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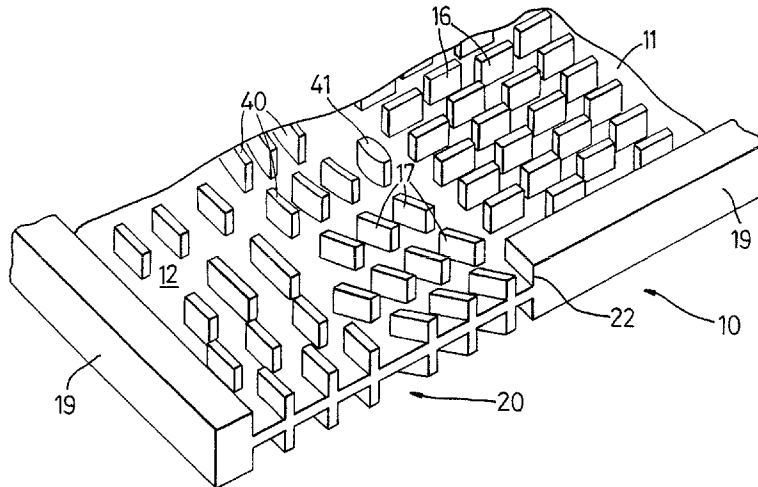
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(54) **ECHANGEUR DE CHALEUR A PLAQUES PRESENTANT DES
ZONES DE REPARTITION**

(54) **PLATE-TYPE HEAT EXCHANGER WITH DISTRIBUTION
ZONE**



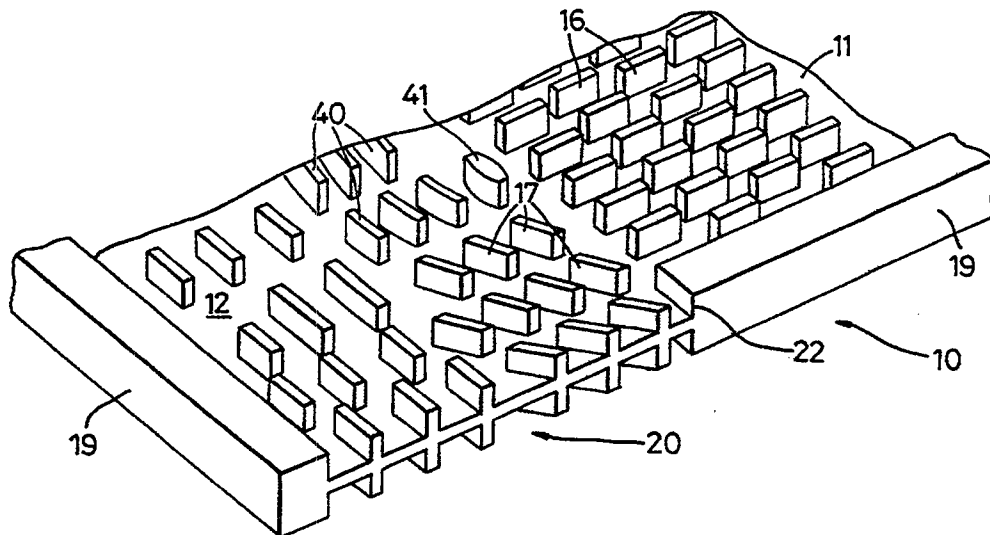
(57) L'invention porte sur un échangeur de chaleur comportant plusieurs plaques (14, 15) reliées face à face l'une à l'autre et qui comportent chacune (14, 15) des ailettes droites (16, 17, 40, 41, 53, 54, 55) délimitant des passages pour l'écoulement du fluide. Chacune des plaques (14, 15) comporte une zone de répartition (12) et une zone principale d'échange de chaleur (11). Les ailettes de la zone de répartition (12) comprennent certaines ailettes (17, 40, 41, 53, 54, 55) présentant une orientation différente de celle des ailettes voisines dans le sens (51, 52) d'écoulement du fluide.

(57) A heat exchanger comprised of a plurality of plates (14, 15) bonded face-to-face with one another. Either or both faces of the plates (14, 15) have upstanding fins (16, 17, 40, 41, 53, 54, 55) which define passages for fluid flow. Each plate (14, 15) has a distribution zone (12) and a main heat exchange zone (11). The fins in the distribution zone (12) include fins (17, 40, 41, 53, 54, 55) which are aligned differently from adjacent fins along the direction (51, 52) of fluid flow.

