A method as claimed in Claim 5, in which a plurality of welds are made simultaneously by a plurality of hot sealing surfaces through different numbers of plies, the heat-sealing surface or surfaces for the weld area or areas of the greater number of plies being advanced through a distance of one-third to two-thirds of the difference in thickness of the greater and lesser number of plies when brought into contact with said weld area or areas and penetrating into the plies a depth of from one-third to two-thirds of the combined thickness thereof.

7. A method as claimed in Claim 5, in which a plurality of welds are made simultaneously by a plurality of heat-sealing surfaces through different numbers of plies, the weld area or areas of the lesser number of plies being elevated from the supporting surface a distance of one-third two two-thirds of the difference in thickness of the greater and lesser number of plies.

8. A method for welding a plurality of superimposed plies of thermoplastic film, substantially as hereinbefore described with reference to Figs. 3 to 5 of the accompanying drawings.

9. An apparatus for carrying out the method of welding a plurality of superimposed plies of thermoplastic film as claimed in any one of Claims 1 to 8, which comprises a base member having a flat supporting surface for the plies, a vertically movable clamping platen co-operating with the base member for compressing the plies, said platen having an elongated narrow aperture for passage therethrough of the heat-sealing element of a vertically movable heat-sealing member, said heat-sealing member being provided with a heater element and with a plurality of machined shoulders equidistant from the axis of said member and equally spaced from the heat-sealing element, while the platen is provided with passageways for cooling fluid and with a plurality of tapped holes for receiving a plurality of screws adjustable to engage and stop the shoulders of the heat sealing member and to thereby limit the penetration of the heat-sealing surface into the plies.

10. An apparatus as claimed in Claim 9, in which the flat supporting surface of the base member is provided with a cushion of resilient material for supporting the plies.

11. An apparatus as claimed in Claims 9 or 10, in which the heat-sealing member comprises a plurality of separate sections, each of said sections comprising a plurality of heat-sealing elements.

12. An apparatus as claimed in Claim 11, in which the heat-sealing elements are disposed in each of the sections in parallel or in branched relationship, respectively.

13. An apparatus as claimed in Claims 11 or 12, in which the platen is provided with



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13 of the composite heat-sealing member are advanced to the film surface by resilient reciprocating means. When sections 12, 13 are advanced, adjustable stop pins mounted on each section engage the top surface of platen 30 and thereby independently regulate the respective penetration of each sealing section into the film plies.

10 Section 12 is provided with parallel sealing surfaces 60, 60¹ and branched sealing surfaces 64, 64¹ that are regulated to penetrate *two film plies* by engagement of adjustable pins 80, 82 with the top surface of clamping platen 30. Section 13 is provided
15 with parallel sealing surfaces 62, 62¹ that are regulated to penetrate *three film plies* by engagement of adjustable pins 84, 86 with the top surface of clamping platen 30.

20 The embodiment of the heat-sealing member shown in Fig. 4, is preferred for making a uniform strength weld construction in a single operation in an extended bag closure, having in its length a varying number of film plies, by providing regulated penetration of the sealing surfaces according to the
25 number of plies under the respective surface area.

30 While the present invention is highly advantageous in the sealing of heavy gauge films, it is not restricted thereto being also suitable for thinner as well as thicker material.

WHAT WE CLAIM IS:—

35 1. A method for welding a plurality of superimposed plies of thermoplastic film, which comprises positioning the plies on a supporting surface, compressing between said supporting surface and a clamping surface the area of said plies surrounding the
40 area of the weld, bringing a heat-sealing surface into contact with said weld area and into the combined thickness of the plies to a predetermined depth, welding said plies while simultaneously cooling the clamping
45 surface, first withdrawing the hot sealing surface from the resulting weld and then releasing the compression by withdrawing the clamping surface from the plies.

50 2. A method as claimed in Claim 1, in which the heat-sealing surface penetrates into the plies to a depth of from one-third to two-thirds of the combined thickness of the plies to be welded.

55 3. A method as claimed in Claims 1 or 2, in which two superimposed plies of thermoplastic film are welded.

60 4. A method as claimed in Claims 1 or 2, in which three superimposed plies of thermoplastic film are welded.

5. A method as claimed in Claims 1 to 4, in which a plurality of welds are made simultaneously by a plurality of hot sealing surfaces.

6. A method as claimed in Claim 5, in which a plurality of welds are made simultaneously by a plurality of hot sealing surfaces through different numbers of plies, the heat-sealing surface or surfaces for the weld area or areas of the greater number of plies being advanced through a distance of one-third to two-thirds of the difference in thickness of the greater and lesser number of plies when brought into contact with said weld area or areas and penetrating into the plies a depth of from one-third to two-thirds of the combined thickness thereof.

7. A method as claimed in Claim 5, in which a plurality of welds are made simultaneously by a plurality of heat-sealing surfaces through different numbers of plies, the weld area or areas of the lesser number of plies being elevated from the supporting surface a distance of one-third to two-thirds of the difference in thickness of the greater and lesser number of plies.

8. A method for welding a plurality of superimposed plies of thermoplastic film, substantially as hereinbefore described with reference to Figs. 3 to 5 of the accompanying drawings.

9. An apparatus for carrying out the method of welding a plurality of superimposed plies of thermoplastic film as claimed in any one of Claims 1 to 8, which comprises a base member having a flat supporting surface for the plies, a vertically movable clamping platen co-operating with the base member for compressing the plies, said platen having an elongated narrow aperture for passage therethrough of the heat-sealing element of a vertically movable heat-sealing member, said heat-sealing member being provided with a heater element and with a plurality of machined shoulders equidistant from the axis of said member and equally spaced from the heat-sealing element, while the platen is provided with passageways for cooling fluid and with a plurality of tapped holes for receiving a plurality of screws adjustable to engage and stop the shoulders of the heat sealing member and to thereby limit the penetration of the heat-sealing surface into the plies.

10. An apparatus as claimed in Claim 9, in which the flat supporting surface of the base member is provided with a cushion of resilient material for supporting the plies.

11. An apparatus as claimed in Claims 9 or 10, in which the heat-sealing member comprises a plurality of separate sections, each of said sections comprising a plurality of heat-sealing elements.

12. An apparatus as claimed in Claim 11, in which the heat-sealing elements are disposed in each of the sections in parallel or in branched relationship, respectively.

13. An apparatus as claimed in Claims 11 or 12, in which the platen is provided with

a plurality of apertures disposed in parallel or in branched relationship, respectively, for passage therethrough of the heat-sealing elements

- 5 14. An apparatus as claimed in any one of Claims 11 to 14, in which each of the sections is provided with adjustable stop pins adapted to engage the upper surface of the platen.

15. An apparatus for welding a plurality 10 of superimposed plies of thermoplastic film, substantially as hereinbefore described and shown in Figs. 1, 2 and 6 to 8 of the accompanying drawings.

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