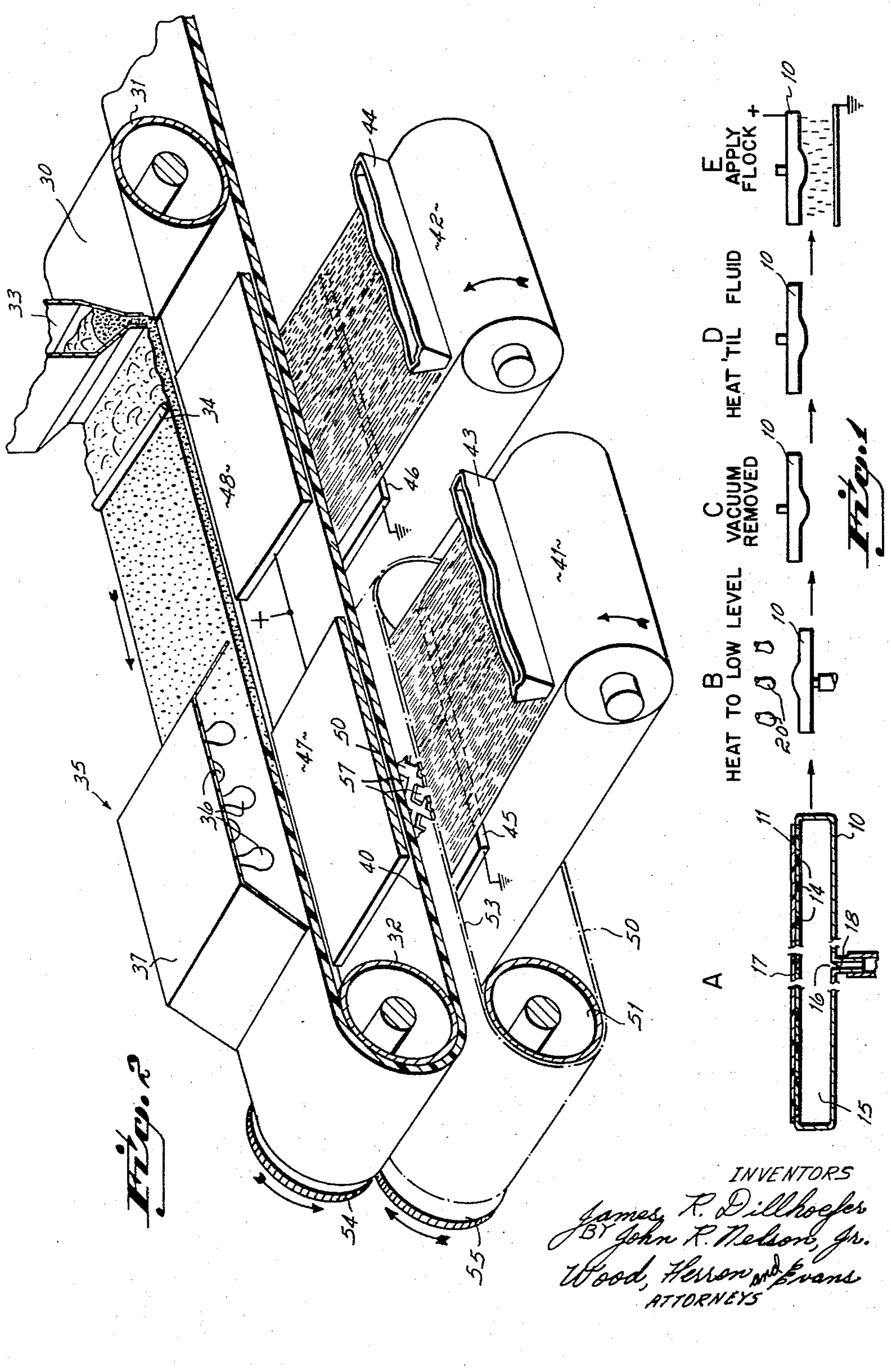
Jan. 30, 1968 J. R. DILLHOEFER ET AL 3,366,503

PROCESS OF EMBEDDING FLOCK IN A POLYETHYLENE SUBSTRATE

Filed Jan. 23, 1967



INVENTORS
James R. Dillhoefer
BY John R. Nelson, Jr.
Wood, Herron and Evans
ATTORNEYS