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(21) International Application Number: PCT/GB97/00848 (22) International Filing Date: 26 March 1997 (26.03.97) (30) Priority Data: 9606801.0 30 March 1996 (30.03.96) GB 9613105.7 21 June 1996 (21.06.96) GB (71) Applicant (for all designated States except US): IMI MARSTON LIMITED [GB/GB]; Wobaston Road, Fordhouses, Wolverhampton WV10 6QJ (GB). (72) Inventors; and (75) Inventors/Applicants (for US only): SYMONDS, Keith, Thomas [GB/GB]; 4 Lansdowne Avenue, Codsall, Staffs WV8 2EN (GB). SYMONDS, Steven, Paul [GB/GB]; 4 Lansdowne Avenue, Codsall, Staffs WV8 2EN (GB). WATTON, Brian, Keith [GB/GB]; Briary Croft, Cross Road, Albrighton, Staffs WV7 3RA (GB). (74) Agents: SYKES, John, C. et al.; IMI plc, Patents and Licensing Dept., P.O. Box 216, Witton, Birmingham B6 7BA (GB).		(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG). Published <i>With international search report.</i>

(54) Title: PLATE-TYPE HEAT EXCHANGER WITH DISTRIBUTION ZONE**(57) Abstract**

A heat exchanger comprised of a plurality of plates (14, 15) bonded face-to-face with one another. Either or both faces of the plates (14, 15) have upstanding fins (16, 17, 40, 41, 53, 54, 55) which define passages for fluid flow. Each plate (14, 15) has a distribution zone (12) and a main heat exchange zone (11). The fins in the distribution zone (12) include fins (17, 40, 41, 53, 54, 55) which are aligned differently from adjacent fins along the direction (51, 52) of fluid flow.

PLATE-TYPE HEAT EXCHANGER WITH DISTRIBUTION ZONETechnical Field

This invention relates to heat exchangers and methods for their manufacture. In particular it relates to “compact” heat exchangers
5 which are characterised by high “area density”. This means that they have a high ratio of heat transfer surface to heat exchange volume.

Background Art

Booklet No. 89 in the Good Practice Guide Series published by the Energy Efficiency Office of the Department of Environment of the
10 UK Government in 1994 describes and illustrates the various types of compact heat exchanger available in the United Kingdom at that date and contains notes on proposals for future developments. Guide No. 89 which may be obtained from the Energy Efficiency Enquiries Bureau (telephone number 44-1235-436-747) is hereby incorporated by
15 reference into this document.

Because of the wide variety of heat exchangers and the differences in their construction, their classification is complex. Once the tube and shell type construction is separated out, there remain a variety of stacked plate, brazed plate, plate-fin, polymer film, porous
20 matrix and other devices. The present invention could be considered to have features common to the stacked plate type of configuration or to the plate-fin configuration depending upon the characteristics used in categorisation.

The invention has its most important application in compact heat exchangers having an area density greater than $700\text{m}^2/\text{m}^3$ when referring to the gas side of a gas/liquid heat exchanger.

Recent developments in compact heat exchanger technology have
5 resulted in significant improvements in area density and in the precision
of manufacture of such heat exchangers such that there is high
constructional integrity and thus much less chance of interaction
between fluids flowing on the different sides of the heat exchanger.
Developments such as the printed circuit heat exchanger e.g. that
10 illustrated in US patent 4,665,975 (the passage of which entitled
"Background of the Invention" is hereby incorporated by way of
reference) have resulted in substantial improvements in heat exchanger
design. Proposals such as that illustrated in GB 2 251 679, which
illustrates a form of perforated plate technology, may lead to extremely
15 compact designs with very high efficiency.

These existing designs focus on the manufacture of standard
plates which can be bonded together e.g. by vacuum brazing or
diffusion bonding to create passageways between the plates through
which the fluids pass. Heat exchange takes place through the plates
20 themselves with a fluid flowing in an adjacent set of passageways,
typically in a direction different from that in which the original fluid is
flowing. Secondary heat exchange surface may extend between such
plates.

In designing a heat exchanger it is theoretically the case that for
25 optimum results the incoming fluid should be distributed uniformly

across the full width of the entry to the heat exchanger. This creates particular difficulties when a fluid is required to enter a heat exchanger via an oblique or side entry at the end of the heat exchanger. The heat exchanger designer in such cases tries to create an environment in what
5 is called the "distribution zone" in US 4,665,975 which prevents an otherwise inevitable disproportionately high flow down the easiest (i.e. lowest pressure drop) passage through the heat exchanger.

