United States Patent [19]

Schott, Jr.

[11] **3,743,252**

[45] **July 3, 1973**

[54] **AIR COOLED EXTRUDER**

[75] Inventor: **Charles M. Schott, Jr.**, Gloucester, Mass.

[73] Assignee: **Gloucester Engineering Co., Inc.**, Gloucester, Mass.

[22] Filed: **Mar. 16, 1972**

[21] Appl. No.: **235,372**

[52] **U.S. Cl.**..... **259/191**, 259/DIG. 18, 425/378

[51] **Int. Cl.**..... **B01f 7/08**

[58] **Field of Search**..... 259/191, 192, 193; 165/109, 157, 183, 184, 124; 259/9, 10, 25, 26; 425/144, 378, 379

[56] **References Cited**

UNITED STATES PATENTS

2,640,033	5/1953	Marshall	259/193
2,774,107	12/1956	Davis	425/378
2,982,990	5/1961	Zomlefer	259/191
3,218,671	11/1965	Justus	425/144
3,317,962	5/1967	Morse	259/191
3,431,599	3/1969	Fogelberg	259/191

Primary Examiner—Robert W. Jenkins
Attorney—John Noel Williams

[57] **ABSTRACT**

Forced air cooled extruder having high heat transfer capability employs preformed fins, preferably of silver-bearing copper plate, heat shrunk about steel barrels. Alternatively fins of less strength are prevented from retaining permanent deformation (due to low temperature exposure) by steel hoops which re-deform the fin upon heating. Fins formed with larger area on downstream side and fins with heat flow restrictions on upstream side enable balanced heat flow conditions to be achieved to avoid warping of barrel and binding of screw therein. Fins with straight parallel sides at barrel, and converging straight sides downstream conforming with planar duct wall portions are shown. End to end series of adjustable dampers across duct cross section which corresponds to barrel length provides regulation of air cooling.

17 Claims, 6 Drawing Figures

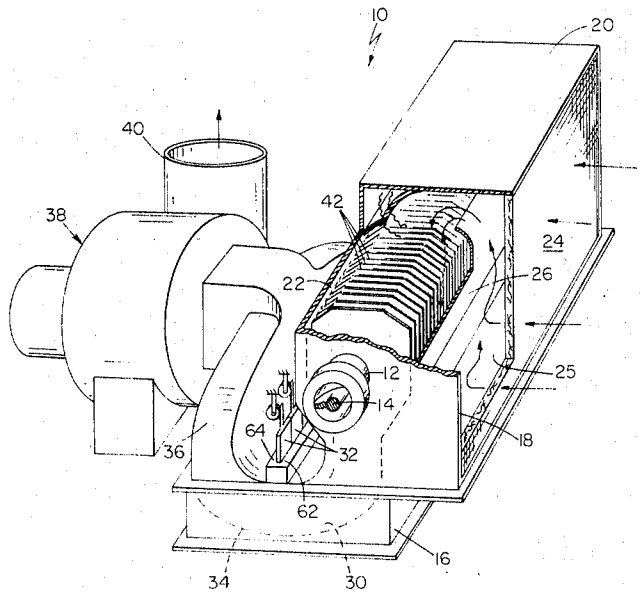
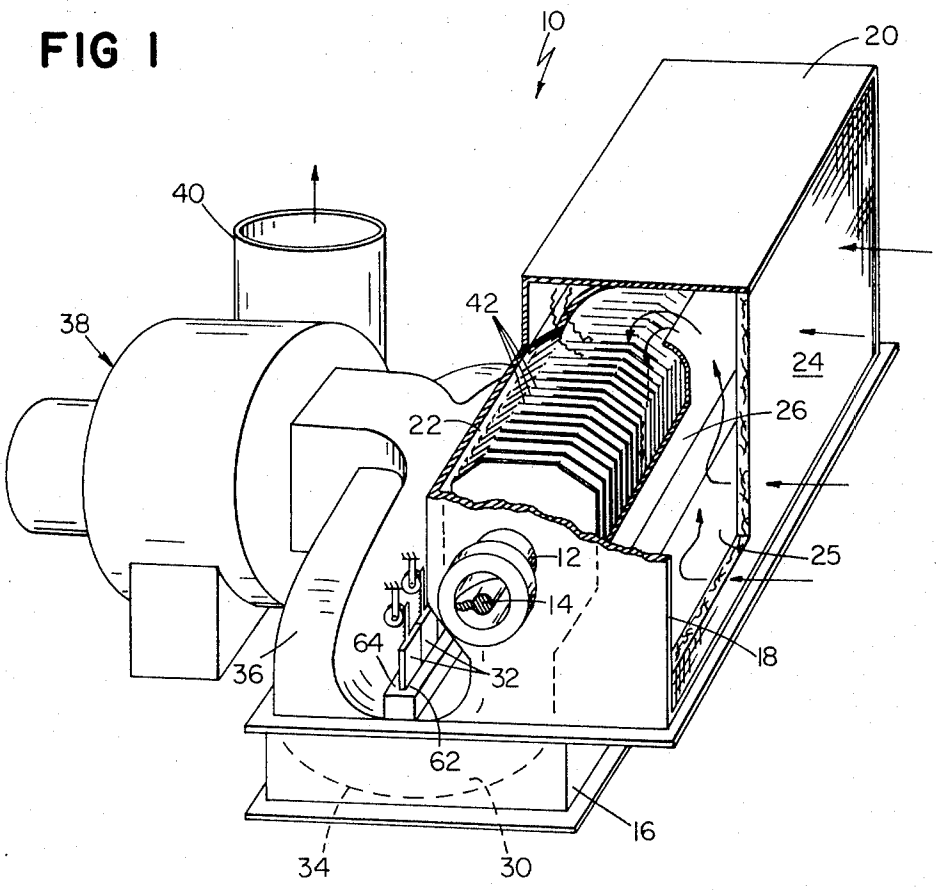


