Oct. 9, 1962 S. H. A. THOMPSON 3,057,166

MACHINES FOR HEAT-FORMING THERMOPLASTIC ARTICLES

Filed March 20, 1961 3 Sheets-Sheet 1

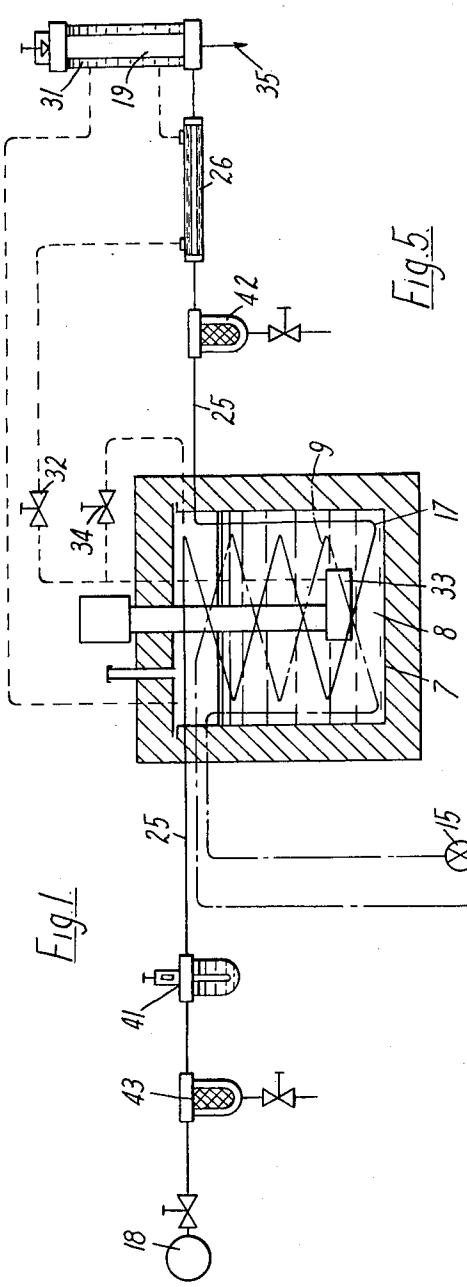

Fig. 1

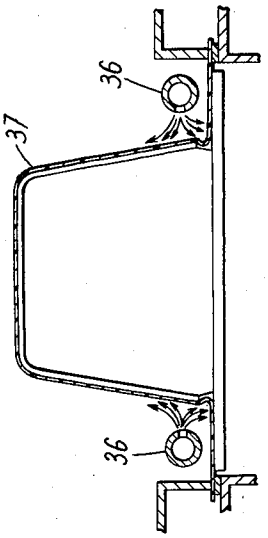

Fig. 5

Inventor
STANLEY HOWARD ABCOCK THOMPSON
By Morris & Bateman
Attorney

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Fig. 2.