The optimum manufacturing requirement, however, is that the plates and other components of a heat exchanger should be as uniform
10 as possible, and straightforward to produce from standard machinery or standard components. Design features running in straight lines i.e. rectilinear, or on fixed radii are particularly desirable. This simplifies assembly and it is much cheaper to produce only a limited number of components than a huge variety. The designer is therefore constrained
15 in his efforts to design a "distribution zone" which has a means of progressively adjusting the flow restrictions and hence the pressure drop as the fluid passes through a distribution zone. Flow restrictions associated with any particular movement of fluid through the distribution zone should ideally be decreased as the distance from the
20 entry to the distribution zone increases.

It is an object of the invention to provide a compact plate-type heat exchanger having a plurality of plates arranged in face-to-face relationship and bonded together, which has progressively changing flow restrictions within the distribution zone enabling a more uniform
25 distribution of flow across the full width of the heat exchanger.

Disclosure of Invention

According to one aspect of the invention, we provide a heat exchanger comprising a plurality of plates bonded face-to-face one to the other, said plates having on their faces a plurality of upstanding fins defining therebetween passages for fluid flow, said heat exchanger having a main heat exchange zone and a distribution zone between the entry to the heat exchanger and the main heat exchange zone, said plates similarly having a main heat exchanger zone and a distribution zone, there being upstanding fins in both said zones of said plates, said upstanding fins in the distribution zone of the plates comprising a plurality of discrete projections along the direction of fluid flow, characterised in that said discrete projections include amongst them a plurality of projections which are aligned differently from adjacent projections along the direction of fluid flow.

The projections are typically created by photochemically or electrochemically etching (or by any other appropriate method) a network of discrete upstanding fins on one or both sides of said plates.

The fluid passageways through the distribution zone are preferably interconnected, the interconnection being provided by spaces between said fins. At the extreme edges of the plates, side bars are typically created from unetched metal. The fins may be of variable length in the direction of fluid flow and offset at different angles to the overall flow direction of fluid through the heat exchange zone. The fins may comprise both rectilinear and curved projections. The fins may be straight-sided, curved or aerofoil-shaped or a combination of each.

Where there are fins on both sides of the plates, the fins on one plate may register with identically configured fins on an adjacent plate and are joined together by e.g. brazing or diffusion bonding, or by the use of adhesives.

5 The fin configuration etched onto one side of a particular plate may be identical to or different from that etched on an adjacent plate, or where a plate is etched on both sides, onto the other side of the same plate. Plane metal sheets may be used as separator plates with two or more finned plates to form one discrete flow layer for a single fluid.

10 The designer of the distribution zone can vary the length of fins, the distance between them, (both along the flow direction and laterally of it), and the density of fins in a particular area of the distribution zone in the direction of fluid flow.

 The discrete projections, or fins, at the entry to the distribution
15 zone may be positioned and angled such as to create a higher flow resistance to fluid which traverses a shorter path through the heat exchanger.

Brief Description of Drawings

 An embodiment of the invention will now be described, by way of
20 example only, with reference to the accompanying drawings in which:

 Figure 1 is a schematic plan view showing a cross-section of a heat exchanger in accordance with the invention;

 Figure 2 is a cut-away view of part of the heat exchanger of Figure 1;

Figure 2A is a cut-away view of part of an alternative heat exchanger;

Figure 3 is a cross-section illustrating a principle of construction of the heat exchanger of Figure 2;

5 Figure 3A is a cross-section (similar to that of Figure 3) illustrating a principle of construction of the heat exchanger of Figure 2A; and

Figure 4 is a schematic view, similar to Figure 1, illustrating certain of the design characteristics of the heat exchangers according to
10 the invention.

Best Mode for Carrying Out the Invention

A heat exchanger 10 (see Figure 1) has a main heat exchange zone 11 connected with a distribution zone 12 at its entry end. Heat exchanger 10 comprises a series of thin plates aligned parallel to one
15 another, some of which are planar 14 and some of which 15 have a plurality of discrete projections or fins 16 and 17 extending towards plate 15. It is a plate of the type 15 (with projections or fins 16) which is seen in Figures 1, 2, 2A and 4.

Plate 15 has fins 16 which extend parallel to one another along
20 the line of flow (shown by arrow 18) through the main heat exchange zone. Within the distribution zone 12, the distributor fins 17 may have some which are parallel to others but their alignment and location is determined by factors which will be described later in this document.

Both types of fin 16 and 17 are photochemically or
25 electrochemically etched from a sheet of parent metal e.g. stainless steel

as are upstanding side bars or spacers 19 which are of the same height as the fins 16, 17. Fins 16, 17 and side bars 19 or spacers are etched on either both sides (Figure 2) or one side only (Figure 2A) of plates 15.