FIG 1


10
20
40
42
38
24
22
26
12
25
14
64
18
36
32
62
16
34
30

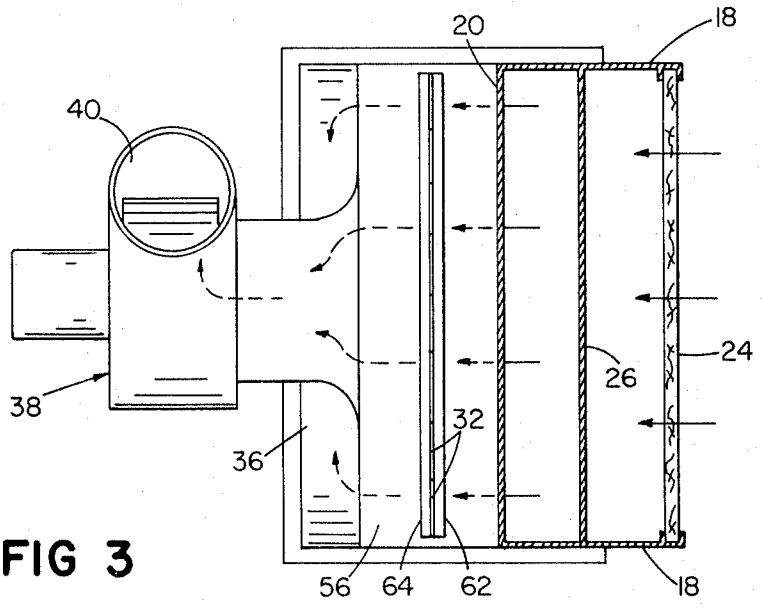

20
18
40
24
26
38
32
36
56
64
62
18

FIG 3

FIG 2

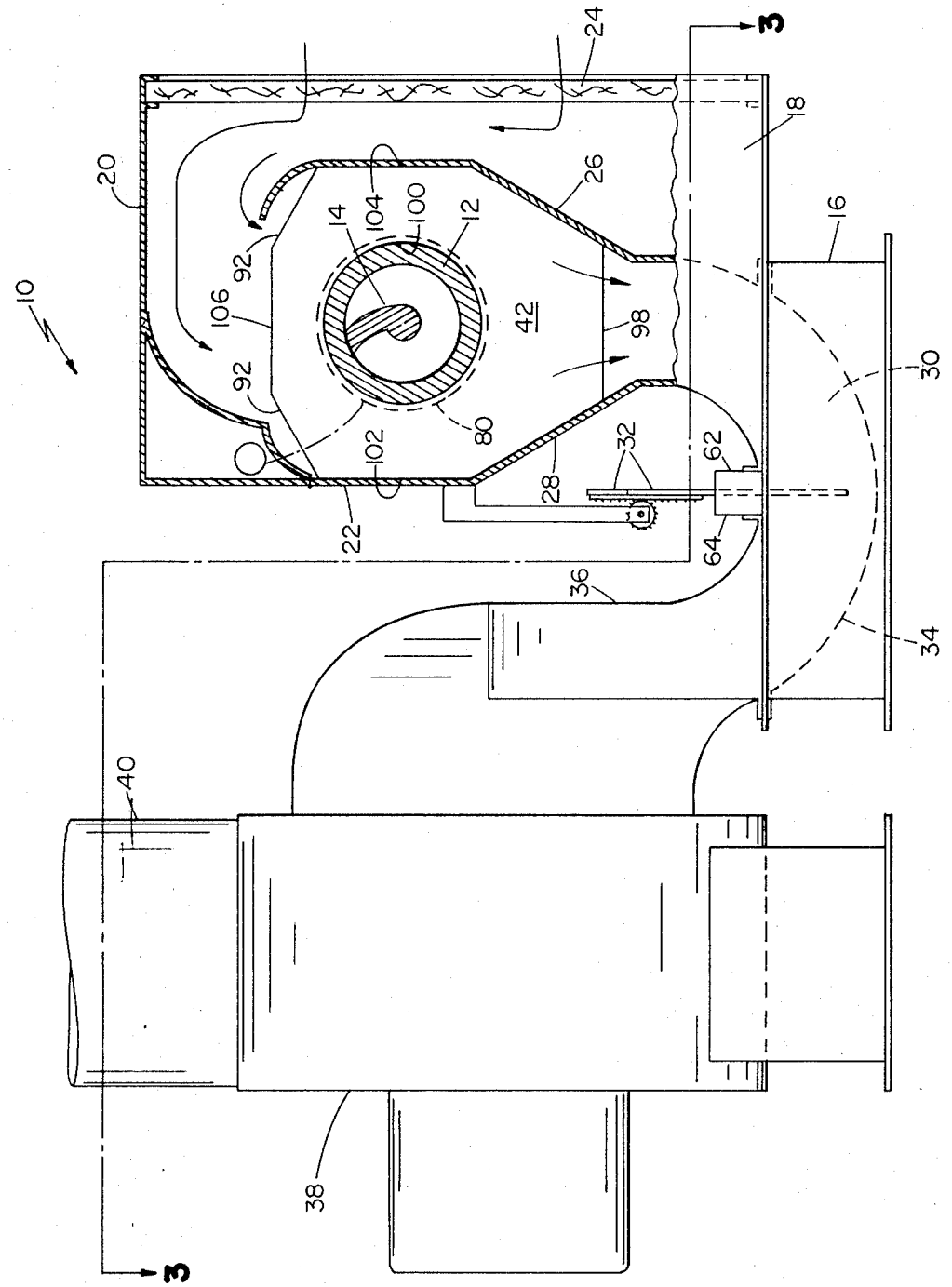

10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
62
64
80
92
98
100
102
104
106
3
3