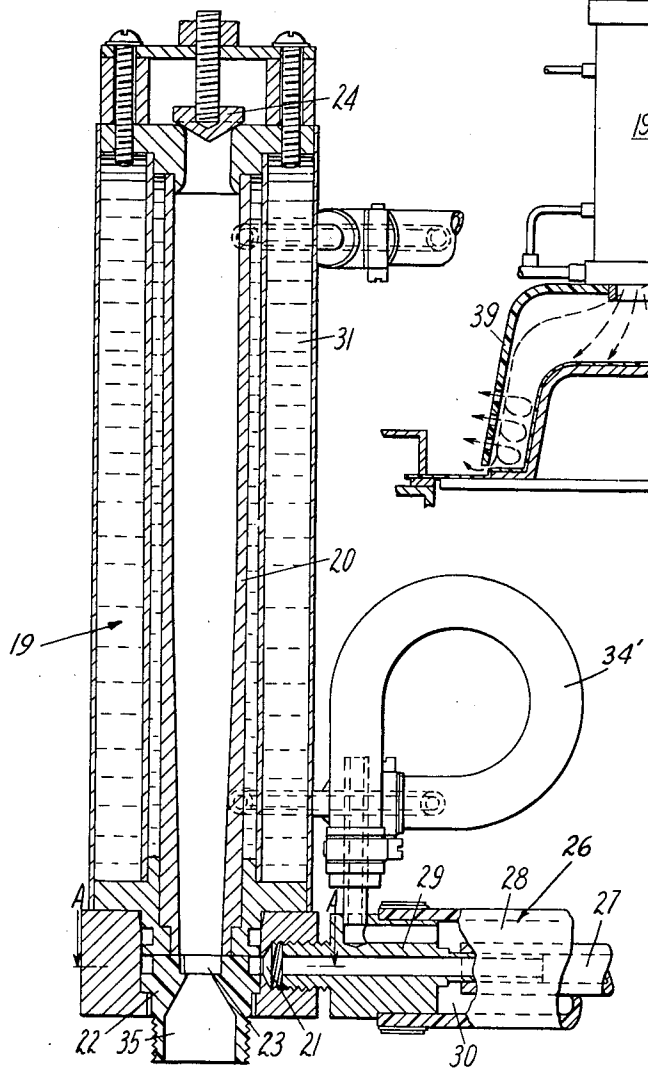
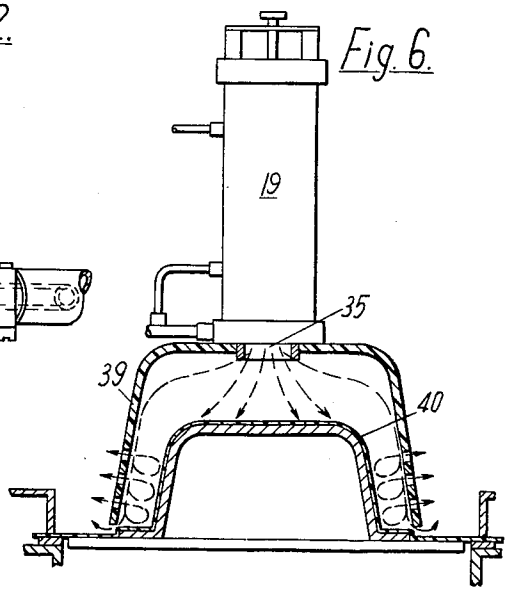


Fig. 6.



Inventor

STANLEY HOWARD ADCOCK THOMPSON

By Morris + Bateman

Attorneys

Oct. 9, 1962 S. H. A. THOMPSON 3,057,166

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Fig. 3.

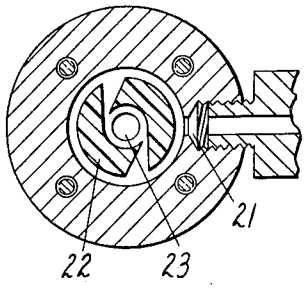
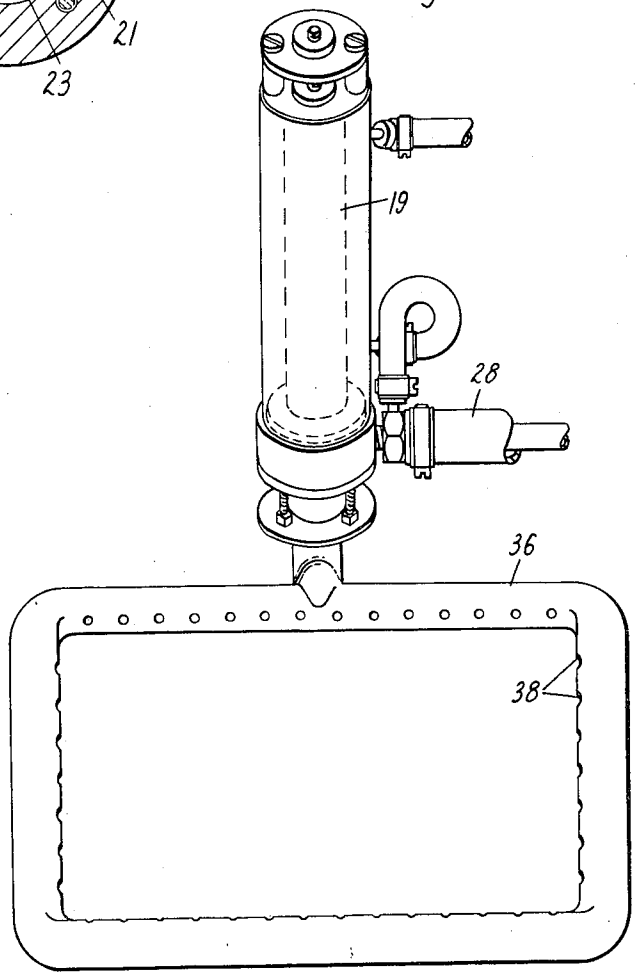


Fig. 4



Inventor

STANLEY HOWARD ADCOCK THOMPSON

By Norris Bateman

Attorney

United States Patent Office

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MACHINES FOR HEAT-FORMING THERMOPLASTIC ARTICLES

Stanley Howard Adcock Thompson, Stoke Bishop, Bristol, England, assignor to Parnall & Sons Limited, Birmingham, England, a British company

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5 Claims. (Cl. 62—5)

This invention relates to improvements in or connected with machines for heat-forming thermoplastic articles, and is directed to apparatus for chilling the mouldings produced in these machines to expedite their removal from the machine.

