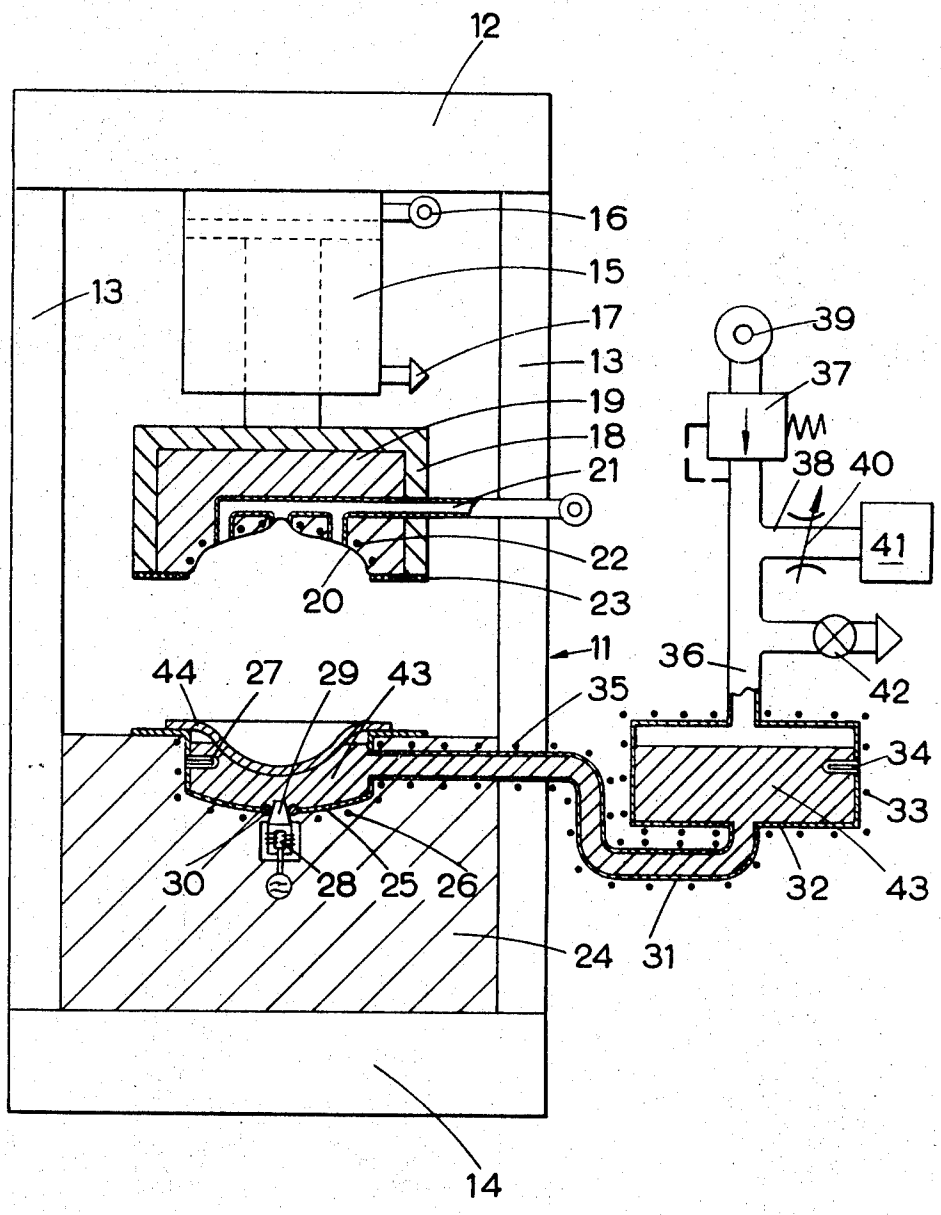
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METHOD OF FORMING SHEET OR PLATE MATERIAL

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METHOD OF FORMING SHEET OR PLATE MATERIAL

Roger David Butler, Kidlington, Ian Frederick Bowers, Freeland, and Cedric Charles Edward Colley, Wheatley, England, assignors to Pressed Steel Fisher Limited, Cowley, Oxford, England, a British company

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ABSTRACT OF THE DISCLOSURE

After forming superplastic sheet or plate material by heating the material to within the superplastic temperature range and then forming the material using at least one die, cooling gas is blown through the die to stiffen the formed material and then the gas pressure is increased to strip the formed material from the die; advantageously gas is also passed through the die during forming to produce a gas bearing or cushion on the forming surface of the die.

