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## **MESH AND METHODS AND APPARATUS FOR FORMING AND USING MESH**

### **FIELD OF THE INVENTION**

5 The present invention relates to methods and apparatus for forming mesh utilising moulded interlinking link elements. The invention also relates to mesh formed by the method of the invention, products incorporating the mesh and methods of using the mesh. Where the term "mesh" is used in this specification it means a mesh formed of interlinking link elements, such as rings.

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### **BACKGROUND**

Mesh formed of interlinking link elements is best known in the form of chain mail. Chain mail has traditionally been formed by interconnecting closed metal rings with open metal rings and then closing the open rings by a process such as  
15 mechanical deformation, welding etc. In another method split rings formed of spring steel or some other resilient material are used as the interlinking link members and are temporarily opened using a tool, such as pliers, to enable interconnection to other link members. In recent times mesh has been formed  
20 from plastics material by joining closed rings with open rings and then mechanically fastening, welding or gluing the open rings closed.

It has been time-consuming, labourious and expensive to manufacture chain mail/mesh using traditional methods. Chain mail/mesh including unclosed link  
25 elements can only be exposed to limited forces before link elements fail. Where the interlinking link elements are closed the joint may detract from the appearance of the finished mesh. Such methods have also limited the materials that may be utilised in the manufacturing of mesh and have limited the practical size of link elements.

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Whilst there have been complex apparatus for forming mesh by folding sections of wire, to date there has been no automated process for the continuous and economic production of chain mail/mesh for mass-market applications.

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### **SUMMARY OF THE INVENTION**



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It is an object of the present invention to provide an automated process and apparatus for the continuous production of mesh.

It is a further object of the present invention to provide mesh having strong structural integrity and an attractive appearance.

It is a further object of the present invention to provide a mesh that is economic to produce for a range of applications.

It is a further object of the invention to provide novel mesh products and methods of using mesh.

Each of the above objects is to be read disjunctively with the object of at least providing the public with a useful choice.

According to first aspect of the invention there is provided a method of forming a mesh comprising:

- a. providing a plurality of link elements; and
- b. moulding a plurality of link elements through the link elements so as to interconnect the link elements to form a continuous mesh of interconnected link elements.

According to a further aspect of the invention there is provided a method comprising:

- a. positioning a first plurality of link elements in a first plurality of first positions in a mould;
- b. positioning a second plurality of link elements in a second plurality of second positions in the mould;
- c. moulding a third plurality of link elements in a third plurality of positions in the mould to interlink with the first plurality and the second plurality of link elements;
- d. advancing a subset of the first plurality of link elements to reside in the second plurality of second positions in the mould; and
- e. moulding a fourth plurality of link elements to interlink with the subset of the first plurality of link elements.

There is also provided a mesh formed by the method of the invention.

According to another aspect of the invention there is provided an apparatus for forming a mesh including a mould formed as a plurality of sections, at least some of which close together to define cavities to mould link elements and separate to release moulded link elements, the mould including:

- a. a plurality of first cavities to retain a plurality of link elements at spaced intervals; and
- b. a plurality of second cavities dimensioned and arranged when the mould sections are closed to form cavities to form link elements in the second cavities that pass through link elements located within the first cavities.

According to a further aspect of the invention there is provided a mesh formed of link elements wherein interlinking link elements are formed as continuous unjoined loops by a moulding process.

According to another aspect of the invention there is provided an apparatus comprising:

- a plurality of link elements without joins interlinked to form a two-dimensional mesh of the link elements.

#### BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described by way of example with reference to the accompanying drawings in which:

**Figure 1** is a perspective view illustrating the relative positions of rings in a method of producing a row of mesh;

**Figure 2** is a front view illustrating the relative positions of rings when a further row of rings is joined;

**Figure 3** is a side view of the rings shown in figure 2;

**Figures 4 and 5** are sectional views of sections of a simple mould to illustrate the operations in a method of manufacturing mesh;

**Figure 6a** is a side view of an apparatus suitable for continuously manufacturing mesh shown in a closed position;

**Figure 6b** is a side view of the apparatus shown in figure 6a in a partially open at configuration;

**Figure 6c** is a side view of the apparatus shown in figure 6a in a fully open configuration;

**Figure 7** is a perspective view showing a portion of the working faces of the two mould sections forming one half of the mould of the apparatus shown in figure 6 with an array of fingers in front of the working face;

**Figure 8** shows a front view of a portion of the working face shown in figure 7;

**Figure 9** shows a front view of a portion of the working face shown in figure 7 and 8 with the fingers raised;

**Figure 10** shows a front view of a portion of the working face shown in figures 7 to 9 without the fingers;

**Figure 11** shows a sectional view along line B-B in figure 10;

**Figure 12** shows a perspective back view of a finger;

**Figure 13** shows a back view of a finger;

**Figure 14** shows a side view of a finger;

**Figure 15** shows a front view of the working face of the mould section opposite to the working face shown in figures 7 to 10;

**Figure 16** shows a perspective view of the working face of the mould section shown in figure 15;

**Figure 17** shows a top view of the mould section shown in figures of 15 and 16;

**Figure 18** shows a cross-sectional view through the mould section shown in figure 16 along line A-A;

**Figures 19A to H** show a variety of possible link element shapes; and

**Figure 20** show a further possible link element shape.

## DETAILED DESCRIPTION OF THE INVENTION

An embodiment of the present invention includes a method of forming mesh in which the link elements may be in the form of unjoined closed loops. However, the link elements may take many forms including forms having a single aperture therethrough, such as rings, forms having multiple apertures etc.

Referring to figure 1 a method for continuously producing mesh is described.

Preformed rings 1 to 4 are arranged in a first orientation with pairs 1, 2 and 3, 4 arranged so that portions of their central apertures overlap. Further such pairs

may be provided in a row at spaced intervals in the plane of rings 1 to 4 to form a length of mesh as required. A ring 5 may then be moulded so that it passes through the central apertures of rings 1 to 4 as shown. Ring 6 illustrates how further rings may simultaneously be formed along row.

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Referring now to figures 2 and 3 the production of a subsequent row of mesh is described. Ring 3 in figure 1 assumes the position of ring 4 in figure 2 and ring 1 in figure 1 assumes the position of ring 2 in figure 2. Ring 5 in figure 1 assumes the position of ring 7 in figure 2. New rings 3 and 1 are introduced to the positions shown in figure 2. A new ring 5 is moulded through the central apertures of rings 1 to 4. In this way it will be seen that by sequentially introducing a new row of rings 1 and 3 and moulding a new ring 5 through new rings 1 and 3 and old rings 2 and 4 that a mesh may be continuously manufactured. It will be appreciated that this pattern may be extended in either direction to obtain the desired width of mesh.

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Referring now to figures 4 and 5 a cross-sectional side view of a basic mould for forming a continuous mesh will be described in the context of the arrangement shown in figure 3. The mould consists of mould sections 9, 10 and 14 and finger 13. Mould sections 9 and 10 part at mould faces 9b and 10a and mould sections 9 and 10 part from finger 13 at faces 9a, 10b and 14b. Annular cavity 12 is dimensioned to retain ring 2 and annular cavity 11 is dimensioned to retain ring 1. The relative component spacings indicated by the letters B, C and D are indicated respectively in figures 2 to 4.

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A finger 13 of semicircular cross-section defines half of the central aperture of ring 5 to be formed in cavity 15. Plastics may be introduced into the mould, when closed as shown in figure 5, to form a ring 5 in cavity 15. Mould sections 9 and 10 may then be moved to the left to open the mould, finger 13 lifted upwards and mould sections 9 and 10 moved apart to free ring 5 moulded in cavity 15.