FIG 4

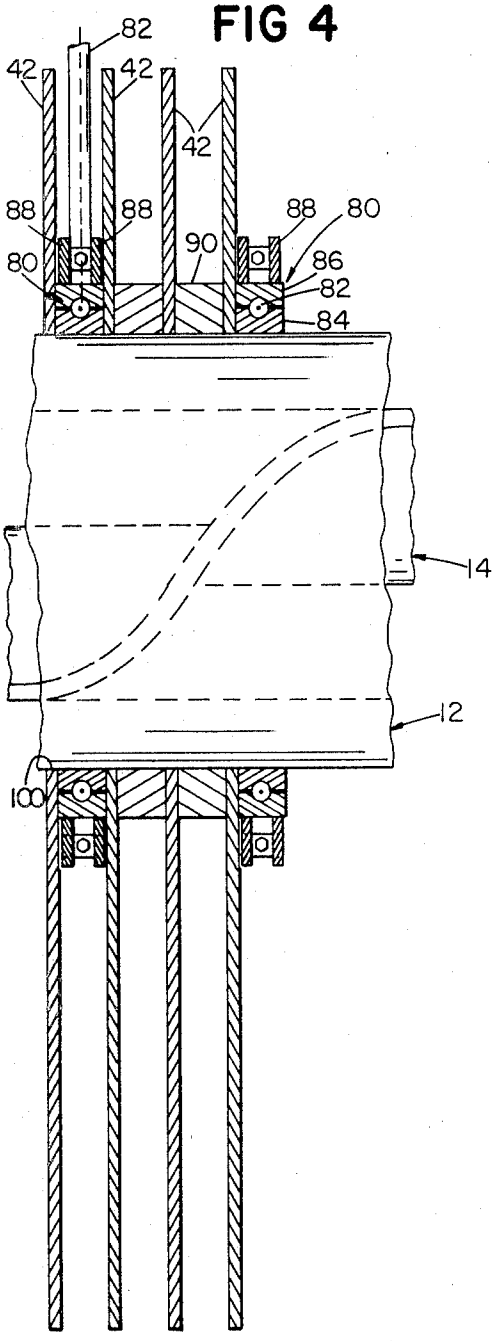

82
42
42
42
88
88
88
80
80
90
86
82
84
14
12
