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(54) COMPOUND LEVER MECHANISM

(71) We, IMPERIAL CHEMICAL INDUSTRIES LIMITED, of Imperial Chemical House, Millbank, London, S.W.1., a British Company, 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:—

This invention relates to a compound lever mechanism and especially to such a mechanism when incorporated in compound lever forceps, pliers and like devices.

According to the invention, a compound lever mechanism of integral construction suitable for incorporation into a compound lever device to which it imparts a scissors-like action, comprises a pair of opposed compound levers, each compound lever comprising two or more first order levers flexibly jointed end to end and each pair of opposed first order levers having a common fulcrum, the said fulcra and joints between the first order levers comprising zones of preferential flexure as hereinafter defined.

By "zone of preferential flexure" is meant a localised portion of the construction which, by virtue of its geometrical configuration and/or physical properties, is adapted to flex when sufficient force is applied to the levers joined by the said zone, or for which the said zone is a fulcrum, without substantial flexure of the levers, the said zone being capable of repeated flexure without fracture such as would prevent the performance of that portion as a joint or fulcrum and providing a line of flexure normal to the plane in which the levers move and about which the levers may rotate in a hinge-like manner, but specifically excluding a pivot which allows rotational movement without flexure.

This type of construction can be designed to allow a desired freedom of movement of the levers in the said plane but at the same time to provide a positive restraint on

unwanted movement of the levers out of the said plane.

A "common fulcrum" may take the form of a single zone of preferential flexure, in which case the adjacent faces of the opposed first order levers are provided with protrusions to enable them to function easily; alternatively the common fulcrum may take the form of a spacer or strut, having a zone of preferential flexure at each end. It is preferred that each common fulcrum comprises a single zone of preferential flexure.

Integral constructions according to our invention may comprise either (1) a single piece of material, for example a moulding, pressing or stamping, or (2) several rigid levers flexibly pointed together by other members having the required flexural properties so as to form an integral construction.

In constructions of type (1), the whole material must be one which has intrinsically high modulus, flexibility and fatigue resistance. Preferably the material is one which also possesses a relatively high elongation to break and high elastic recovery. In such constructions, the zones of preferential flexure are introduced by careful design of the relative parts of the construction. Thus, the relative dimensions of those parts of the constructions which are to function as levers are chosen so as to impart sufficient rigidity in the direction in which levering forces are to be applied, and those parts of the construction which are to function as fulcra or joints are designed so that they have a low resistance to flexure in the desired direction. This may be conveniently achieved by reducing the thickness of material along the desired line of flexure. The degree to which this is done will depend upon the physical properties of the material of construction and on the number of repeated flexures the mechanism is likely to be required to perform in its designed lifetime.

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In constructions of type (2), whereas the relative rigidity or flexibility of the component parts may be controlled merely by choice of their physical dimensions, much greater latitude is possible since materials having the most appropriate properties may be chosen for the respective parts provided that they may be joined together into an integral construction. However, such constructions may require several forming and assembling operations.

In view of this, it is much preferred that a mechanism according to our invention comprises a single piece of material. A variety of mouldable or malleable materials may be used, provided that they are capable of imparting the required rigidity, flexibility and fatigue resistance to the appropriate parts of the mechanism. The choice of material for any particular application is further governed by the intended conditions of service under which the device is to be used. For example, in a mechanism intended to be used a relatively small number of times and then discarded, fatigue resistance would be far less important than if the device were intended to function many thousands of times without fracture of its flexible parts.

In many applications, especially where ease and cheapness of construction, corrosion resistance and lightness are important, mechanisms according to our invention may be readily produced as a single piece of a suitable plastics material, for example a one-shot injection moulding. Polypropylene is a particularly suitable material for this purpose, since it is readily injection moulded, inert and cheap and also possesses an unusually high fatigue resistance in thin sections, which is commonly referred to as the "hinge effect".

An especially useful form of our mechanism is one which each compound lever comprises two first order levers, as will be readily appreciated from the following description.

In a preferred form of our invention, the compound lever mechanism is one in which each compound lever comprises two first order levers and is incorporated in a compound lever device to which it imparts a scissors-like action. Such devices may be, for example, forceps, pliers, tongs, clamps or scissors. For convenience they will hereinafter be referred to simply as forceps.

Our compound lever mechanism may be incorporated in a forceps by affixing jaws and handles to the free ends of the appropriate first order levers of the mechanism; but preferably the jaws and handles of the forceps comprise integral extensions of the said first order levers. Thus, the whole forceps may be constructed from a single piece of plastics material, for example as a stamp-

ing or pressing, or as a one-shot injection moulding.

