

(21) Application No 8719357.9

(22) Date of filing 15.08.1987

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(51) INT CL'
B21D 22/10 // B21D 37/20

(52) UK CL (Edition J)
B3Q Q2AX2 Q2A3 Q2A8 Q2G
B3A A163B

(56) Documents cited
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(58) Field of search
UK CL (Edition J) B3A, B3Q
INT CL' B21D, B23P

(54) A sheet metal forming tool and methods of making and using same

(57) A sheet metal forming tool has a die (11) and a punch (13), the die (11) having recess (12) into which is secured an insert (20) of a deformable but incompressible material such as rubber or an elastomer (eg polyurethane, chloroprene).

The volume of the insert (20) is such that when the punch (13) and die (11) are brought together into a position of closest proximity, with a sheet metal blank (16), the remaining volume is filled by the insert (20). The insert (20) has a protuberance (17) and acts so as to clamp the sheet metal blank (16) between the punch (13) and the die (11) before urging the sheet metal blank (16) into a reverse form cavity (15) in the punch (13). In an alternative form, the insert can be carried by the punch. The insert can be a flexible bag filled with liquid.

The tool of figure 1 can be made by a method comprising machining the punch (13), applying a release agent to the punch, filling a recess in the die (11) with the insert material while the punch is engaged in the die, and separating the punch and die after the insert material has solidified.

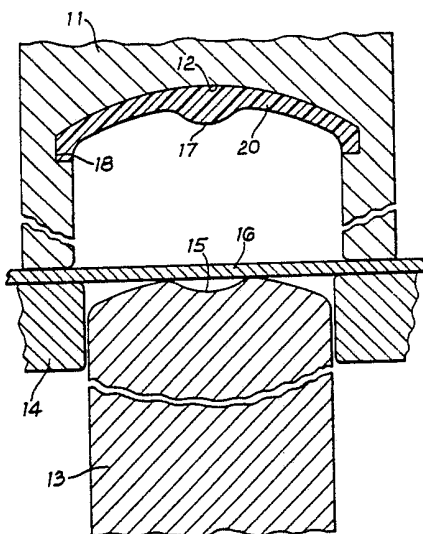


Fig. 1

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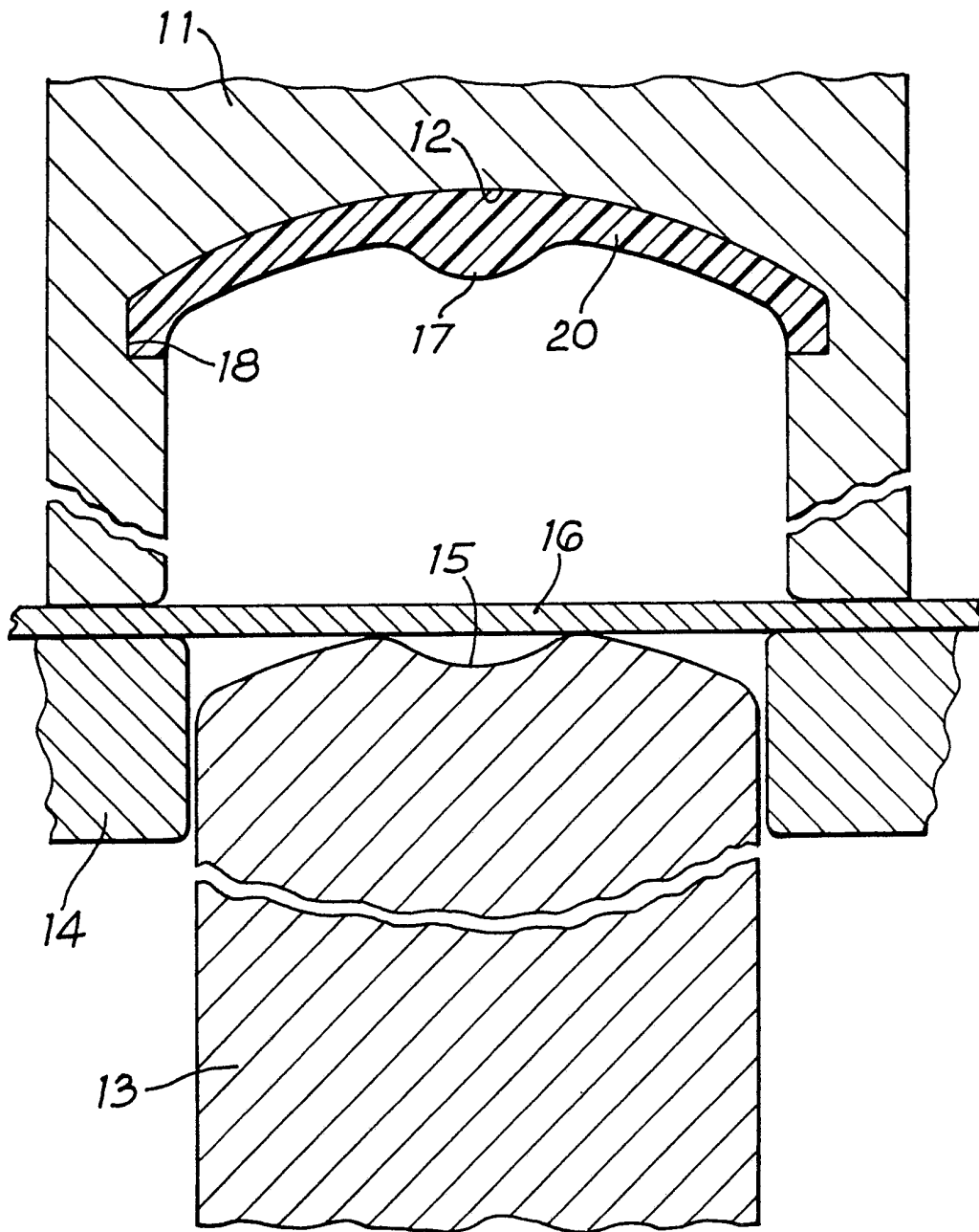