100

FIG 6

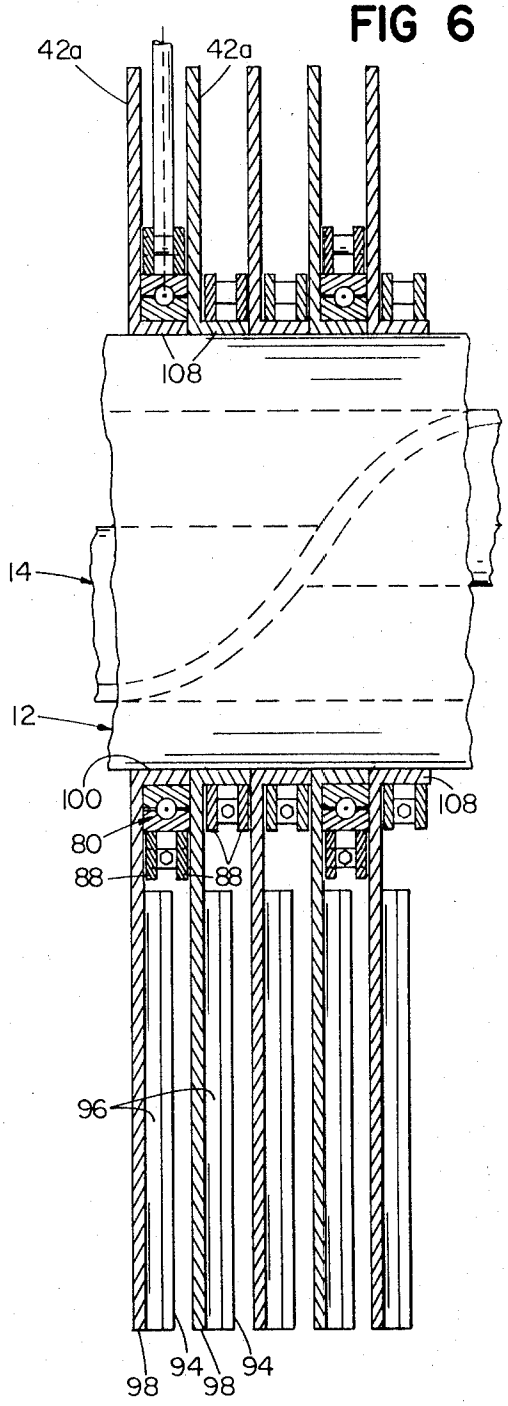
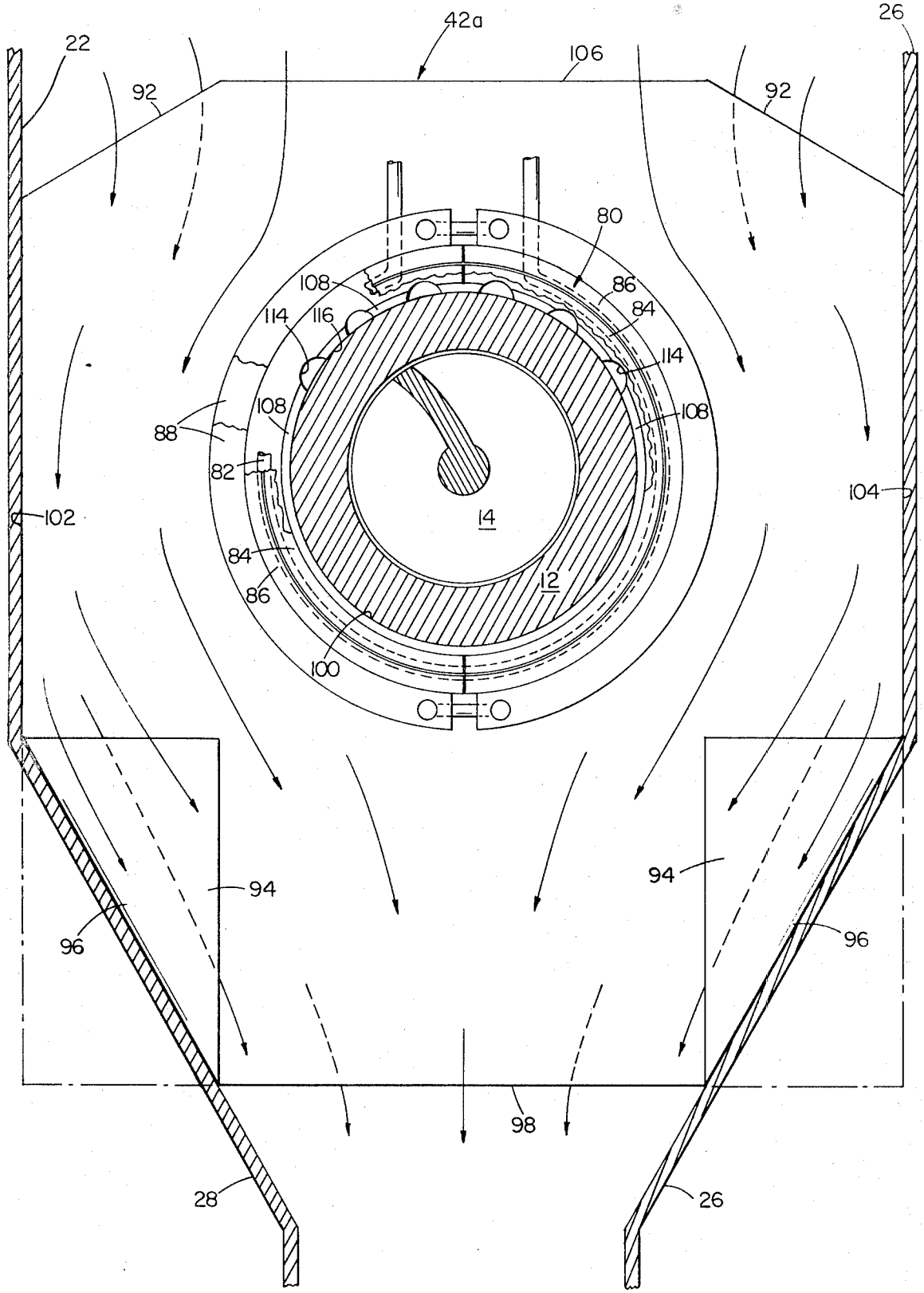