One-piece forceps according to one embodiment of our invention possess several advantages over the traditional forms in which two non-identical members are joined together by means of a pivot, apart from the obvious advantages that only one shape of article needs to be produced and that the operation of assembling two parts by means of a pivot is obviated. For example, since opposite jaws and handles are not rigidly connected there is no inherent tendency for the jaws to "cross-beak" i.e. displace out of the normal plane of movement. Furthermore, when constructed from resilient materials, such as moulded plastics, the natural resilience imparted to the compound lever mechanism will tend to accommodate excessive force applied to the handles, thus limiting the force transmitted to the object being gripped in the jaws. The aforementioned resilience may also be utilised to bias the forceps into an unstressed "open" position, so that they do not have to be moved manually to the open position after use.

A forceps according to one embodiment of our invention may also be readily provided with means for locking it temporarily in its gripping position to enable it to be used as a clamp or clip. For example, co-operating hook-like members may be provided on the inner surfaces of the handles; alternatively a plug or spacer may be inserted in the orifice defined by the levers, joints and fulcrum of the compound lever mechanism. Since this orifice commonly comprises a quadrilateral or a star shape, the angles of which are radically altered when the forceps is moved from its fully open to fully closed position, the insertion of an appropriately shaped plug may be used to lock the jaws in their closed or open positions or, indeed, in any intermediate position if so desired.

Our forceps may be designed with a variety of handles and jaws to enable them to be used in a wide range of applications. Examples of possible applications include wound dressing or obstetric forceps, photographic or philatelic forceps, eyebrow tweezers, sugar tongs, salad servers, pruning aids or seedling lifters. It is also within the scope of our invention to substitute blade members for the jaws to produce scissors.

When moulded in plastics materials our forceps possess intrinsic insulating and acid-resistant properties which may be used to advantage. For example, they may be used to hold wires during soldering or to immerse objects in acid baths. When provided with releasable means to retain the jaws in their gripping positions, they may be used

as clips or clamps for a variety of purposes, for example, as haemostat clamps, paper clips or clothes pegs.

As has already been mentioned, forceps according to our invention may be advantageously formed from polypropylene because of its well-known "hinge" effect. However, other plastics materials may also be used, especially in applications which are not required to withstand the remarkable degree of repeated flexing possible with polypropylene. For example, forceps may be moulded from polyethylene and its copolymers; polyamides, such as nylon; or polyesters, such as polyethylene terephthalate.

When certain polymers are used, for example, nylon and polyacetal, hinges may be incorporated in the device by localised compression of the polymer in those areas in which the aforementioned zones of preferential flexure are to be located. Such hinges are known as "crined" hinges.

In order that the invention may be more fully understood, several embodiments will be described, by way of example only, with reference to the accompanying drawings of which

Figure 1 is a plan view of a general purpose forceps incorporating a compound lever mechanism according to our invention;

Figure 2 is a side elevation of the forceps of Figure 1;

Figure 3 is an isometric view of photographic tongs according to our invention;

Figure 4 is an isometric view of a dressing forceps or haemostat clamp according to our invention; and

Figure 5 is a part view of the forceps of Figure 4 locked in its gripping position.

Referring to Figures 1 and 2, the forceps illustrated comprises in essence, a single laminar piece of polypropylene of substantially uniform thickness, formed in the shape shown in Figure 1, the extremities being tapered slightly as shown in Figure 2. This shape was chosen so that it generated several well-defined zones or members within the overall integral construction. For convenience, the remainder of this description will be phrased as though the forceps illustrated consisted essentially of four individual lever-like members flexibly interconnected.

Four flat members, or levers, 1, 2, 3, 4, are provided with pointed extremities, adjacent points of which are flexibly jointed by thin elongate webs 5, 6, 7, 8, the planes of said webs being normal to the plane of the drawing.

Pairs of articulated levers 1 and 4, and 2 and 3 thus form a pair of opposed com-

pound levers, webs 6 and 7 being capable of acting as flexible joints between the component levers of each pair, while webs 5 and 8 are capable of acting as common fulcrum between the two compound levers, about which levers 1, 2, 3 and 4 may function as first order levers. Levers 1 and 2 are designed as gripping jaws, having serrations on their inner faces, whereas levers or handles 3 and 4 are provided with rings 9 and 10 at their extremities remote from flexible webs 6, 7 and 8, to facilitate operation, scissors fashion.