Fig. 1

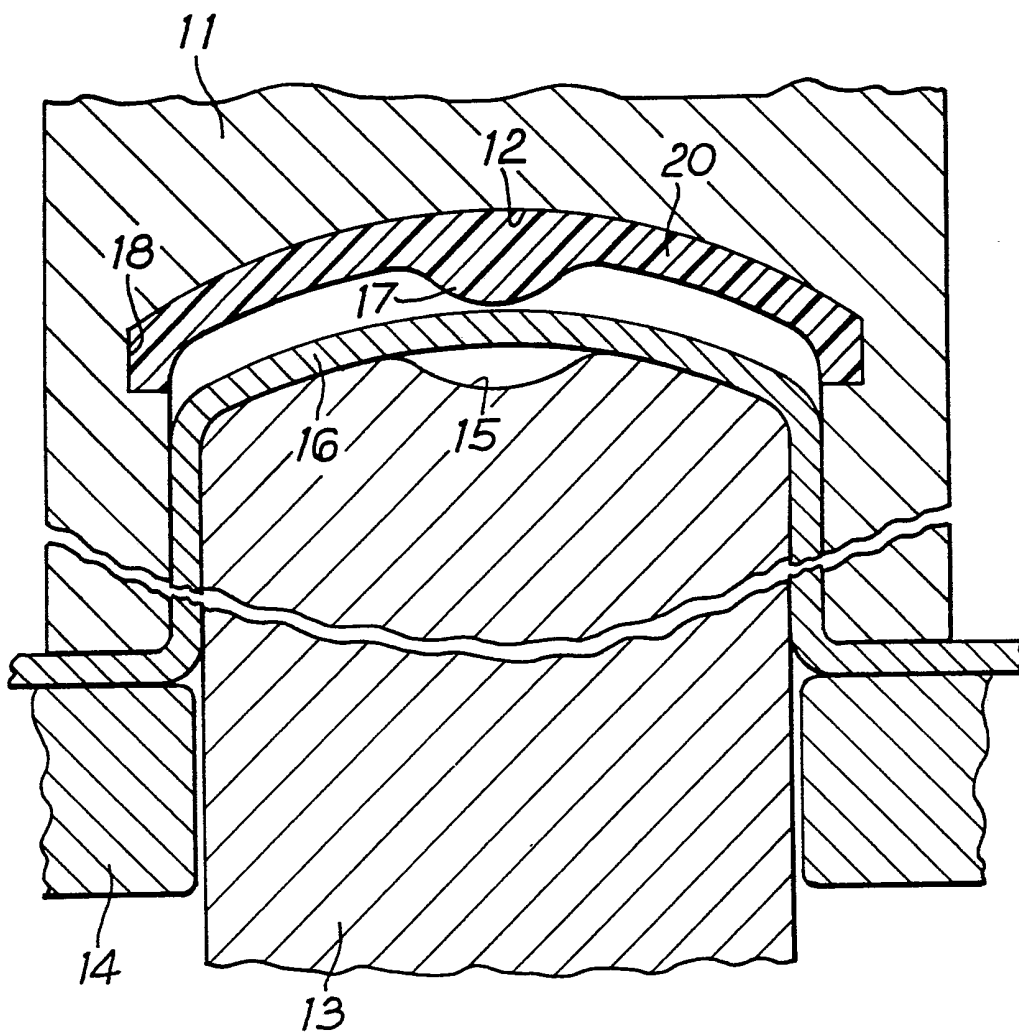


Fig. 2