When both sides of a plate are etched, the fins are coincident with one another, such that they will register identically with fins 16, 17 and side bars 19 on adjacent plates 15 as seen in Figure 3. When etched on one side only, plate 15 may be stacked or shown in Figure 3A.

The side bars or spacers 19 extend around the periphery of plate 15 except for portions where an entry 20 and an exit 21 to the heat exchanger 10 are provided. The entry 20 is a side entry into the distribution zone 12 of heat exchanger 10 such that fluid passing through the heat exchanger 10 can enter at right angles to the direction of fluid flow through the main heat exchange zone 11. The exit 21 is similarly treated to permit fluid to exit at right angles to the flow through the main heat exchange zone 11. Fins 16, 17 are shown only in the portion of heat exchanger 10 adjacent entry 20, but in practice they extend throughout the heat exchanger. The junction between the distribution zone 12 and the main heat exchange zone 11 extends across the heat exchanger from the side 22 of entry 20 away from the end of the heat exchanger. The junction between the main heat exchange zone 11 and the exit distribution zone is shown by dashed line 23 in Figure 1. Side entry and exit configurations enable heat exchangers to be provided with multi-stream capability.

Plates 14 and plates 15 which are etched on both sides are arranged in a stack, part of which is seen in Figure 3. A pair of etched

plates 15 are arranged with their fins 16 and side bars 19 registered (Figure 3 illustrates a fin configuration in the main heat exchange zone 11). Planar plates (side plates 14) are added to provide a sandwich, or flow layer 30 which has enclosed passageways 30, all of which will carry the same fluid. An adjacent flow layer (not shown) can be built up parallel to that shown in Figure 3 and registering with its side bars 19. A different fluid will flow through the adjacent flow layer, and it may be that the fin pattern and distribution in adjacent flow layers may be different according to the fluid characteristics. The number of plates 15 making up a single flow layer may also be more than two. Typically the entry and exit to the heat exchanger for different fluids are arranged to be from different sides of the heat exchanger, and this may be achieved by etching the entry and exit through the side bars 19 in different positions.

15 An alternative build up of plates which are etched only on one side is shown in Figure 3A.

The separation of the fins 17 in the distribution zones 12 (both along the overall flow direction and laterally of it) is generally not uniform, even at entry 20. The flow passageways in the distribution zones 12 which are created by the fins 17 are able to interact with each other by way of the spacings along the flow direction.

Fins 16, 17 may be positioned anywhere on the surface of plate 15 where it is desired. As illustrated in this example, in the heat exchange zone 11 the fins 16 are arranged in rows in a regular pattern with alternate rows offset relative to each other i.e. the leading edge of each

fin 16 in one row trails (or leads) the leading edge of each fin 16 in an adjacent row. The pitch of fins 16 may be such that the gap between fins along the flow direction is greater than the fin length. Each offset fin may then be more than a fin length behind the leading edge of a fin
5 in an adjacent row. In the distribution zone 12, the fins 17 are arranged in lines which will curve towards the heat exchange zone 11. Alternate lines of fins 17 are then offset from one another in a similar way to the rows of fins 16 in the heat exchange zone 11. The offset fins, or some of them, may be angled differently from adjacent fins 17. The length of
10 the fins 17 may be different at different positions in the distribution zone 12 e.g. the length may be greater as the flow approaches the heat exchange zone 11. The pitch of fins 17 may also change along their line through the distribution zone 12.

There may be supplementary fins 53, 54, 55 within the
15 distribution zone 12 which do not form part of lines of fins 17, along the flow direction, whether offset or otherwise. These supplementary fins 53, 54, 55 are used to give a local higher fin density and to make small adjustments to the flow patterns to enhance even distribution of fluid across the whole of the heat exchange zone 11. Fins may be curved 40,
20 aerofoil 41 or straight and they may be set at a variety of angles to the fluid flow.

A typical distribution side entry (see Figure 4) could be designed such that the pitch and angle of fins 17 which are encountered by the fluid entering adjacent the point of entry 20 furthest from side 22, are
25 such as to create a lower resistance to flow than the fins 17 (which are

differently pitched and angled) encountered by fluid entering the distribution zone 12 closer to side 22 of entry 20. In this way a higher flow resistance may be created to fluid which takes a shorter path (e.g. arrow 51 - see Figure 4) than that which takes a longer path (e.g. arrow 52 - see Figure 4) through the heat exchanger 10.