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To form the next row the ring in cavity 11 is moved to cavity 12, a new ring is placed in cavity 11, the mould is closed as shown in figure 5 and a new ring is formed in cavity 15. It will be appreciated that figure 5 shows a section of a mould which may be repeated along the mould to form a continuous row of mesh.

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Referring now to figures 6a to 18 an apparatus for continuous mesh production is described. Figures 6a to 6c show the major components of the apparatus including mould sections 30, 31 and 32. Mould sections 30 and 31 can separate from mould section 32 as seen in figures 6b and 6c. A plurality of fingers, one of which is indicated at 37a move with mould section 30 and are movable vertically with respect thereto. Mould section 30 is movable with respect to mould section 31 to allow moulded link elements to be released as shown in figure 6b. Arm 33 is connected to bar 34 (shown in figure 7 and subsequently) which raises and lowers the fingers 37a as roller 35 is guided in slot 36 and section 30 is moved away from section 32.

Referring now to figures 7 to 11 a portion of the working faces of mould sections 30 and 31 are shown. These working faces may extend to the left and to the right as required to form a desired width of mesh. A plurality of fingers, of which only 37a to 37d are indicated, are secured to bar 34. Bar 34 is connected to arm 35 and raises and lowers fingers 37a to 37d as roller 35 moves in track 36. Figure 9 shows fingers 37a to 37d in their raised position whilst figures 7 and 8 show fingers 37a to 37d in their lowered position.

Preformed rings are supplied to the apparatus through supply tubes, some of which are indicated at 43a to 43e. Referring to figures 12 to 14 the form of the fingers 37a to 37d is shown. Finger 37a has partial annular cavities 39 and 40 in rear face 38. These cavities 39 and 40 are positioned so that when the fingers 37a to 37d are in the raised position shown in figure 9 rings supplied from supply tubes 43a to 43e may be located within partial annular cavities 39 and 40 of adjacent fingers. Cavities 39 and 40 include biasing elements 49 which urge rings retained therein away from cavities 39 and 40. The end 42 of finger 37a is engaged with bar 34. The distal end 41 is scalloped to assist product exit from the mould.

Referring now to figures 9 and 10 the working faces of mould sections 30 and 31 include cavities 45a to 45e for accommodating preformed rings and cavities 44a to 44e for accommodating rings overlapping those in cavities 45a to 45e. Ejector pins 48a to 48e move in and out in a direction normal to the page to assist in ejecting rings as will be described later. Ejector pins 48a to 48e include undercut

sections 47a to 47e which accommodate rings within cavities 45a to 45e when retracted.

Referring now to figure 11 a view along the line B-B is shown (see figure 10). It can be seen that semicircular cavities 46a to 46e are provided normal to the working face of mould section 31. Semicircular protrusions 55a to 55e which define half the circular core of a ring extend from mould section 30 so that when the mould is closed half an annular ring is defined by cavities 46a to 46e and protrusions 55a to 55e.

Referring to figures 15 to 18 the working face of mould section 32 shown. A plurality of semicircular recesses 51a to 51d form the other half of the annular cavities which form the moulded rings. Fingers 37a to 37d locate within cavities 50a to 50d with fingers 37a to 37d defining half of the core of rings formed in the annular cavities (the other half being formed by protrusions 55a to 55e). Injectors 53a to 53d (see figure 18) inject molten material into semicircular cavities 51a to 51d through apertures 52a to 52d during moulding. In one embodiment, the material is thermoplastic. In another embodiment, the material is metal.

Operation of the apparatus will now be described with reference to figures 6a to 18. Initially mould sections 30 and 31 are separated from mould section 32 and the fingers are in the raised position shown in figures 6c and 9. Rings contained in supply tubes 43a to 43e are urged towards fingers 37a to 37d and are retained within recesses 39 and 40 of respective fingers. Bar 34 is then moved down as mould sections 30 and 31 are moved towards mould section 32, so that the fingers assume the positions shown in figure 8. Biasing elements 49 in recesses 39 and 40 urge the rings into recesses 44a to 44e. These rings overlap rings already positioned within recesses 45a to 45e.