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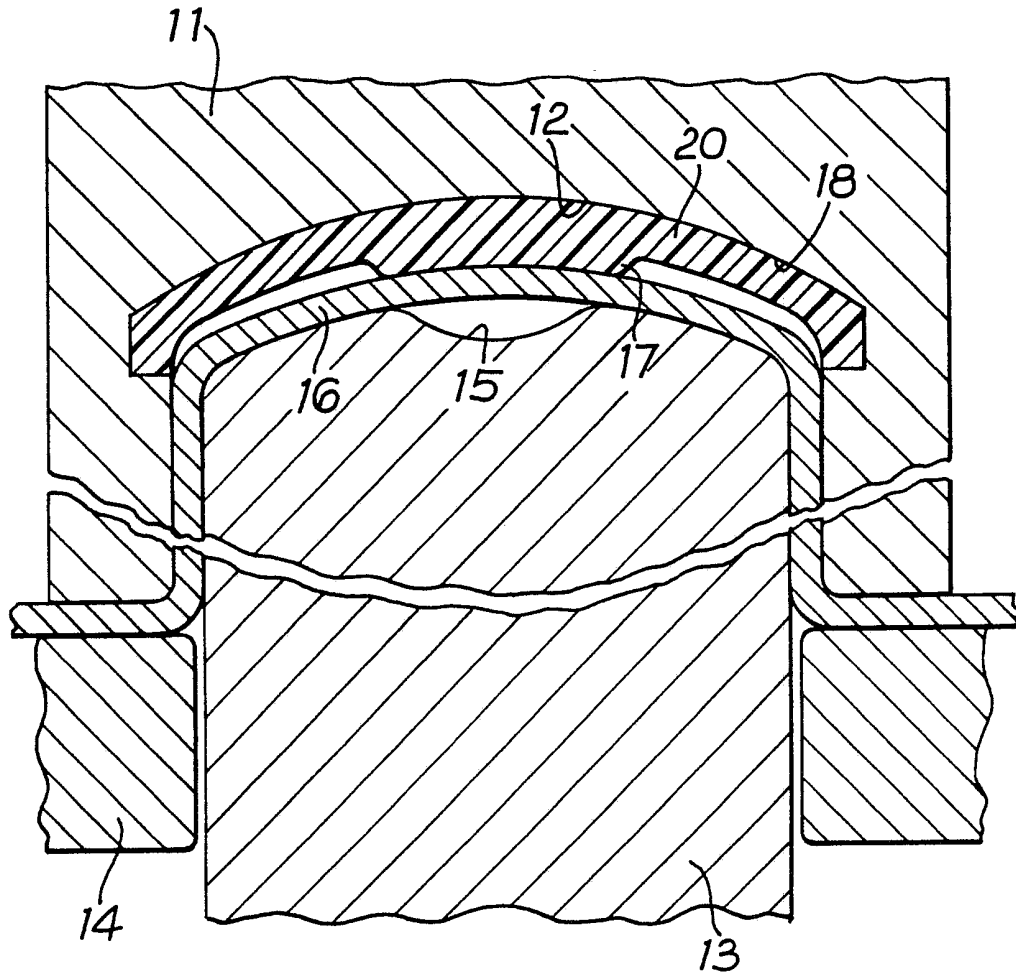