United States Patent Office

3,366,503
Patented Jan. 30, 1968

3,366,503
PROCESS OF EMBEDDING FLOCK IN A POLYETHYLENE SUBSTRATE

James R. Dillhoefer, Cleveland Heights, and John R. Nelson, Jr., Mentor, Ohio, assignors to Eagle-Picher Industries Inc., Cincinnati, Ohio, a corporation of Ohio

Continuation-in-part of application Ser. No. 486,358, Sept. 10, 1965. This application Jan. 23, 1967, Ser. No. 629,039
10 Claims. (Cl. 117—17)

ABSTRACT OF THE DISCLOSURE

A process for making a flocked article including the steps of supporting molten polyethylene or mixtures of polyethylene and other thermoplastic materials against gravity and flocking upwardly into the molten material.

This is a continuation-in-part of my copending application Ser. No. 486,358 filed Sept. 10, 1965, now abandoned. This invention relates to a process for manufacturing a flocked article and, more particularly, the invention is directed to the adhering of flock fibers directly to a plastic substrate.

Flocking is the art of depositing and adhering short fibers to the surface of an article to provide the article with a cut pile surface. The present invention is concerned particularly with the flocking of sheets of material as contrasted to three-dimensional objects and the invention will be described in that context.

A principal use of flocked sheet material is in the manufacture of automotive floor coverings or similar carpeting. The flocked sheet material has been found to be very satisfactory in such applications because of its unusual resistance to abrasion or wear as by the heels of the vehicle occupants continually grinding into the surface of the floor covering. Another reason for the interest of the automotive industry in flocked carpeting resides in the ability to introduce interesting patterns of multi-colored flock into the surface of the carpeting and in the ability to produce a carpeting of rich, luxuriant appearance.

In the evolution of the art of flocking, fibers were first sifted by means of gravity onto an article whose surface had been first coated with an adhesive. Subsequently, it was found that by establishing a high voltage electrostatic field between the source of flock fibers and the article, the fibers could be driven more efficiently into the article and with a better orientation.

The use of an adhesive for securing the fibers to the sheet introduced a variable into the process for not all adhesives are chemically compatible with the substrate or with the fibers and a reproducible, satisfactory adherence is difficult to attain. The present invention is concerned with the elimination of the need for an adhesive as well as the elimination of the step required in applying the adhesive to the substrate. More specifically, an objective of the invention has been to improve the manufacture of flocked sheets by bringing a plastic sheet to a molten condition and driving the fibers directly into the molten plastic.

A still further objective has been to support the molten layer of plastic facing downwardly and, using an electrostatic field, to drive the flock fibers upwardly into the surface of the plastic.

There is an important advantage to be derived from flocking the molten plastic against gravity which relates to the fact that in an electrostatic field, the flock fibers become charged when leaving the source and, in moving in the electrostatic field, become oriented generally perpendicularly to the surface to which they are driven. However, a certain percentage of the fibers lose that chargeable characteristic which enables them to become oriented in the electrostatic field and, when flocked in the direction of the gravitational force, they fall in a random pattern against the adhesive or fluid plastic. By flocking against gravity, only those fibers susceptible of becoming charged so as to move against gravity through the force of the electrostatic field are driven into the substrate. Thus, only those fibers which are susceptible of perpendicular orientation engage the surface of the substrate, thereby avoiding any measurable random orientation of the fibers.

It has been another objective of the invention to provide a process for flocking a plastic substrate, the process including the final step of post curing the substrate. The post curing step involves the raising of the flocked substrate to a temperature above its melting point but below the melting point of the fibers and maintaining the article at that temperature for a limited period of time. Empirically, it has been determined that the post curing step is critically important to the provision of a satisfactory bond between high melting point fibers and a comparatively low melting point substrate as, for example, nylon fibers and a polyolefin substrate. In other combinations as, for example, olefin to olefin, the post curing step has been found to materially augment bonding of the fibers to the substrate.

These and other objectives of the invention will become more readily apparent from the following detailed description taken in conjunction with the accompanying drawings in which:

FIG. 1 is a diagrammatic view illustrating the steps in the process of flocking a molded textured sheet, and

FIG. 2 is a diagrammatic perspective view of a form of flocking apparatus.