Mould sections 30 and 31 are then closed against mould section 32 so that fingers 37a to 37d are accommodated within recesses 50a to 50d (see figure 6a). Mould section 30 is also urged back into mould section 31 as the mould is closed. When the mould is closed recesses 51a to 51d and 46a to 46d define a disc shaped cavity. Fingers 37a to 37d in conjunction with projections 55a to 55e define a circular core so that a series of annular cavities are defined.

In one embodiment plastics is then injected by injectors 53a to 53d into cavities 51a to 51d so that rings are formed in cavities 51a to 51d and 46a to 46d.

Alternatively, cavities 51a to 51d (or another part of the mould cavity for each ring) may be commonly fed with molten material. Mould section 31 is then  
5 moved away from mould section 32 (as shown in figure 6b) and simultaneously mould section 30, which is biased with respect to mould section 31, moves away from mould section 31 sufficiently to enable rings formed in the mould to be released from mould section 30. Mould sections 30 and 31 are then moved further away, as indicated in figure 6c, along with fingers 37a to 37d. As mould  
10 sections 30 and 31 are moved away from mould section 32 roller 35 reaches a section in slot 36 where it causes bar 34 to rise. Bar 34 eventually rises to the position shown in figures 6c and 9.

At this point ejector pins 48a to 48e move in a direction out of the page to eject  
15 rings retained within cavities 45a to 45e. However, the rings in recesses 44a to 44e are retained as they are located on top of ejector pins 48a to 48e and behind fingers 37a to 37e. Fingers 37a to 37e are then partially lowered as mould section 30 is moved towards mould section 32 to retain the rings in recesses 44a to 44e. Ejector pins 48a to 48e are then retracted and the rings retained in  
20 recesses 44a to 44e then drop into recesses 45a to 45e. Mould sections 30 and 31 then close with mould section 32 and the apparatus is ready for the next mould cycle.

Although the link elements are shown to be formed in rows it will be appreciated  
25 that other moulding arrangements may be employed. For example adjacent link elements may be offset with respect to one another. It will also be appreciated that the apparatus may be adapted to enable two sheets of mesh to be joined. It will be appreciated that the method of invention may be implemented in many ways.

30 Following production the mesh may undergo further treatment processes. In the process of "flash flaming" the mesh may be exposed to a high-temperature heat source for a short period of time so that any minor surface imperfections are melted and each link element has a substantially smooth surface. Further, a  
35 coating may be applied to the mesh by electroplating, spray painting or some

other coating process. Coatings may be applied to provide physical properties or a particular appearance.

5 Mesh formed by the method of invention may be further processed to form products. A mesh may be maintained in a desired configuration, for example by draping the mesh over a mould, and then heating it so that the link elements fuse together and then cooling it so that the linking elements remain fixed relative to one another forming a rigid structure.

10 Alternatively, the mesh may be maintained in a desired configuration and a settable composition, such as a resin, is then applied and configuration is maintained until the settable material sets to form a rigid structure.

15 Link elements may be formed of a variety of materials that can exist in a fluid phase and then set, such as plastics, metals, glass, absorbent or non absorbent foams, flexible polymers etc. A mesh may contain a mixture of linking elements formed of different materials. Further, the optical characteristics of link elements may be varied over the mesh to create a pattern or particular visual appearance. For example, different patterns may be created using link elements of different  
20 colours and/or transparent link elements.

Link elements may also take a variety of shapes which may be mixed with a mesh. Some examples of closed loop link elements are shown in figures 19A to 19H. Other novelty shapes such as hearts etc may also be used. Further, link  
25 elements may have patterns or indicia moulded into their surface.

Figure 20 shows another form of link element in the form of a circular disc 66 having a plurality of apertures 67 to 70 provided therethrough. Rings or other linking elements may be formed through apertures 67 to 70. It will be  
30 appreciated that a wide variety of link element shapes and configurations may be employed as well as traditional mesh arrangements utilising 1:3; 1:4 or 1:6 link element layouts.