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CLAIMS :

1. A heat exchanger comprising a plurality of plates (14, 15) bonded face-to-face one to the other, said plates (14, 15) having on their faces a plurality of upstanding fins (16, 17, 40, 41, 53, 54, 55) defining
5 therebetween passages for fluid flow, said heat exchanger having a main heat exchange zone (11) and a distribution zone (12) between the entry to the heat exchanger and the main heat exchanger zone (11), said plates (14, 15) similarly having a main heat exchanger zone (11) and a distribution zone (12), there being upstanding fins in both said zones of
10 said plates, said upstanding fins in the distribution zone of the plates (14, 15) comprising a plurality of discrete projections (17, 40, 41, 53, 54, 55) along the direction of fluid flow, characterised in that said discrete projections include amongst them a plurality of projections which are aligned differently from adjacent projections along the
15 direction (51, 52) of fluid flow.
2. A heat exchanger as claimed in claim 1 characterised in that said discrete projections within the distribution zone (12) comprise both rectilinear projections (17) and curved projections (40).
20
3. A heat exchanger as claimed in claim 1 characterised in that said discrete projections within the distribution zone (12) comprise projections (17, 40) of different lengths along the direction of fluid flow.

4. A heat exchanger as claimed in claim 1 characterised in that the density of said discrete projections within the distribution zone (12) varies in the direction of fluid flow.

5 5. A heat exchanger as claimed in claim 1 characterised in that the pattern of said discrete projections within the distribution zone (12) is different for alternate plates of the heat exchanger.

10 6. A heat exchanger as claimed in claim 1 characterised in that the discrete projections at the entry to the distribution zone (12) are positioned and angled such as to create a higher flow resistance to fluid which traverse the shortest path through the heat exchanger.

15 7. A heat exchanger as claimed in claim 1 characterised in that certain discrete projections within the distribution zone (12) are of aerofoil (41) section.

20 8. A heat exchanger as claimed in claim 1 characterised in that said discrete projections are provided on both sides of a plate (15).