In use, when inward pressure is applied to handles 3, 4, by insertion of thumb and forefinger in rings 9, 10, the forceps is caused to assume the shape shown in broken lines in the drawing. It will be seen that this has the effect of bringing together jaws 1 and 2 in a gripping action. Because of the natural resilience of polypropylene on release of the inward pressure on handles 9, 10, the forceps springs back to its original shape. Once the jaws 1, 2 have been brought together further inward pressure results in outward movement of webs 6, 7 thus limiting the pressure transmitted to the jaws 1, 2.

The thickness of webs 5, 6, 7, 8 must be such that they present considerably less resistance to flexure than is possessed by levers 1, 2, 3, 4. Generally speaking the webs have a thickness of about 0.020 ins. to 0.060 ins., to allow ready flexure but to impart sufficient resistance to twisting of the device about the normal plane of its laminar parts.

The device illustrated was made from "Propathene" (R.T.M.), I.C.I.'s brand of polypropylene. Data relating to the choice of dimensions to obtain best use of the "hinge effect" in this material may be obtained from the I.C.I. publication "Propathene for Integral Hinges".

It will be appreciated that the proportions of levers 1, 2, 3, 4 may be varied considerably within the general concept of our invention, to give rigidity to certain parts of the device, to allow the jaws to accommodate articles of various shapes, or to vary the degree of leverage obtainable.

Photographic tongs, illustrated in Figure 3, are one example of such a modification. Again these are of integral polypropylene construction and have a general similarity to the forceps of Figure 1 as indicated by the reference numerals 1 to 10 which refer to like parts. Additionally, the tongs of Figure 3 are provided with spatulate members 11, 12 at the extremities of jaw members 1, 2. Raised ridges 13 are provided on the co-operating faces of spatulate members 11, 12 to improve their grip. Protrusions 14 are provided on the lower faces of handles 3, 4, close to rings 9, 10. Tongs as illustrated

- in Figure 3 are particularly adapted for use in photographic developing or the like. In use, prints, film, etc. may be readily gripped by the spatulate ends 11, 12 and protrusions 14 to allow the tongs to be hooked on to the side of a developer dish while the jaws rest on the bottom of the dish, thus preventing the tongs from inadvertently slipping into the dish.
- 10 Wound dressing forceps illustrated in Figures 4 and 5 consist of a one-shot injection moulding of polypropylene. It is of similar general form to the forceps illustrated in Figure 1. These dressing forceps are suitable for inclusion in sterile packs enclosed in air-tight plastics bags, generally referred to as "dressing packs". Sterilisation of the forceps may be performed after packing by means of ethylene oxide treatment or irradiation, in keeping with known techniques.
- Forceps illustrated in Figures 4 and 5 are provided with interlockable hook-like members 15, 16 on the inner faces of handles 3, 4. These may be used to secure the jaws in their gripping position with a "snap" action; they may be released by relative displacement of handles 3, 4 out of the normal plane of movement.
- Lockable forceps of this type may be used as temporary haemostat clamps, being supplied pre-sterilised in airtight packs as described above. However, it may be desirable to omit hook-like members 15, 16 if the forceps are to be used exclusively for handling dressings.
- The invention has been illustrated by means of devices incorporating a pair of compound levers each comprising two first order levers; but it will be readily appreciated that the same constructional principles may be repeated in the longitudinal direction of the drawing by using compound levers comprising three or more first order levers, to produce devices akin to a "lazy tongs". Such devices have well-known applications where remote control is required.
- comprising zones of preferential flexure as hereinbefore defined.
2. A compound lever mechanism as claimed in claim 1 which is formed from a single piece of plastics material.
3. A compound lever mechanism as claimed in claim 2 wherein the plastics material is polypropylene.
4. A compound lever mechanism as claimed in claim 1, 2 or 3 wherein each compound lever comprises two first order levers.
5. Forceps incorporating a compound lever mechanism as claimed in claim 4 in which the jaws and handles of the forceps comprise integral extensions of the first order levers of the compound lever mechanism.
6. Forceps as claimed in claim 5 which comprise a single piece of plastics material.
7. Forceps as claimed in claim 6 which are constructed by a one-shot injection moulding.
8. Forceps as claimed in claim 6 or 7 wherein the plastics material is polypropylene.
9. Forceps as claimed in claim 6 or 7 wherein the plastics material is polyethylene or a copolymer thereof, or a polyamide.
10. Forceps as claimed in claim 6 or 7 wherein the plastics material is a polyester, for example polyethylene terephthalate.
11. Forceps as claimed in claim 9 wherein the polyamide is nylon and the zone of preferential flexure is constructed by localised compression of the polymer.
12. Forceps as claimed in any of claims 5 to 11 having means for releasably locking it in its gripping position.
13. A method of constructing forceps as claimed in claim 7 which comprises injection moulding the forceps in a single operation.
14. Forceps substantially as hereinbefore described with reference to and as illustrated in Figure 1.
15. Photographic tongs substantially as hereinbefore described with reference to and as illustrated in Figure 3.
16. A dressing forceps or surgical clamp substantially as hereinbefore described with reference to and as illustrated in Figure 4.
17. A lazy-tongs device of integral construction incorporating a compound lever mechanism as claimed in claim 1.