Fig. 3

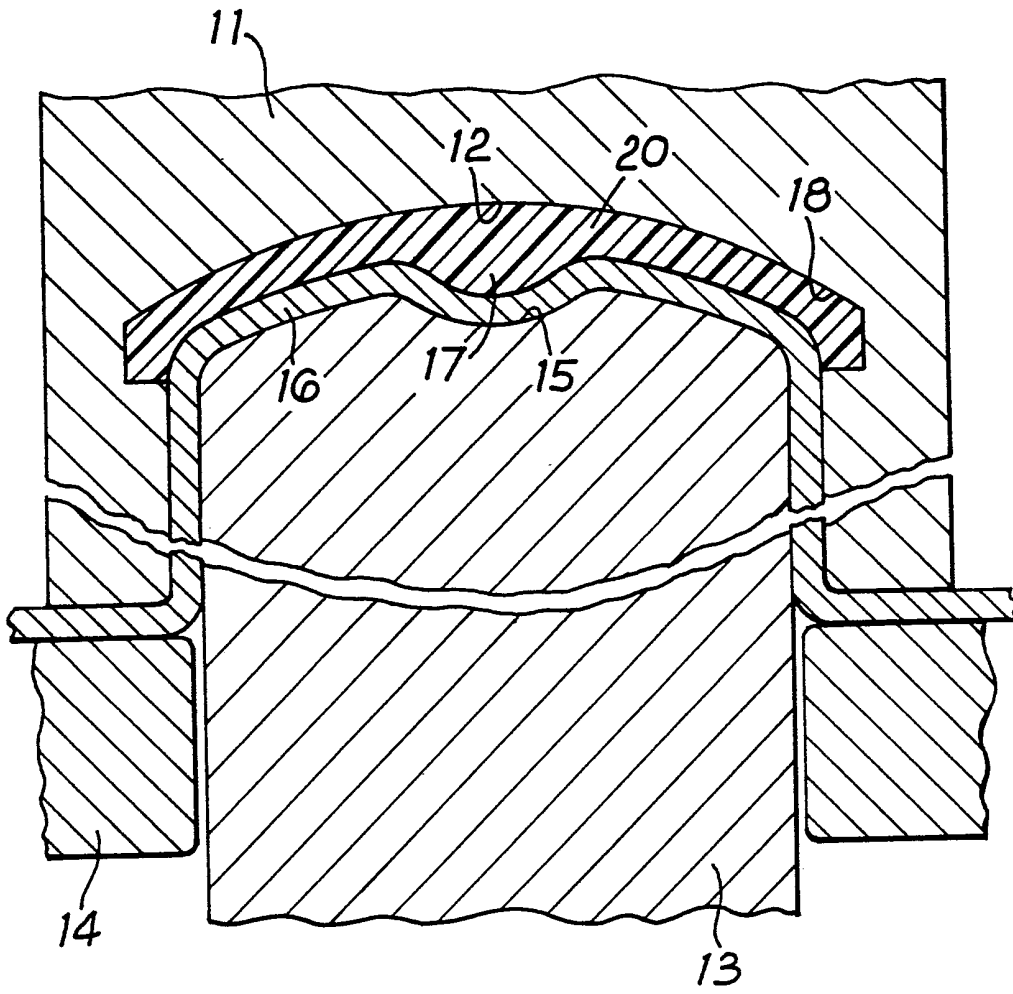


Fig. 4

A Sheet Metal Forming Tool and methods
of making and using same.

This invention relates to metal forming and in particular to a sheet metal forming tool for drawing sheet metal such as panels for motor vehicles and methods of making such a tool and use in the production of such panels.

It is known that sheet metal can be formed into non-planar shapes such as motor vehicle body panels by using a drawing process in which the sheet metal is drawn over a punch by the movement of a die.

It is a problem with such prior art metal forming tools that it is difficult to control the sheet metal during the drawing process and this can result in the panel produced being defective. This is particularly so where there is a requirement for a reverse form in the panel which will almost always result in unnecessary deformation of the panel in the region of the reverse form.

It is an object of this invention to provide a metal forming tool that provides greater control over the sheet metal during the forming process.

According to a first aspect of the invention there is provided a sheet metal forming tool having a die and a punch at least one of which is provided with an insert able to undergo a limited initial deformation before becoming substantially incompressible, the insert being restrained by the walls of a recess into which it is fitted and being of such a volume that when the punch and die are brought together into a position of closest proximity with the sheet metal being formed in-situ the remaining volume is filled by the insert.

The insert may be made from a rubber or elastomeric material such as polyurethane.

Alternatively, the insert may be a flexible bag filled with a liquid.

According to a second aspect of the invention there is provided a method of manufacturing a metal forming tool according to said first aspect of the invention which includes the steps of machining the punch to the correct shape and dimensions; applying to the punch a removable coating of a release agent of thickness equal to that of the sheet metal to be formed; producing a die having a recess in it; bringing the punch and die into a position corresponding to that of closest proximity; filling the recess with the insert material; allowing the insert material to solidify; separating the punch and die and removing the release agent from the punch.