As indicated above, the invention has as its essential step the flocking of molten plastic against gravity. There are a number of subsidary conditions which will be discussed below and which must be taken into consideration in the performance of a process which will provide the most satisfactory manufactured article. Prior to the actual flocking step, the plastic material may be brought to that condition of readiness to receive a deposit of flock fibers in any one of several different processes beginning with one of several starting materials. The plastic material may initially be a particulate or powdered plastic which is held on a support and heated until it fuses and flows together to form a single coherent viscous sheet of approximately the consistency of honey. Alternatively, the plastic may be extruded onto a moving belt, for example, and flocked before the temperature of the plastic has been reduced to the point of freezing the plastic or flocked after reheating if the plastic freezes after extruding. In a third alternative, a sheet of thermoplastic material is secured to a mold and brought to a molten condition after which it is flocked against gravity.

Apparatus by which the steps of the process may be carried out are diagrammatically illustrated in FIGS. 1 and 2. Referring to FIG. 1, the apparatus employed is designed to produce a contoured flocked article using a sheet of plastic material as the substrate. The appartus illustrated at step A comprises a support in the form of a mold **10** having a mold surface **11**. The mold **10** may be of the type described in copending application Ser. No. 453,937, filed May 7, 1965, now Patent No. 3,337,908, in the name of Nelson, et al. The mold is metallic, at least on the surface **11** which receives the sheet to be flocked, so that the mold can function additionally as an electrode in the flocking process. The mold is perforated as indicated at **14** and has a cavity **15** which is adapted to be evacuated through the port **16** having a one-way valve **18**. A sheet of plastic material **17** is adapted to be placed on the surface **11** and a vacuum created in the chamber **15** to cause the evacuation of the space between the surface **11** and the sheet **17** to hold the sheet against the surface **11** in general conformity to the contour of the surface.

Following the mounting of the sheet on the mold and evacuation of the space between the mold and the sheet, the next succeeding step of the process indicated at B is performed. In that step, the sheet is heated as by a heat source constituted by infrared lamps **20** until the sheet becomes warm, that is, the sheet is raised to a temperature of approximately 200° F. The heating may be performed in an oven or by any other suitable apparatus. The temperature of the sheet is raised to that minimum temperature which permits the sheet to attain the degree of flexibility which enables it to conform quite closely to the surface **11** of the mold, but the sheet is not sufficiently fluid to permit it to be drawn into the evacuating holes **14**.

The mold is then inverted at step C and the source of vacuum is removed. A one-way valve **18** in the port **16** prevents the immediate release of the vacuum between the sheet and the surface **11** in order to prevent the immediate dropping of the sheet from the mold when the vacuum source is removed. At step D in the process, the sheet is heated until it becomes fluid, the surface tension of the fluid plastic maintaining the sheet in position on the mold.

As soon as the sheet has been brought to a fluid condition, the step illustrated at E proceeds and the article is flocked under the conditions which will be more fully described below.

In FIG. 2, there is illustrated an alternative form of apparatus for the continuous production of a flocked web. The apparatus includes a support in the form of a conveyor belt **30** which is wrapped about two drums **31** and **32**. Apparatus **33** for applying a thermoplastic material to the belt **30** is located adjacent its upper flight at the upstream end of that flight. The apparatus **33** may simply be a hopper for applying a continuous supply of granules to the belt or the apparatus may be an extruder for applying a continuous film of plastic to the belt. A doctor roll **34** is located above the belt and is adapted to level the applied plastic material to a predetermined thickness.

A heat source **35** constituted by a bank of infrared lamps **36**, for example, mounted in a hood **37** is located downstream of the doctor roll **34** and is adapted to raise the temperature of the plastic material until it attains that condition of fluidity suitable for the flocking process. The surface tension of the fluid plastic causes it to adhere to the belt as the belt passes around the drum **32** and over a supply of flock.