WHAT WE CLAIM IS:—

1. A compound lever mechanism of integral construction suitable for incorporation into a compound lever device to which it imparts a scissors-like action, comprising a pair of opposed compound levers, each compound lever comprising two or more first order levers flexibly jointed end to end and each pair of opposed first order levers having a common fulcrum, the said fulcrum and joints between the first order levers

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in Figure 3 are particularly adapted for use in photographic developing or the like. In use, prints, film, etc. may be readily gripped by the spatulate ends 11, 12 and protrusions 14 to allow the tongs to be hooked on to the side of a developer dish while the jaws rest on the bottom of the dish, thus preventing the tongs from inadvertently slipping into the dish.

10 Wound dressing forceps illustrated in Figures 4 and 5 consist of a one-shot injection moulding of polypropylene. It is of similar general form to the forceps illustrated in Figure 1. These dressing forceps are suitable for inclusion in sterile packs enclosed in air-tight plastics bags, generally referred to as "dressing packs". Sterilisation of the forceps may be performed after packing by means of ethylene oxide treatment or irradiation, in keeping with known techniques.

Forceps illustrated in Figures 4 and 5 are provided with interlockable hook-like members 15, 16 on the inner faces of handles 3, 4. These may be used to secure the jaws in their gripping position with a "snap" action; they may be released by relative displacement of handles 3, 4 out of the normal plane of movement.

Lockable forceps of this type may be used as temporary haemostat clamps, being supplied pre-sterilised in airtight packs as described above. However, it may be desirable to omit hook-like members 15, 16 if the forceps are to be used exclusively for handling dressings.

The invention has been illustrated by means of devices incorporating a pair of compound levers each comprising two first order levers; but it will be readily appreciated that the same constructional principles may be repeated in the longitudinal direction of the drawing by using compound levers comprising three or more first order levers, to produce devices akin to a "lazy tongs". Such devices have well-known applications where remote control is required.

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1. A compound lever mechanism of integral construction suitable for incorporation into a compound lever device to which it imparts a scissors-like action, comprising a pair of opposed compound levers, each compound lever comprising two or more first order levers flexibly jointed end to end and each pair of opposed first order levers having a common fulcrum, the said fulcra and joints between the first order levers

comprising zones of preferential flexure as hereinbefore defined.

2. A compound lever mechanism as claimed in claim 1 which is formed from a single piece of plastics material.

3. A compound lever mechanism as claimed in claim 2 wherein the plastics material is polypropylene.

4. A compound lever mechanism as claimed in claim 1, 2 or 3 wherein each compound lever comprises two first order levers.

5. Forceps incorporating a compound lever mechanism as claimed in claim 4 in which the jaws and handles of the forceps comprise integral extensions of the first order levers of the compound lever mechanism.

6. Forceps as claimed in claim 5 which comprise a single piece of plastics material.

7. Forceps as claimed in claim 6 which are constructed by a one-shot injection moulding.

8. Forceps as claimed in claim 6 or 7 wherein the plastics material is polypropylene.

9. Forceps as claimed in claim 6 or 7 wherein the plastics material is polyethylene or a copolymer thereof, or a polyamide.

10. Forceps as claimed in claim 6 or 7 wherein the plastics material is a polyester, for example polyethylene terephthalate.

11. Forceps as claimed in claim 9 wherein the polyamide is nylon and the zone of preferential flexure is constructed by localised compression of the polymer.

12. Forceps as claimed in any of claims 5 to 11 having means for releasably locking it in its gripping position.

13. A method of constructing forceps as claimed in claim 7 which comprises injection moulding the forceps in a single operation.

14. Forceps substantially as hereinbefore described with reference to and as illustrated in Figure 1.

15. Photographic tongs substantially as hereinbefore described with reference to and as illustrated in Figure 3.

16. A dressing forceps or surgical clamp substantially as hereinbefore described with reference to and as illustrated in Figure 4.

17. A lazy-tongs device of integral construction incorporating a compound lever mechanism as claimed in claim 1.

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