This invention relates to a method of forming, or shaping, sheet or plate material that exhibits superplasticity within a limited range of temperatures.

It is known that within a limited range of temperatures certain metal alloys, such as the eutectoid alloy of aluminium and zinc, and the eutectic alloy of aluminium and silicon, may be in a state such that they have especially low values of resistance to deformation and extremely high plasticity as compared with other similar alloys having different proportions of the elements, or to the same alloy in a different state or at a temperature outside said range. This phenomenon occurs below a certain strain rate at any particular temperature within the said temperature range and is known as superplasticity, and for convenience metal alloys which are capable of exhibiting this phenomenon are termed "superplastic" in this specification.

The object of this invention is to provide a method of forming or shaping superplastic sheet or plate material.

According to the invention a method of forming superplastic sheet or plate material by heating the material to within the superplastic temperature range and then forming the material using at least one die, includes so passing a gas through the die that the formed material is cooled, and then so increasing the gas pressure that the formed material is stripped from the die surface; the material being cooled to a temperature at which it is sufficiently rigid not to be permanently deformed during stripping.

Preferably the method also includes so passing gas through the die during forming that the gas generates a gas bearing or cushion on the surface of the die.

The gas may be passed through ducts formed in the die or the gas may be passed through a porous die.

An exemplary embodiment of the invention will now be described, solely by way of illustration with reference to the accompanying drawing which is a schematic, partially-sectioned, elevation of apparatus for effecting the invention.

The forming apparatus shown in the drawing includes a restraining frame **11** comprising a top platen **12** connected by tie posts, such as **13**, to a lower platen **14**.

A two-way, pneumatic piston and cylinder device **15** having an inlet **16** and an outlet **17**, supports a mould casing **18**.

Previously cast in the mould casing **18** is a concrete die **19** having a forming surface **20** and incorporating a compressed air inlet duct **21** and electric resistance heating coils **22** the duct **21** being connected to a controlled source of compressed air (not shown) and the coils **22** being controlled by a thermocouple temperature controlling device (not shown) responsive to temperature adjacent the forming surface **20**. The die **19** is fitted with a steel sealing flange **23** having deep narrow radial slots (not shown) formed on the outer, workpiece-holding, face.

The lower platen **14** supports a concrete back-up block **24** in which is embedded a steel forming chamber **25**. Electric resistance heating coils **26** are embedded in the concrete block **24** adjacent the chamber **25** and are controlled by a thermocouple enclosed in a metal or refractory sheath **27** extending into the chamber **25** and connected to a temperature controlling device (not shown).

A high frequency signal generator **28** has a horn **29** which extends into the chamber **25**, and is sealed by a high temperature O-ring **30**.

The chamber **25** is connected by a pipe **31** to a reservoir **32**. The reservoir **32** is surrounded by electric resistance heating coils **33** controlled by a thermocouple enclosed in a metal or refractory sheath **34** and connected to a temperature controlling device (not shown), and the pipe **31** is surrounded by further electric resistance heating coils **35** of which those adjacent the reservoir **32** are controlled by a thermocouple in the sheath **34** whilst those adjacent the forming chamber **25** are controlled by the thermocouple in the sheath **27**.

The top of the reservoir **32** is connected by the pipe **36** and through a pressure regulating valve **37** to a compressed air source inlet **39**, and is also connected by the branch pipe **38** through a metering valve **40** to a variable preset metering pump **41**. Furthermore the pipe **36** is provided with a pressure release valve **42**.

The reservoir **32**, the pipe **31** and the forming chamber **25** are filled with a low melting fusible metal alloy **43** having a melting point of 150° C. and maintained at 260° C. by the resistance heaters **26**, **33** and **35**; and the forming surface **20** of the die **19** is also maintained at 260° C. by the heating coils **22**.

In operation, a superplastic sheet workpiece **44** is placed as shown in the drawings; the workpiece may be formed of the eutectoid alloy of zinc and aluminium which has been prepared by quenching the sheet in water from 325°–350° C. to room temperature in order to induce the required superplastic state.