Alternatively, the method of manufacturing the metal forming tool may include the steps of machining the die to the correct shape and dimensions; applying to the die a removable coating of a release agent of thickness equal to that of the sheet metal to be formed; producing a punch having a recess in it; bringing the die and punch into a position corresponding to that of closest proximity; filling the recess with the insert material; allowing the insert material to solidify; separating the die and punch and removing the release agent from the die.

According to a third aspect of the invention there is provided a method of manufacturing a reverse form panel using a metal forming tool according to said first aspect of the invention comprising the steps of;- inserting a sheet metal blank between the open punch and die; bringing the punch and die together to cause an initial deformation of the insert causing it to act so as to clamp the sheet metal blank; continuing the bringing together of the punch and die to a position of closest proximity to produce said reverse form; separating the punch and die and removing the formed sheet metal blank from between the punch and die.

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

Fig 1 is a cross-section through a metal forming tool according to the first aspect of the invention showing the punch and die in a partially separated position at the start of the pressing operation;

Fig 2 is a cross-section similar to Fig 1 but showing the sheet metal drawn over the punch just prior to contact between the insert and the sheet metal blank;

Fig 3 is a cross-section similar to that of Figs 1 and 2 but showing the punch and die in a position just after contact between the insert and the sheet metal blank;

Fig 4 is a cross-section similar to that of Figs 1 to 3 but showing the punch and die in the position of closest proximity.

With reference to Figs 1 to 4 there is shown a metal forming tool having a die 11, a punch 13 and a blank holder 14.

The die 11 has a recess 12 formed in an end face into which is fitted an insert 20 in the form of a block of polyurethane. The insert 20 is restrained by the peripheral walls 18 of the recess 12 and is of such a volume that when the punch 13 and die 11 are brought together into a position of closest proximity with a sheet metal blank 16 in-situ the remaining volume is filled by the insert.

The punch 13 has a reverse form cavity 15 at some point on the end face to produce in combination with a complementary protruberance 17 on the insert 20 a reverse form on the sheet metal blank 16 when the punch 13 and die are brought into the position of closest proximity.

Operation of the metal forming tool is as follows, first the punch 13 and the die 11 are separated allowing the sheet metal blank 16 which is to be formed into an outer door skin for a motor vehicle to be inserted therebetween.

The die 11 is then urged downward by a press (not shown) into contact with the upper surface of the sheet metal blank 16 as shown in Fig 1. Further downward movement of the die 11 also moves the blank holder 14 against the action of an air cushion or springs (not shown) urging the blank holder upwards to provide a clamping force. The sheet metal blank 16 is thereby clamped between the die 11 and the blank holder 14 causing the sheet metal blank 16 to be drawn over the punch 13 as shown in Fig 2.

Further downward movement of the die 11 results in the end of the protruberance 17 contacting the upper surface of the sheet metal blank 16. However, instead of the sheet metal blank 16 being pushed by the protruberance 17 into the cavity 15, as would happen with a conventional die, the protruberance undergoes a slight initial deformation as shown in Fig 3, the resistance to deformation of the protruberance 17 being less than that of the sheet metal blank.

The insert 20 during this initial deformation acts so as to clamp the sheet metal blank 16 around the periphery of the reverse form cavity 15.

As the die 11 is moved yet further towards the position of closest proximity between the end faces of the die and punch 11 and 13 the available volume between the die 11 and the punch 13 reduces but the insert 20 being made from an incompressible material acts so as to maintain its original volume.

The internal resistance to deformation of the insert is therefor increased to such an extent that it overcomes the resistance to deformation of the sheet metal blank 16 causing the sheet metal blank 16 to be forced into the cavity 15 under the action of the protruberance 17 to form a door handle recess as shown in Fig 4. During this final deformation of the sheet metal blank 16 the insert 20 continues to maintain its clamping effect on the sheet metal blank 16 thereby controlling the deformation of the sheet metal blank 16.

After reaching the position of closest proximity the die 11 begins to move upwardly away from the punch 13 until it reaches a position where the sheet metal blank 16 can be removed.

The metal forming tool previously described can be made in the following manner.

Firstly, the punch 13 is cast and then machined using a numerically controlled milling machine and then finish ground to produce the correct shape, size and surface finish.

The die 11 is made by casting it complete with recess 12 in a suitable material and then shot blasting the walls 18 of the recess 12 to provide a good keying surface.

The punch 13 is then coated with a release agent in the form of wax to a thickness corresponding to the thickness of the sheet metal 16 to be formed.