42a
42a
108
14
12
100
108
80
88
88
96
98
94
98
94

FIG 5


42a
26
22
106
92
92
80
108
86
84
114
116
114
108
108
88
82
102
104
14
12
84
86
100
94
94
96
96
98
28
26

AIR COOLED EXTRUDER

This invention relates to extruders of the forced air cooled type.

Such an extruder is shown in the 1951 U.S. Pat. No. 2,574,907. Other prior art patents are U.S. Pat. Nos. 2,774,107; 2,893,055; 3,119,149; 3,218,671 and 3,353,212. In the field of heat transfer tubes U. S. Pat. No. 1,958,364 is noted.

Although forced air cooled extruders have the potential advantage of low cost of construction and operation, those extruders which have high heat rating (meaning those which have a high heat output in comparison to size and usually also having high throughput of plastic) have been constructed instead with water cooling systems (with attendant need either to waste the heated water or provide a further cooling system for cooling the water for reuse, and with added complexity of equipment). It has been generally accepted that water cooling was necessary in order to simultaneously transfer the large amount of heat generated and to maintain relatively constant temperatures about the barrel to avoid barrel warpage and consequent damage to the extruder screw, barrel or both.

It is a principal object of the invention to provide forced air cooled extruders having high cooling capacity and capable of high performance, and at the same time of simple, relatively low cost, improved construction.

In one aspect of the invention, an extruder comprising a metal barrel containing an extruder screw is provided with a plurality of preformed external metal heat-conducting fins transverse to the barrel axis which are heat shrunk onto the barrel for exposure to forced air flow. The fins in their preformed shape have apertures corresponding generally in shape to, but in unstressed shape, smaller than, the respective peripheral barrel portions. These fins are expanded with high heat and then cooled and shrunk i.e., "heat shrunk") tightly about the barrel into pressure-applying intimate heat-transfer relation with the metal of the barrel. Such construction is effective to provide a very low-resistance heat transfer path from resin within the barrel through the shrunk-fit joint, the fin, to air in the air flow path. Such heat transfer properties together with the fact that the fins are individually preformed and placed gives great latitude in the selection of the air gap width between fins, depth of the air gap between fin edge and barrel, and fin thickness, enabling achievement of a highly effective cooling rate suitable for high production extruders.

In preferred embodiments each fin has a greater effective surface area in the air flow path on the downstream side of the barrel on the upstream side. In other preferred embodiments: the fins are formed of planar plates and downstream portions of each fin are bent from the general plane of the fin into turbulence-producing position, the resultant turbulence contributing to greater cooling efficiency; the portions of the fins contacting the barrel are spaced apart longitudinally and heaters (serving also as spacers) are disposed on the barrel between neighboring pairs of fins; and the fins include heat flow restricting openings in the upstream portion of the fins effective to reduce heat transfer between the upstream fin portions and the adjacent barrel surface. In certain preferred embodiments the fins are thicker adjacent the barrel than at locations

spaced from the barrel thereby providing an outwardly facing surface on each fin, about which a hoop is disposed, effective to maintain metal-to-metal contact of the fin and the barrel despite tendency, in the absence of the hoop, for the fin aperture to be permanently enlarged due to fin deformation beyond elastic limit with certain fin metals under certain thermal conditions.