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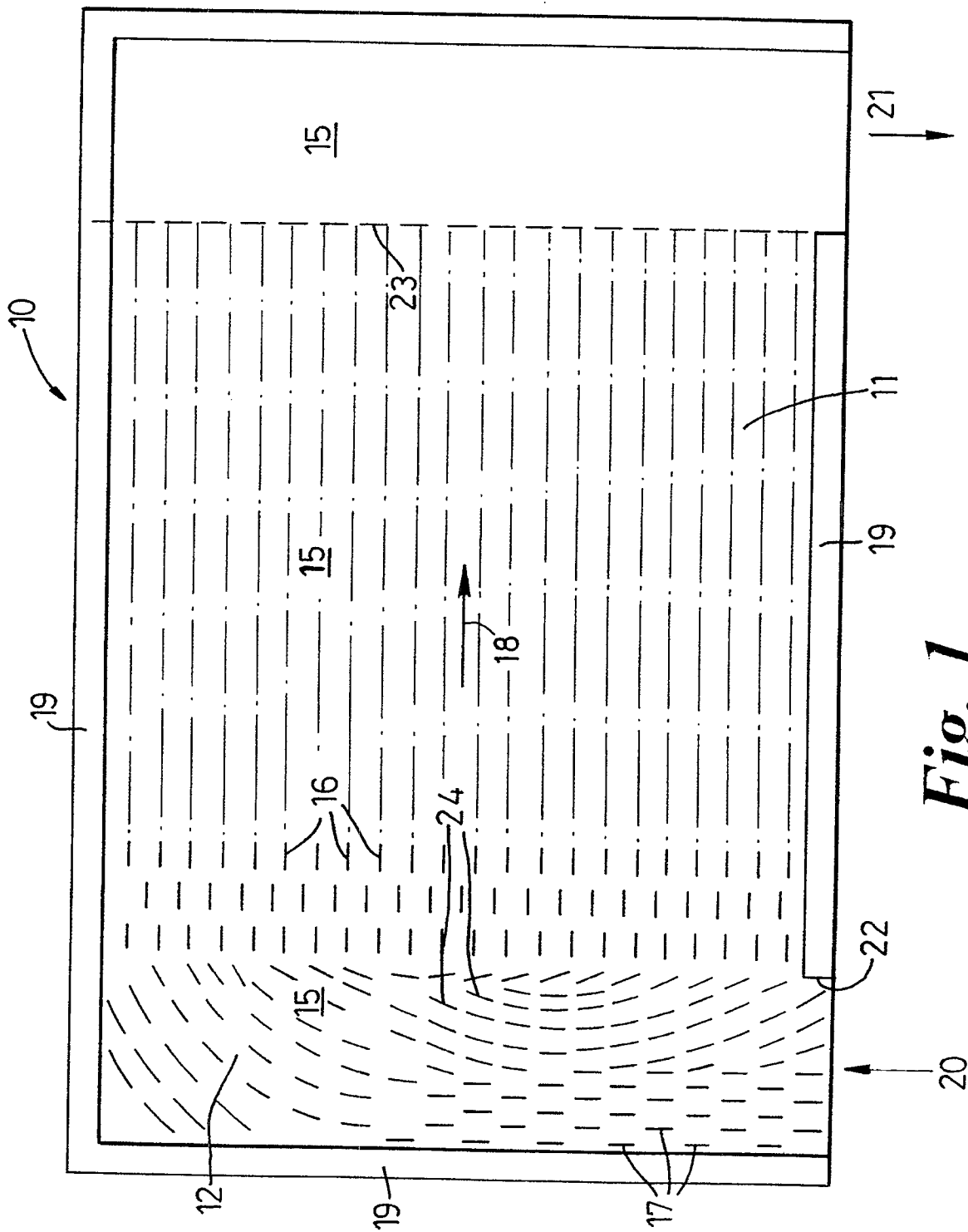
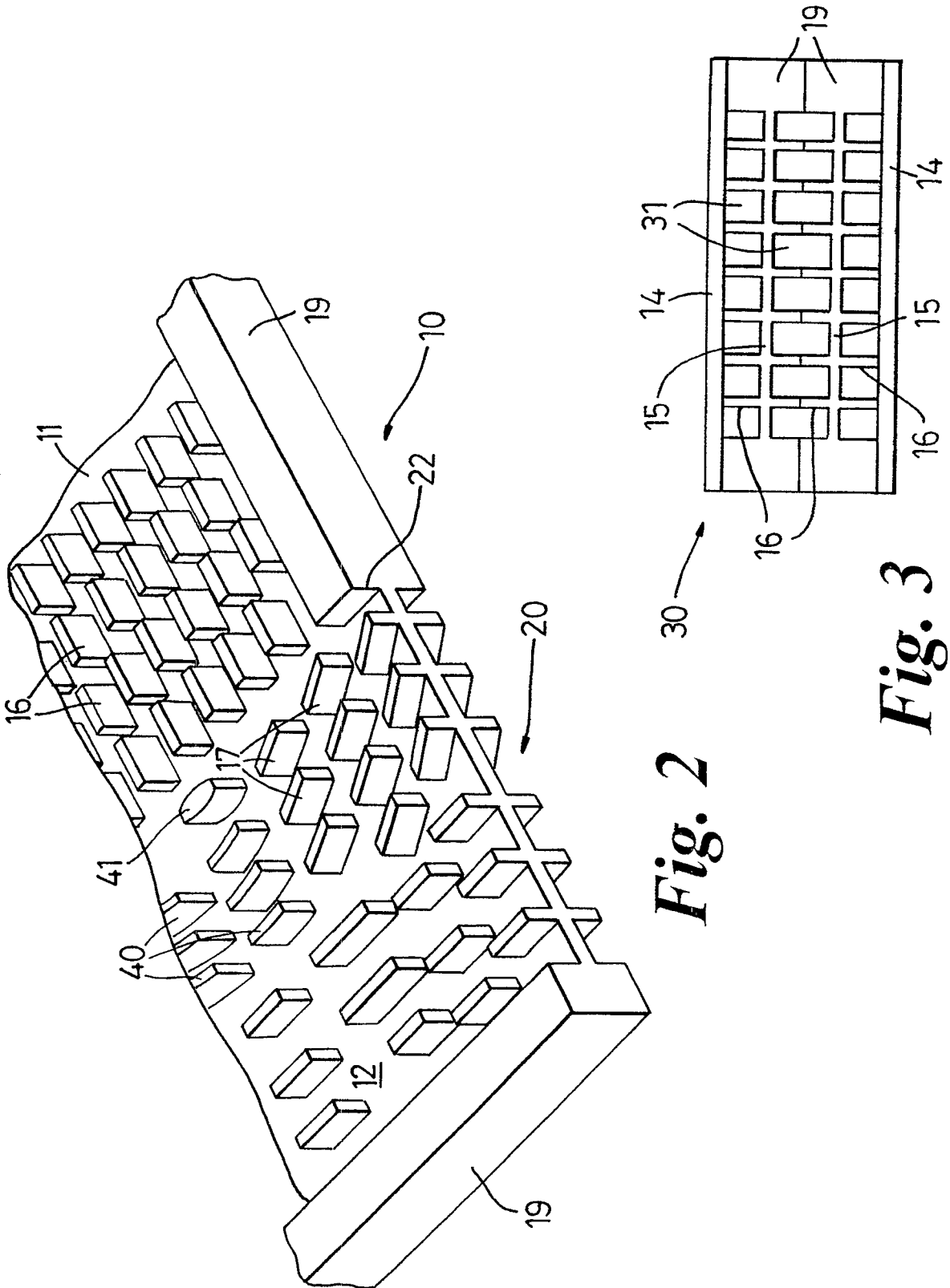