The belt **30** has a lower flight **40** which passes over a first flock supply belt **41** and a second flock supply belt **42**. The supply belt **41** receives a supply of flock fibers of a first color from a hopper **43** of the type described in said copending application Ser. No. 453,937, filed May 7, 1965. Similarly, the belt **42** receives a second supply of flock fibers from a hopper **44**, the fibers of the second hopper being of a color different from that of the first hopper. Electrode plates **45** and **46** connected at ground potential are mounted below the respective flock supply belts. Cooperating electrodes **47** and **48** are mounted above the lower flight **40** of the belt **30** and are connected to a source of high potential. The thus cooperating electrode pairs **45**, **47** and **46**, **48** provide the electrostatic force required for the flocking operation.

A flexible stencil **50** formed as an endless belt passing around drums **51** and **52** has an upper flight **53** which passes between the lower flight **40** of belt **30** and the upper flight of the hopper supply belt. The drums **32** and **51** are connected together by meshing gears **54** and

55 fixed to the drums **32** and **51** respectively to cause the upper flight of the stencil to move at the same lineal speed and in the same direction as the lower flight **40** of the conveyor belt **30**.

In the operation of the apparatus of FIG. 2, the plastic material is deposited on the belt **30** from the supply apparatus **33** and is brought to a predetermined thickness by the doctor roll **34**. The plastic material is then melted by the heating apparatus **35** and in that condition adheres to the belt **30**. It passes around the drum **32** with the belt and between the electrodes **45** and **47** and immediately above the stencil **50**. The electrostatic force provided by voltage between the plates **45** and **47** causes the flock fibers to be driven upwardly through openings **57** and to be embedded into the fluid plastic sheet in a predetermined pattern determined by the openings in the stencil. The duration of any increment of the plastic sheet between the two electrodes **45** and **47** is sufficiently long to permit a complete deposit of flock onto the exposed area of the plastic sheet.

The sheet thereafter passes over the second supply of flock between eleectrodes **46** and **48**. Since there is no stencil for blocking the movement of the flock from the belt **42** to the plastic sheet, the remaining unflocked areas of the sheet receive a deposit of flock.

After completion of the flocking steps, the temperature of the substrate is maintained (or brought) to a temperature above its melting temperature but below the melting temperature of the fibers for a predetermined period of time. This heat treatment, following flocking, appears to provide a more intimate contact of the substrate with the fibers and hence improves its "pull test."

After the post flocking heat step, or after flocking if no post flocking heat is used, the substrate is permitted to cool and is thereafter removed from the supporting belt.

The process of flocking the molten plastic sheets against gravity involves a number of factors which admit of some variation as will be discused below. The ultimate objective in the variation of any of the factors is to obtain an adherence or penetration of the flock fibers into the substrate to the extent that each fiber can withstand at least a sixteen pound pull test. The pull test involves an instrument (manufactured by Instron) having means for holding the flocked article and means for clamping a measured group of flock fibers (one inch by ⅛ inch) and pulling them out of the substrate at a constant rate (ten inches per minute). The applied tension is measured and that required to pull the fibers out of the substrate provides a measure of adherence which is referred to as the "pull test." Among the factors contributing to adherence are the following:

(1) Substrate material
(2) Fiber material
(3) Thickness of substrate
(4) Temperature applied to the substrate
(5) Time of application of heat
(6) Applied voltage
(7) Distance between the electrodes
(8) Post cure

The preferred substrate of the present invention is polyethylene or a mixture of polyethylene and other thermoplastics wherein the major portion of the mixture is polyethylene. Thermoplastic materials which can be mixed with polyethylene and provide a satisfactory substrate are ethylene vinyl acetate and ethylene ethyl acrylate. Polypropylene, rayon, and nylon have proved to be satisfactory materials for the fibers. Satisfactory articles have been manufactured in which the nylon fibers have a denier of 53 and a length of 0.120 inch and in which the polypropylene fibers have a denier of 30 and a length of 0.160 inch. These dimensions are not critical and any fibers properly prepared to receive an electrostatic charge may be used.

The thickness of the substrate should not be less than approximately 0.015 inch, for it has been found that the required depth of penetration of the fibers for a satisfactory tuft pull should be between 0.007 and 0.018 inch. The maximum thickness of the substrate appears to be determined only by the ability of the substrate to maintain itself on the mold against the pull of gravity.