35 Mesh formed by the method or apparatus of invention may find use in a wide variety of applications including: filtration; pollution control; signage, flags,

displays etc.; conveyors ; baffles; armour, clothing ; furniture, such as hammocks, deck chairs etc; screens, curtains etc..

5 It has been found that mesh is particularly effective at collecting materials such as oil from the surface of a fluid, such as water. A mesh formed of link elements formed of absorbent material or including links formed of an absorbent material in may provide additional capacity for oil collection. The mesh may be provided on a drum or as part of a conveyor system so that collected material may be continuously removed by a washing system or wringer etc..

10 There is thus provided a quick and economic method and apparatus for the continuous manufacture of mesh using a variety of materials. Mesh having a range of physical and optical properties may be produced. The mesh may have good structural strength and a smooth surface appearance. The method may also allow mesh having small link elements to be produced economically.

20 While the present invention has been illustrated by the description of the embodiments thereof, and while the embodiments have been described in detail, it is not the intention of the Applicant to restrict or in any way limit the scope of the appended claims to such detail. Additional advantages and modifications will readily appear to those skilled in the art. Therefore, the invention in its broader aspects is not limited to the specific details, representative apparatus and method, and illustrative examples shown and described. Accordingly, departures may be made from such details without departure from the spirit or scope of the Applicant's general inventive concept.

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**Claims**

1. A method of forming a mesh comprising:
  - a. providing a plurality of link elements; and
  - b. moulding a plurality of link elements through the link elements so as to interconnect the link elements to form a continuous mesh of interconnected link elements.
2. A method as claimed in claim 1 wherein a plurality of link elements in a row are successively provided and are interconnected together and to previously provided link elements by link elements moulded therethrough.
3. A method as claimed in claim 2 wherein, apart from at the edges of the mesh, the moulded link elements link on each side to a previously provided link element and to a link element of a new row provided.
4. A method as claimed in any one of the preceding claims wherein the moulded link elements are formed in an orientation transverse to the link elements they interconnect with.
5. A method as claimed in claim 4 wherein the moulded link elements are formed substantially normal to the link elements they interconnect with.
6. A method as claimed in any one of the preceding claims wherein the link elements are in the form of a closed loop having a central aperture.
7. A method as claimed in any one of the preceding claims wherein the link elements are rings.
8. A method as claimed in any one of claims 1 to 5 wherein the link elements have multiple apertures for receiving link elements moulded therethrough.
9. A method as claimed in claim 1 wherein a first plurality of link elements are provided in a first plurality of cavities within a mould.
10. A method as claimed in claim 9 wherein the first plurality of link elements are successively fed through the first cavities over a number of moulding cycles such that each first link element is interconnected to at least two moulded link elements on either side.
11. A method as claimed in claim 10 wherein 2 link elements are contained within each first cavity during moulding.
12. A method as claimed in any one of the preceding claims wherein the link elements are formed of plastics.
13. A method as claimed in any one of the preceding claims wherein the link elements are formed of glass.