Fig. 1

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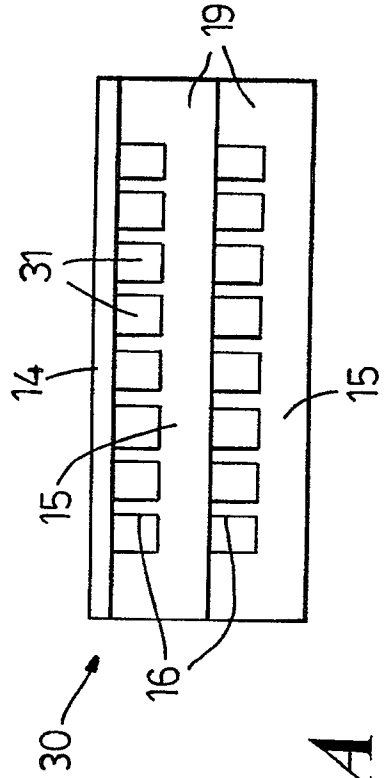
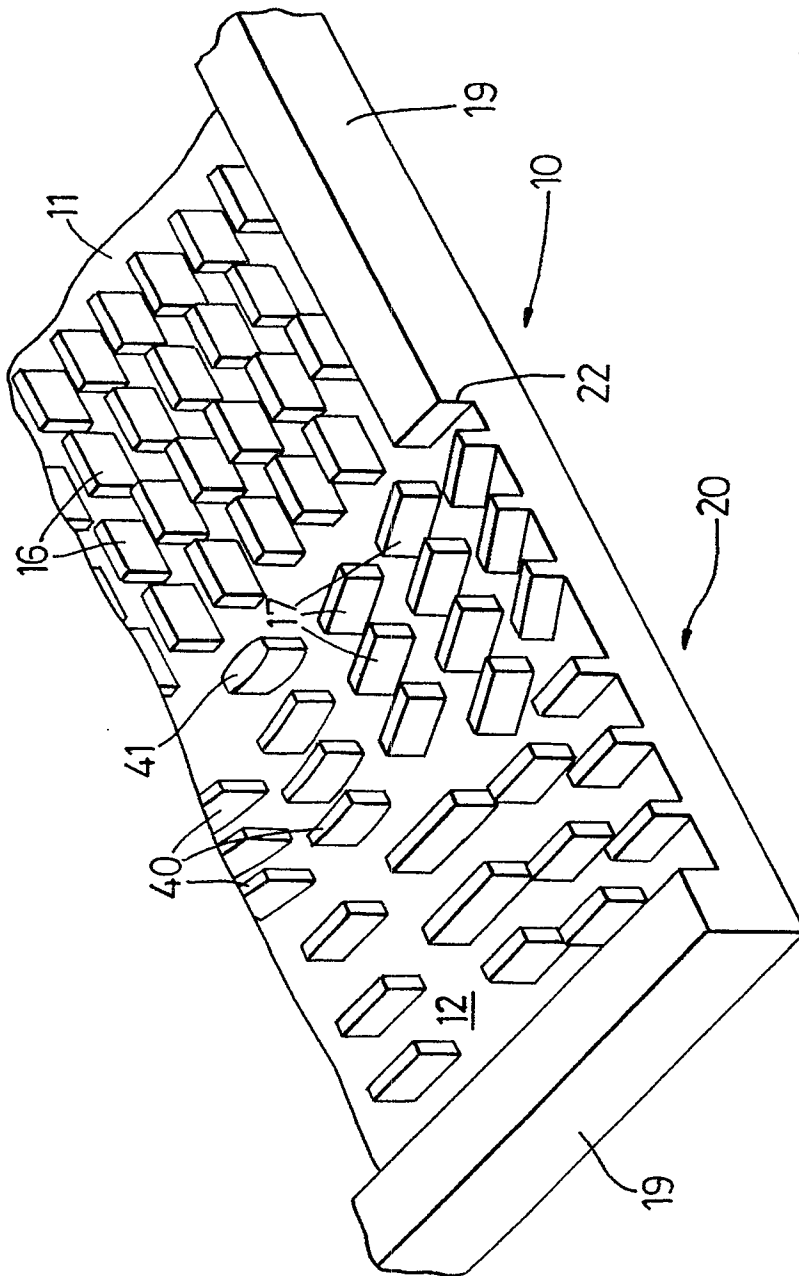