In another aspect of the invention there is provided a system for the flow of cooling air past the barrel including a series of dampers which extend parallel to the barrel axis in an elongated cross-section portion of the ducting, being independently operable to provide different rates of flow of cooling air past different portions of the barrel. Preferably the air flow is produced by a single blower acting through a connecting duct section of considerably narrower width and preferably, cooling fins as described above are combined with this feature.

Also featured are fins having straight parallel sides aligned with the barrel, the inward converging straight sides extending therebeyond in the direction of the air flow conforming to planar walls of the ductwork, an economical and efficient construction.

Other objects, features, and advantages of the invention will appear from the following description of preferred embodiments taken together with the accompanying drawings.

In the drawings:

FIG. 1 is a partially broken away perspective view of an extruder constructed according to the invention including an air cooling system;

FIG. 2 is an end elevation, partially in section, of the extruder of FIG. 1;

FIG. 3 is a view taken at 3—3 of FIG. 2;

FIGS. 4 and 6 are longitudinal sections of an extruder barrel and of various heat transfer fins and heaters adjacent the barrel; and

FIG. 5 is a front elevation of a heat transfer fin having an alternative preferred configuration in heat transfer relation with an extruder barrel.

Referring to FIGS. 1 and 2 the extruder 10 includes a horizontally mounted barrel 12 and an extruder screw 14 within the barrel for mixing and pressurizing molten reson. (Appropriate feeding apparatus for introducing solid resin into the extruder and a die and associated apparatus at the extruder outlet are not shown.) Frame 16 supports the barrel 12 and the remainder of the extruder to be described.

A series of generally planar, heat transfer fins 42 are mounted upon barrel 12 with their planes generally perpendicular to the axis of the barrel.

Fins 42 are asymmetrical, having more surface area on the air flow downstream side of the barrel than on the upstream side and taper on the downstream side to match the narrowing of the air flow path produced by the tapering of baffle 26 and portion 28 of side wall 22, described below.

Referring to FIG. 4 heaters 80 are mounted directly upon the barrel between various neighboring pairs of fins 42 (these being functional at start-up of the extruder and to supply heat to certain regions of the barrel under certain operating conditions). Each heater 80 comprises a resistive heating medium 82 enclosed by mating aluminum annular rings 84, 86. A pair of steel retaining hoops 88 clamp the aluminum rings and heating medium to each other and the barrel 12.

The separation of fins 42 along the barrel 12 may vary, since greater cooling may be required at the out-

let end of the barrel than at the inlet end. In the areas of high cooling requirement, however, a spacing between adjacent one eighth thick fins will be about ½ inch and heaters **80** similarly have a width of ½ inch. Copper spacer rings **90** of similar width are provided between neighboring pairs of fins **42** which have no heater **80** between them. Where greater spacing of fins **42** is desired, a plurality of rings **90** is employed between neighboring pairs of fins.

In construction each fin is individually preformed from a plate of conductive metal and has an aperture slightly smaller than the outer diameter of the extruder barrel upon which it is to be mounted. Each fin is individually heat-expanded, slid into position on the barrel and cooled and shrunk fit onto the barrel, with spacer and/or heaters being placed between successive fins.

With a barrel **12** internal diameter of 4 ½ inches and an outer diameter of 6 ¼ inches, the fin **42** is formed from a ⅛ inch thick sheet of silver-bearing copper (with silver in the range of 5 to 25 ounces per ton of copper) which is 13 inches high and 12 inches wide. The upper corners of the fin **42** are cut off to provide edges **92** which slope 30° from the horizontal. Aperture **100** which receives the barrel **12** is centered between side edges **102, 104.** At its point of closest approach aperture **100** is approximately 1 ¾ inches from upper edge **106** and approximately four and 7/8 inches from lower edge **98.** In forming the fin **42,** the aperture **100** is given a diameter approximately 0.013 inch smaller than the outer diameter of barrel **12.** Each fin **42** is heated to slightly enlarge the aperture **100** and then assembled over the barrel **12.** Upon cooling, the fin **42** will then tightly grip the barrel **12.** After each individual fin **42** is shrunk fit onto the barrel **12,** appropriate heaters **80** or spacers **90** are installed before the next fin **42** is similarly shrunk onto the barrel.