Polyurethane to metal adhesive is then brushed on to the cavity in the die 11 to assist adhesion between the insert 20 and the die 11.

The punch 13 and die 11 are then interengaged into a position corresponding to the position of closest proximity and the insert 20 in the form of liquid polyurethane is poured into the recess 12 to occupy the remaining volume between the punch 13 and the die 11.

After allowing the polyurethane to set into the solid state the punch 13 and die 11 are separated leaving the insert 20 bonded firmly to the walls 18 of the recess 12.

The wax is then removed from the punch 13 by steam cleaning or immersion in a suitable solvent to produce a sheet metal forming tool suitable for use in the method of manufacture of a motor vehicle body panel as previously described.

Although this invention has been described with reference to a specific embodiment in which the insert is made from polyurethane it is not limited to such a material, other rubber or elastomeric materials that can be deformed but are substantially incompressible could be used such as chloroprene.

Similarly, it would be possible to replace the polyurethane insert with a flexible bag containing liquid, in which case the volume of the bag and liquid would need to be equal to the remaining volume between the punch and the die at the position of closest proximity with the sheet metal blank in-situ. This could be achieved in a similar manner to that previously described with reference to the manufacture of the polyurethane block but instead of injecting polyurethane into the recess it would be necessary to

bond a bag of flexible impervious material within the recess of the die; bring the die and punch into a position corresponding to that of closest proximity; fill the bag with liquid; seal the bag and separate the punch and die.

This invention has been described with reference to an arrangement where the insert is attached to the die and the punch has a reverse form cavity the reverse arrangement could also be used, in which case the die would be accurately made and the punch with insert made in a manner similar to that previously described with reference to the manufacture of the die.

Although this invention has been described with reference to a single action reverse form drawing tool it is not limited to such a tool and could be used in other metal forming tools where good control of the sheet metal being formed is required.

Claims

1. A sheet metal forming tool having a die and a punch at least one of which is provided with an insert able to undergo a limited initial deformation before becoming substantially incompressible, the insert being restrained by the walls of a recess into which it is fitted and being of such a volume that when the punch and die are brought together into a position of closest proximity with the sheet metal being formed in-situ the remaining volume is filled by the insert.
2. A sheet metal forming tool as claimed in claim 1 in which the insert is made from a rubber or elastomeric material.
3. A sheet metal forming tool as claimed in claim 2 in which, the insert is made from polyurethane.
4. A sheet metal forming tool as claimed in claim 1 in which the insert is a flexible bag filled with a liquid.
5. A sheet metal forming tool as claimed in any of claims 1 to 4 in which the sheet metal forming tool is a reverse form drawing tool.

6. A sheet metal forming tool as claimed in claim 5 when dependent upon claim 2 or claim 3 in which the punch has a reverse form cavity in it and the die has a complementary protruberance formed by said insert.

7. A sheet metal forming tool as claimed in claim 5 when dependent upon claim 2 or claim 3 in which the die has a reverse form cavity in it and the punch has a complementary protruberance formed by said insert.

8. A method of manufacturing a metal forming tool as claimed in claim 6 including the steps of machining the punch to the correct shape and dimensions; applying to the punch a removable coating of a release agent of thickness equal to that of the sheet metal to be formed; producing a die having a recess in it; bringing the punch and die into a position corresponding to that of closest proximity; filling the recess with the insert material; allowing the insert material to solidify; separating the punch and die and removing the release agent from the punch.

9. A method of manufacturing a metal forming tool as claimed in claim 7 including the steps of machining the die to the correct shape and dimensions; applying to the die a removable coating of a release agent of thickness equal to that of the sheet metal to be formed; producing a punch having a recess in it; bringing the die and punch into a position corresponding to that of closest proximity; filling the recess with the insert material; allowing the insert material to solidify; separating the die and punch and removing the release agent from the die.

10. A method of manufacturing a metal forming tool as claimed in claim 8 or in claim 9 in which the recess is filled by injection of the insert material.

11. A method of manufacturing a metal forming tool as claimed in any of claims 8 to 10 in which the release agent is wax.

12. A method of manufacturing a reverse form panel using a metal forming tool according to claims 6 or 7 comprising the steps of;- inserting a sheet metal blank between the open punch and die; bringing the punch and die together to cause an initial deformation of the insert causing it to act so as to clamp the sheet metal blank; continuing the bringing together of the punch and die to a position of closest proximity to cause the protruberance to force the sheet metal blank into the reverse form cavity thereby to produce said reverse form; separating the punch and die and removing the formed sheet metal blank from between the punch and die.