Fig. 2A

Fig. 3A

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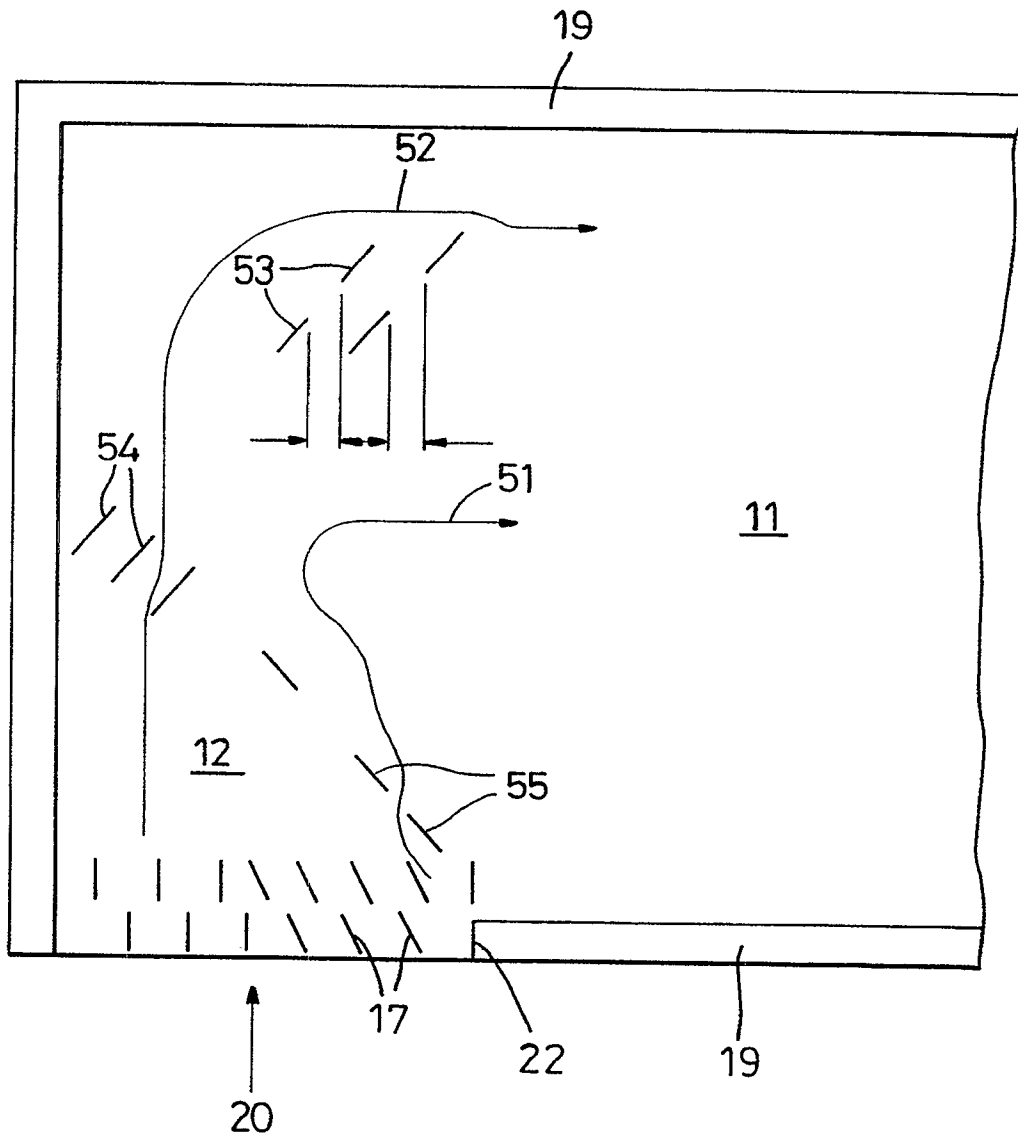


Fig. 4