The temperature of the melting atmosphere surrounding the plastic will, of course, be determined in part by the material of which the fibers and the substrate are formed. Polyethylene, for example, should be heated to a uniform temperature in the range of 375° to 400° F. This temperature within this range is subject to variation, depending upon factors such as the type of flock fiber, thickness of the substrate, and the post cure and the ultimate quality of the product desired.

For example, when flocking with polypropylene fibers, the polyethylene substrate should be raised to a temperature of 375–385° F. While this is well above the melting point of the polypropylene fibers (335° F.), the temperature of the substrate is low enough that the polypropylene fibers do not melt completely upon impingement with the hot substrate. Rather, the substrate appears to be fluid enough for the fibers to get good penetration into it and their embedded ends melt slightly to form a ball which tends to facilitate the anchorage of the fibers to the substrate.

In flocking with nylon fibers, it is preferable to raise the temperature of the substrate 390–400° F. The higher temperature in the case of the nylon fibers appears to be necessary in order to obtain the required penetration of the nylon fibers into the substrate. A temperature substantially higher than 400° F. is undesirable because it causes discoloration or oxidation of the fibers.

The applied voltage and distance between the electrode plates should be selected to assure a satisfactory depth of penetration. For example, to obtain a satisfactory depth of penetration, the applied voltage should be between 25,000 and 50,000 volts direct current and the spacing between the electrodes should be between three and five inches. The depth of penetration which has proved satisfactory to obtain the minimum tuft pull is between 0.007 and 0.018 inch.

Following flocking, and preferably before the substrate cools to its freezing point, the flocked substrate is subjected to heat (post cure) to maintain its temperature above the melting temperature of the polyethylene (280° F.) and below the melting temperature of the fibers (polypropylene 335° F.) (nylon 440° F.). The length of time during which the substrate is subjected to heat following flocking will depend upon the temperature of the heat applied and, as indicated, the temperature will depend in part upon the melting point of the fibers which have been flocked into the substrate. By way of example, if the article is flocked with polypropylene fibers, the temperature of the substrate should be maintained at about 300° F. for approximately ten minutes. If the article is flocked with nylon fibers, the temperature of the substrate should be maintained at approximately 375° F. for three to five minutes.

Example 1

Ninety parts by weight of polyethylene (800 E by Eastman Kodak) were intimately mixed with ten parts by weight of ethylene ethyl acrylate (6169 by Union Carbide) and raised to a temperature of 380° F. While held at this temperature and supported on a flat plate, the plate was inverted so that the molten plastic mixture faced downwardly. Using the plate as one electrode, the plastic mixture was flocked at 40,000 volts D.C. with a spacing of approximately four inches between electrodes. The substrate was flocked with nylon fibers having a denier of 53 and a length of 0.120 inch.

The flocked article was subjected to a post flocking

heat treatment of 375° for five minutes. After cooling, the article responded satisfactorily to a tuft pull test.

Example 2

The steps of Example 1 were performed as set forth in Example 1 except that 85 parts of polyethylene and 15 parts of ethylene ethyl acrylate were mixed together to form the substrate. The flocked substrate responded satisfactorily to a tuft pull test.

Example 3

The steps of Example 1 were performed as set forth in Example 1 except that four different substrates were formed. The first was 100% polyethylene. The second, third, and fourth were 90%, 80%, and 70% polyethylene, respectively, with the remainder being ethylene vinyl acetate. In all four cases, the substrate responded satisfactorily to a tuft pull test.

Example 4

The steps of Examples 1–3 were performed as set forth in Examples 1–3 except that the flock fibers employed were polypropylene having a denier of 30 and a length of 0.160" and except that in the post flock treatment, a flocked substrate was subjected to a temperature of 300° F. for approximately ten minutes. The articles responded satisfactorily to tuft pull tests.

We claim:

1. The process of embedding flock fibers in a polyethylene substrate comprising the steps of
   - subjecting the polyethylene to an elecated temperature until it becomes a viscous fluid, said polyethylene being on a support in the form of a sheet which is at least 0.015 inch thick,
   - positioning the support over a supply of flock fibers with the polyethylene in a viscous fluid state facing downwardly,
   - applying a voltage between the support and the supply of the fibers to drive the ends of the fibers into the viscous fluid polyethylene,
   - cooling the sheet below its melting point, and
   - removing the sheet from the support.