The invention consists of apparatus for chilling heat-formed thermoplastic articles, comprising in combination an air line, a heat exchanger connected in said air line for cooling the air flowing therethrough, a vortex type cooling tube the inlet whereof is connected to receive the cooled air in the air line, and a manifold connected to the vortex cooling tube to direct the cold fraction of air derived from said tube onto the surface of a moulding. Preferably the vortex tube incorporates a cooling jacket connected in a circuit for carrying the coolant liquid of the heat exchanger, and a second heat exchanger also cooled by said coolant liquid is provided to cool air flowing from the first heat exchanger into the vortex tube.

Further features of the invention will appear from the following description.

Preferred means for carrying the invention into practice is described, by way of example only, with reference to the accompanying drawings, wherein:

FIGURE 1 is a schematic diagram of apparatus according to the invention.

FIGURE 2 is a part sectional elevation of a vortex type cooling tube incorporated in the apparatus.

FIGURE 3 is a cross-section on the line A—A of FIGURE 2.

FIGURE 4 is a perspective view of the aforesaid vortex tube connected to one example of an air distributing manifold, and

FIGURES 5 and 6 show in part sectional elevation two alternative modes of application of the invention in a heat forming machine.

Referring initially to FIGURE 1 of the drawings there is provided a heat exchanger comprising a thermally lagged tank **7** containing ethylene glycol brine **8** serving as a coolant liquid. The coolant liquid is itself cooled by a refrigerating circuit (shown in chain lines) comprising an evaporator coil **9** immersed in the brine **8**, before the evaporator a compressor motor **10**, a condenser **11**, a liquid receiver **12**, a liquid stop valve **13**, a dehydrator **14**, and a thermostatically controlled expansion valve **15**, and after the evaporator coil **9** a return pipe **16** carrying the refrigerant fluid back to the compressor **10**.

Also immersed in the brine bath **8** is a helical pipe **17** connected to carry air under pressure from a compressor **18** to the inlet of a Hilsch type vortex tube unit **19**. As best shown in FIGURES 2 and 3 the vortex tube unit **19** generally comprises a tubular body **20** having adjacent one end an air inlet nozzle **21** directing an air current into the interior of the tube **20** tangentially relative to the cylindrical form of its interior wall. Adjacent the inlet nozzle **21** the vortex tube is restricted by an element **22** having a central aperture **23** which permits the escape of a cooled fraction of the air injected into the tube, whereas the opposite end of the tube incorporates an adjustable throttle **24** for determining the fraction of hot air escaping from the tube. Advantageously the vortex tube **20** is of frusto-conical form diverging from the element **22** towards the throttled hot air outlet **24**.

For a more detailed description of the aforesaid known type of vortex tube unit reference can be made to pages 154 to 156 of "Engineering" of August 1, 1958, published in Great Britain, and to earlier references specified therein.

In the vertex tube unit **19** we find that the inlet nozzle **21** and the apertured element **22** through which the cold air is ejected, are advantageously composed of a heat insulating material such as for example nylon in order to reduce heat losses in these regions of the tube.

Between the tank **7** and the inlet end of the vortex tube unit **19** is connected in the air line **25** a second heat exchanger **26** for further cooling the air flowing into the inlet of the vortex tube. This heat exchanger comprises a pair of flexible concentric tubes **27** and **28** connected by bushes at each end to form an annular jacket **30** about the inner tube **27** whereby air flowing through the inner tube is cooled by brine pumped from the tank **7** through the said jacket **30**. Preferably the vortex tube unit **19** also incorporates a cooling jacket **31** connected in the circuit of the coolant liquid in series with the jacket **30**.