In this example the workpiece **44** has been pre-stretched by conventionally forming it in a press to the shape shown in the drawing. The workpiece **44** is placed in position as shown and the pneumatic device **15** is operated to move the die **19** towards the forming chamber **25** until the sealing flange **23** is loosely holding the workpiece **44**; the release valve **42** is closed, and the preset metering pump **41** is actuated to increase the pressure on the hot alloy **43** sufficiently to cause the alloy **43** in the forming chamber **25** to contact the workpiece **44** and thereby raise the temperature of the workpiece to 260° C., the air within the chamber **25** being displaced past the periphery of the workpiece **44**.

The device **15** is then operated to firmly grip the workpiece **44** and effect a seal between the workpiece **44** and the fluid chamber **25**. The signal generator **28** is energised and high pressure compressed air is admitted through the inlet **39**, the pressure regulating valve **37** and the pipe **36** into the reservoir **32**, and thereby the hot alloy **43** in the forming chamber **25** forces the workpiece **44** towards the surface **20** of the die.

Compressed air is then admitted through the duct **21** to generate an air bearing or cushion on the surface **20** of the die **19**. It will, of course, be understood that the ducting arrangement shown in the drawings is purely schematic, since the detailed design will depend on the various parameters individual to each workpiece. However as a generality the arrangement which will normal-

ly include a plurality of ducts connected to associated channels, is such that as a specific region of the workpiece is forced into close proximity with the die surface, the pressure of compressed air acting on that region is slightly in excess of the pressure of the hot alloy **43** by an amount which is sufficient to prevent contact of the workpiece with the die, but is insufficient to deform the shaped region of the workpiece; over the remainder of the workpiece the pressure of the compressed air will be lower than the forming pressure of the hot alloy **43** due to the relatively free escape of compressed air to the slots in the flange **23** which act as exhaust slots and which have a total exhaust area larger than the combined area of the compressed air inlets. Thus a pressure gradient exists from the region of the workpiece that is in close proximity to the die towards the exhaust slots, and hence final forming takes place progressively from the said regions to the exhaust slots.

During forming it will be understood that the air pressure in the pipe **36** and restrictions to flow must be such that the critical value of strain rate is not exceeded.

After the workpiece **44** has been formed to the required shape, the electric heating coils **22** are turned off, and the pressure release valve **42** is opened to allow the level of the hot alloy **43** in the forming chamber **25** to fall and simultaneously the pressure applied to the duct **21** is also allowed to fall.

The pressure in the pneumatic device **15** is then released.

Compressed air is then admitted at low pressure through the duct **21** to cool the workpiece **44** until it is sufficiently rigid to resist permanent deformation on stripping from the die **19**.

Stripping is then effected by increasing the pressure until the workpiece is stripped from the surface of the die.

The pneumatic device **15** is then operated to lift the die **19**, and the workpiece is removed.

What we claim is:

1. The method of forming superplastic sheet or plate workpiece material which includes the following steps:

(a) heating the workpiece to within its superplastic temperature range,

(b) deforming the workpiece at superplastic strain rates by forcing it against a die,

(c) removing the deforming force,

(d) expelling gas from the surface of the die so that the gas flows across substantially the entire surface of at least one face of the formed workpiece and towards the periphery thereof, thereby cooling the sheet,

(e) then increasing the gas pressure that the workpiece is stripped from the die.

2. The method of claim **1** including the additional step of

(a) expelling gas from the surface of the die recited at step (b) at such a rate that a cushion of air is maintained between the workpiece and the die during the deformation of the workpiece but at a rate insufficient to deform the die shaped regions of the workpiece.

3. The method of claim **2** wherein the step (a) takes place with a radially outwardly diminishing pressure gradient between the die and the workpiece.

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RICHARD J. HERBST, Primary Examiner

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18—19; 72—344, 364

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,529,458 Dated September 22, 1970

Inventor(s) R. D. Butler et al

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Claims priority, application Great Britain,

December 23, 1966 57,755/66; March 15, 1967 12068/67.

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(SEAL)
Attest:

Edward M. Fletcher, Jr.
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WILLIAM E. SCHUYLER, JR.
Commissioner of Patents

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