2. The process of embedding flock fibers in a polyethylene substrate comprising the steps of
   - subjecting the polyethylene to an elevated temperature until it becomes a viscous fluid, said polyethylene being on a support in the form of a sheet which is at least 0.015 inch thick.
   - positioning the support over a supply of flock fibers with the polyethylene in a viscous fluid state facing downwardly,
   - applying a voltage between the support and the supply of fibers to drive the ends of the fibers into the viscous fluid polyethylene,
   - subjecting the sheet to an elevated temperature above the melting point of the polyethylene and below the melting point of the fibers for a limited period of time to increase the adherence of the fibers to the polyethylene,
   - cooling the sheet below its melting point, and
   - removing the sheet from the support.

3. The process according to claim 2 in which said fibers are selected from the group consisting of nylon and polypropylene.

4. The process according to claim 2 in which, following flocking, the sheet is maintained at a temperature of approximately 300°–375° F. for three to ten minutes.

5. The process of embedding flock fibers in a polyethylene substrate comprising the steps of
   - subjecting the polyethylene to an elevated temperature until it becomes a viscous fluid, said polyethylene being on a support in the form of a sheet which is at least 0.015 inch thick,
   - positioning the support over a supply of flock fibers

with the polyethylene in a viscous fluid state facing downwardly,

applying a voltage between the support and the supply of fibers to drive the ends of the fibers into the viscous fluid polyethylene to a depth of at least approximately 0.007 inch,

cooling the sheet below its melting point, and

removing the sheet from the support.

6. The process of embedding flock fibers in a substrate consisting of at least predominantly polyethylene,

subjecting the substrate to an elevated temperature until it becomes a viscous fluid, said substrate being on a support in the form of a sheet which is at least 0.015 inch thick,

positioning the support over a supply of flock fibers with the substrate in a viscous fluid state facing downwardly,

applying a voltage between the support and the supply of fibers to drive the ends of the fibers into the viscous fluid substrate to a depth of at least approximately 0.007 inch,

cooling the substrate below its melting point, and

removing the sheet from the support.

7. The process according to claim **6** in which said substrate is a mixture of polyethylene and another thermoplastic material.

8. The process according to claim **6** in which said substrate is a mixture of polyethylene and a substance selected from the group consisting of ethylene ethyl acrylate and ethylene vinyl acetate.

9. The process according to claim **8** in which the substrate is at least 70 parts by weight polyethylene.

10. The process of embedding flock fibers in a substrate consisting of at least predominantly polyethylene,

subjecting the substrate to an elevated temperature until it becomes a viscous fluid, said substrate being on a support in the form of a sheet which is at least 0.015 inch thick,

positioning the support over a supply of flock fibers with the substrate in a viscous fluid state facing downwardly,

applying a voltage between the support and the supply of fibers to drive the ends of the fibers into the viscous fluid substrate,

cooling the substrate below its melting point, and removing the sheet from the support.

References Cited

UNITED STATES PATENTS

2,087,260	7/1937	Miller	117—17
2,222,539	11/1940	Meston	156—246
2,290,238	7/1942	Hickok	117—25
2,308,624	1/1943	Povech	117—33
2,472,551	6/1949	Smith	264—131
2,553,259	8/1951	Miller	117—33
2,567,186	9/1951	Cross et al.	117—16
2,686,733	8/1954	Burridge et al.	117—17
2,689,801	9/1954	D'Anelio	117—16
2,784,630	3/1957	Koprow et al.	117—17
2,844,489	7/1958	Gemmer	117—21
2,907,671	10/1959	Duviver	117—16
3,099,572	7/1963	Rion et al.	117—16
3,168,603	2/1965	Seefluth	264—69
3,212,137	10/1965	Lemettre	264—25
3,215,584	11/1965	McConnell et al.	117—33
3,257,743	6/1966	Closson et al.	117—16
3,275,487	9/1966	Lemelson	156—72

FOREIGN PATENTS

453,234	9/1936	Great Britain.

WILLIAM D. MARTIN, *Primary Examiner.*

E. J. CABIC, *Assistant Examiner.*