The brine **8** is circulated (shown in broken lines in FIGURE 1) from the tank **7** through an adjusting valve **32**, though the flexible heat exchanger **26**, and through the vortex tube cooling jacket **31** back to the tank **7** by means of an electric motor driven pump **33** incorporated in the tank. Preferably a portion of the brine flowing through the aforesaid circuit is by-passed through a valve **34** (FIGURE 1) and a conduit **34'** (FIGURE 2) back into the tank so as to agitate the brine therein.

The cold air fraction outlet **35** of the vortex tube is connected to a manifold for distributing the cold air over the surface of a thermoplastic moulding prior to removal of the moulding from the moulding machine. For example as shown in FIGURES 4 and 5 the vortex tube outlet may be connected to an endless pipe **36** shaped so as to surround the moulding **37** and provided with perforations **38** in its wall for directing cold air jets onto the moulding. Alternatively, as illustrated in FIGURE 6, the cold air outlet **35** of the vortex tube **19** may be mounted on a heat insulating cowl **39** shaped for location over the moulding **40** so as to enclose cold air currents between the cowl and moulding.

It is found in practice that difficulty may be encountered in cooling the supply of compressed air substantially below ambient temperature due to the formation of frost over the surfaces of the heat exchanger which frost may result in the blockage of the heat exchanger tubing **17**. This difficulty can be obviated by the injection of ethylene glycol into the air stream prior to its introduction into the cooling coil **17** within the tank **7**, whereby the wall of the tubing **17** is wetted causing the water condensation in the tube to remain liquid due to the freezing point depression of the ethylene glycol/water solution.

The injection of the ethylene glycol into the air pressure line can be conveniently effected by connecting in the air line **25** a cleaner **43** and a conventional type of drip feed lubricator **41** wherein ethylene glycol takes the place of the oil. The ethylene glycol solution which has been swept through the heat exchanger tubing **17** in the tank is separated from the air by means of a conventional form of separator **42**.

In one example of operation of the above described apparatus compressed air was admitted to the cooling coil **17** within the tank at a presure of 90 p.s.i. with the brine temperature maintained at 20° F. The temperature of the air entering the coil was 68° F. At the point of entering the flexible heat exchanger **26** the air temperature was reduced at 30° F., and with the hot fraction throttle **24** of the vortex tube **19** closed and the brine circulating through the vortex tube jacket **31**, an air volume of 15 cubic feet per minute was delivered through the cold air

outlet 35 of the vortex tube at a temperature of minus 15° F.

I claim:

1. Apparatus for chilling heat-formed thermoplastic articles, comprising in combination an air line, a heat exchanger connected in said air line for cooling the air flowing therethrough, a vortex type cooling tube the inlet whereof is connected to receive the cooled air in the air line, said cooling tube having an outlet for discharging a cold fraction of air successively cooled by said heat exchanger and said cooling tube, and a manifold directly connected to the said outlet of the vortex cooling tube to direct the cold fraction of air derived from said tube onto the surface of an article.

2. Apparatus for chilling heat-formed thermoplastic articles comprising in combination a heat exchanger vessel containing coolant liquid, refrigerating apparatus having an evaporator immersed in said liquid, means providing a source of air under pressure and comprising an air conduit extending through said liquid coolant, a vortex type air cooling tube having an inlet connected to said air conduit to receive air cooled in said conduit, means providing a cooling jacket about said conduit between said vessel and said cooling unit, means providing a cooling jacket about said cooling tube, pump means connected to circulate said liquid coolant through both of said jackets, and means for discharging air cooled by said tube onto said articles comprising a manifold connected to the cold air fraction outlet of said vortex cooling tube.

3. Apparatus as defined in claim 2 further comprising a system of valving and conduit means for re-introducing directly into the vessel at least a part of said coolant liquid that has passed through said jackets for agitating the liquid coolant in said vessel.

4. Apparatus according to claim 1 comprising means for feeding a freezing point depressing component into said air conduit before it enters the heat exchanger vessel, and a separator unit connected in the air conduit after it leaves the heat exchanger vessel.

5. Apparatus for providing a continuous source of chilled gas comprising a vessel containing liquid coolant, means for refrigerating said coolant liquid to a desired temperature, means providing a source of said gas under pressure, a vortex type gas cooling unit having an inlet connected by conduit means to said source and an outlet adapted to be connected to a point of use for said chilled gas, a heat exchanger connected to receive said refrigerated coolant and operatively connected to said conduit means for cooling gas flowing through said conduit means before entry into said unit, and means for applying said refrigerated coolant to said unit for further cooling of the gas passing through said unit.

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