With the silver-bearing copper composition of the fin, and a steel barrel, it is found that a temperature range of −30° F to +500° F can be achieved, covering the operation range and environmental temperatures, without danger of permanent deformation and loss of heat-shrunk fit. This particular metal is found to have adequate fatigue and creep resistant properties along with excellent heat conductivity.

The extruder barrel **12** thus provided with fins and heaters is enclosed by walls or ductwork defining an air flow path past the barrel, i.e. end walls **18** (only one being visible in FIG. **1.**), top wall **20** and side wall **22.** At one side of the extruder barrel **12** there is an inlet filter **24** as long as the barrel with a height approximately four times the outer diameter of the barrel **12.** For a barrel having a 4½ inch bore and a 6¼ inch outer diameter, the filter is preferably about 2 feet high.

A baffle **26,** provided between the barrel **12** and the filter **24,** guides the air to a position above the barrel, from whence it flows downwardly past the barrel. Baffles **26** and **28** (the latter a planar extension of planar wall **22**) define s downward air path past the barrel to a turning discharge air flow path **30** which for a portion remains as wide as the barrel is long, i.e. 9 feet for a 4 ½ inch diameter bore extruder. In this portion are mounted a series of end-to-end vertically slidable dampers **32** in the form of plates, in guides **62, 64,** at a location where the path has completed a 90° turn and has a substantially horizontal orientation. The lower wall **34** defining path **30** curves upwardly beyond dampers **32** and is joined with a transition section **36** which leads to exhaust fan **38.**

The air from the outlet **40** has substantially elevated temperature and therefore is supplied to appropriate ductwork to usefully employ the warmed air (e.g., for heating of the building in which the extruder is located).

As the cooling air passes along the fins **42** from their upper to their lower portions, it becomes warmed and therefore less efficient in cooling the lower portions of the fins than the upper portions of the fins. The provision of a greater surface area of the fin on the downstream side of barrel than on the upstream side counter-balances the reduced cooling efficiency of the air to produce a more uniform removal of heat from all peripheral portions of the barrel **12,** avoiding barrel warpage which would impede operation or harm the screw.

A series of longitudinally spaced apart thermocouples (not shown) may be embedded in the barrel, preferably adjacent the conventional lining of the internal surface of the barrel, which can give useful information in choosing both the power to be delivered to the heaters and the optimum setting of the various dampers **32.**

With such a construction it is possible to produce outputs on the order of 700 to 800 pounds per hour of low density polyethylene with an extruder having a 3 ½ inch diameter bore barrel or 1000 to 1200 pounds per hour with an extruder having 4 ½ inch diameter bore barrel.

FIGS. **5** and **6** illustrate an alternative preferred embodiment. The lower corner portions of the fin **42***a* are bent around to provide turbulence producing portions **94.** Bend lines **96** make an angle of 60° with a reference line drawn through lower edge **98** of fin **42***a*. Portions **94** are bent so as to be centered within the ½ inch open space between the facing surfaces of neighboring fins **42***a*.

Flange **108** is provided by a forming operation on fin **42***a* adjacent aperture **100** and projects in the axial direction of the barrel for a distance of ½ inch from the surface of the fin. This flange or burr **108** can serve, therefore, as an integral spacer. (A flange of less axial dimension could be employed retaining the benefits to be described and permitting the placement of heaters **80** directly upon barrel **12** and requiring the use of additional spacers, while retaining a uniform spacing between all neighboring pairs of fins.) Steel retaining bands **110** are disposed upon outer surfaces **112** of flanges **108.** With such bands the fins may be made out of aluminum. These will ensure that even if the fins are subject to very low temperatures (which because of the higher coefficient of expansion can lead to deformation of the aluminum about the steel barrel beyond the elastic limit), tight contact will be preserved when heated again due to re-deformation caused by the steel hoops as the aluminum tends to expand.

Heat flow restricting openings are provided on the upstream portion of the fin **42***a* in the form of arcuate relieved areas **114** of the fin at the aperture **100.** Lands **116** are provided between neighboring pairs of arcuate formations **114.** The lands **116** are in contact with the outer surface of barrel **12.** The arcuate formations **114** have a radius which is substantially smaller than the radius of the aperture **100.** The series of formations **114** extends approximately ⅛ of the distance around the periphery of the aperture **100.**

Thus in addition to increasing the removal of heat on the downstream side of the barrel by providing increased surface area of the heat transfer fins, uniformity of heat removal is achieved by reducing the heat removal from the upstream portions of the barrel by reducing the area of contact between the barrel surface and the fins; limiting it to lands **116.**

In the embodiment shown in FIGS. **5** and **6,** the fins **42***a* achieve even greater transfer of heat from the fin to the air in the downstream portions of the fin because of the air turbulence produced by portions **94.**

While preferred embodiments of the invention have been described in detail, other embodiments will occur to those skilled in the art and are within the following claims.