14. A method as claimed in any one of the preceding claims wherein the link elements are formed of metal.
15. A method as claimed in any one of the preceding claims wherein some link elements have different optical characteristics.
- 5 16. A method as claimed in claim 15 wherein some link elements have different colours which form a pattern in the mesh.
17. A method as claimed in any one of the preceding claims wherein the mesh is subjected to flash flaming after formation of the mesh.
- 10 18. A method as claimed in any one of the preceding claims in which the mesh is maintained in a desired configuration and heated so that link elements fuse together when cooled so that the mesh retains the desired configuration.
19. A method as claimed in any one of the preceding claims wherein the mesh is electroplated after formation of the mesh.
- 15 20. A method as claimed in any one of the preceding claims wherein a binding agent is applied to the mesh which when set forms a rigid composite product.
21. A method as claimed in claim 20 wherein the binding agent is a resin.
22. A method comprising:
- 20 a. positioning a first plurality of link elements in a first plurality of first positions in a mould;
- b. positioning a second plurality of link elements in a second plurality of second positions in the mould;
- 25 c. moulding a third plurality of link elements in a third plurality of positions in the mould to interlink with the first plurality and the second plurality of link elements;
- d. advancing a subset of the first plurality of link elements to reside in the second plurality of second positions in the mould; and
- 30 e. moulding a fourth plurality of link elements to interlink with the subset of the first plurality of link elements.
23. Mesh formed by the method of any one of the preceding claims.
24. An apparatus for forming a mesh including a mould formed as a plurality of sections, at least some of which close together to define cavities to mould link elements and separate to release moulded link elements, the mould including:
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- a. a plurality of first cavities to retain a plurality of link elements at spaced intervals; and
- b. a plurality of second cavities dimensioned and arranged when the mould sections are closed to form cavities to form link elements in the second cavities that pass through link elements located within the first cavities.

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25. An apparatus as claimed in claim 24 wherein the first cavities are provided in a row at spaced intervals and the second cavities are dimensioned and arranged to form link elements interconnecting with link elements located within adjacent first cavities.

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26. An apparatus as claimed in claim 25 wherein the first cavities are dimensioned and arranged to retain link elements substantially in a first plane and the second cavities are dimensioned and arranged so that link elements formed in the second cavities lie generally in a plane transverse to the first plane.

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27. Apparatus is claimed in any one of claims 24 to 26 wherein the first cavities accommodate a plurality of link elements

28. An apparatus as claimed in any one of claims 24 to 26 wherein the first cavities accommodate two link elements.

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29. An apparatus as claimed in claim 27 or claim 28 including a mechanism for sequentially advancing link elements retained within the first cavities from an input end to an output end.

30. An apparatus as claimed in any one of claims 24 to 29 wherein the mould includes first and second mould sections which together define part of the second cavities and a third mould section which defines the other portion.

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31. An apparatus as claimed in claim 30 wherein retractable fingers define a portion of an aperture to be formed within each link element moulded in each second cavity.

32. An apparatus as claimed in claim 30 or claim 31 wherein a portion of each second cavity is defined by the first and second mould sections which may be moved relative to each other to release linking elements moulded therein.

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33. An apparatus as claimed in any one of claims 30 to 32 wherein the third mould section and the fingers define the remaining portions of the second mould cavities.

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34. An apparatus as claimed in any one of claims 31 to 33 wherein the fingers feed link elements to the first cavities.
35. An apparatus as claimed in any one of claims 24 to 34 including ejectors for ejecting rings from the first cavities.
- 5 36. A mesh formed of link elements wherein interlinking link elements are formed as continuous unjoined loops by a moulding process.
37. A mesh as claimed in claim 36 formed of plastics.
38. A mesh as claimed in claim 36 formed of metal.
39. A mesh as claimed in claim 36 formed of glass.
- 10 40. A mesh as claimed in claim 36 formed of a flexible polymer.
41. A mesh as claimed in claim 36 formed of an absorbent foam.
42. A mesh as claimed in any one of claims 36 to 41 wherein some of the link elements have different optical properties.
43. A mesh as claimed in any one of claims 36 to 41 wherein some of the link elements are different colours.
- 15 44. A mesh as claimed in claim 43 wherein the different coloured link elements form a pattern or graphic design.
45. A mesh as claimed in claim 36 wherein the link elements have substantially identical shape.
- 20 46. A mesh as claimed in claim 36 wherein the link elements have substantially identical cross-section.
47. A mesh as claimed in claim 36 wherein some of the link elements have multiple apertures therethrough.
48. A mesh is claimed in claim 36 or claim 41 wherein the mesh is a pollution collection mesh.
- 25 49. A mesh as claimed in claim 48 in the form of a continuous loop.
50. A mesh comprising a plurality of link elements without joins interlinked to form a two-dimensional mesh of the link elements.