What is claimed is:

1. In an extruder comprising a metal barrel having a longitudinal axis and containing an extruder screw for mixing and pressurizing molten resin within the confines of said barrel, external metal heat conducting fins transverse to said axis, extending about said barrel, and means defining an air flow path for cooling air over said fins, said path being generally perpendicular to the longitudinal axis of said barrel, the improvement wherein said heat-conducting fins are performed, each having an aperture corresponding generally in shape to, but having an unstressed shape smaller than, a respective peripheral barrel portion to which it is attached, said fins being heat-shrunk about said portion into pressure applying intimate heat transfer relation therewith, the apparatus effective to transfer heat from said resin through said barrel and through said shrunk fit joint and fin to air in said path.

2. The apparatus as claimed in claim **1** wherein each fin has a greater effective surface area in the air flow path on the downstream side of said barrel than on the upstream side of said barrel.

3. The apparatus as claimed in claim **1** wherein said fins are formed of planar plates, downstream portions of each fin being bent from the general plane of said fin into turbulence-producing position, resultant turbulence contributing to cooling efficiency.

4. The apparatus as claimed in claim **3** wherein downstream corner portions of said fin are bent along straight lines.

5. The apparatus as claimed in claim **1** wherein the portions of said fins contacting said barrel are spaced apart longitudinally and heaters are disposed between neighboring pairs of said fins, said heaters being disposed in heat transfer relation to said barrel.

6. The apparatus as claimed in claim **1** including heat flow restricting openings in the upstream portion of said fins effective to reduce the heat transfer between said upstream fin portions and the adjacent barrel surface.

7. Apparatus as claimed in claim **6** wherein said heat flow restricting openings of a fin comprise relieved areas of said fin at said aperture on the upstream side of said fin, the fin at said relieved areas being out of contact with said barrel.

8. Apparatus as claimed in claim **7** wherein said relieved areas comprise a plurality of spaced apart arcuate formations in said fin, of radius smaller than the general radius of said aperture.

9. Apparatus as claimed in claim **8** wherein said plurality of relieved areas extends approximately one third of the distance around the periphery of said aperture, on the upstream side thereof.

10. The apparatus as claimed in claim **1** wherein a said fin is thicker adjacent said barrel than at locations spaced from said barrel thereby providing an outwardly facing surface on said fin; and retaining means engaging each said surface comprising a hoop disposed upon said surface and substantially surrounding said barrel, said hoop effective to maintain said metal-to-metal contact of said fin and barrel despite tendency in the absence of said hoop for said fin aperture to be permanently enlarged due to fin deformation beyond its elastic limit under certain thermal conditions.

11. The apparatus as claimed in claim **10** wherein each said hoop comprises high-strength steel.

12. The apparatus as claimed in claim **11** wherein said barrel comprises steel and said fins comprise aluminum.

13. The apparatus as claimed in claim **1** wherein said barrel comprises steel and said fins comprise silver-bearing copper.

14. In an extruder comprising an elongated barrel in which a screw works and extrudes plastic, the extruder having a cooling system comprising a series of transverse cooling fins secured to the exterior of the barrel, a blower and ducting arranged to cause a forced flow of air past said fins and damper means for regulating said air flow, the improvement wherein said ducting includes a duct portion adjacent said barrel having an elongated cross-section in the direction parallel to said barrel and said damper means comprising a multiplicity of individually operable dampers arranged in series to extend end-to-end across the long dimension of said cross-section, the dampers and the respective portions of the air flow path defined by said ducting communicating with respective portions of said barrel whereby varying air flow rates and attendant varying cooling effect along the length of said barrel can be achieved by varying the settings of various of said plurality of dampers.

15. The extruder of claim **14** wherein said dampers comprise plates mounted in slides.

16. Apparatus as claimed in claim **14** including a plurality of cooling fins in heat transfer relation with said barrel, at least a portion of said fins having a greater effective surface area on the downstream side of said barrel than on the upstream side of said barrel.

17. In an extruder comprising a metal barrel having a longitudinal axis and containing an extruder screw for mixing and pressurizing molten resin within the confines of said barrel, external metal heat-conducting fins transverse to said axis, extending about said barrel, and means defining an air flow path for cooling air over said fins, said path being generally perpendicular to the longitudinal axis of said barrel, the improvement wherein said heat-conducting fins are preformed of metal plate, said fins having a pair of straight parallel sides in alignment with said barrel and a pair of inwardly converging straight sides extending therebeyond in the direction of air flow and said straight sides conforming substantially to planar walls forming said air flow path.

* * * * *