

Feb. 17, 1970

R. P. TRASK II

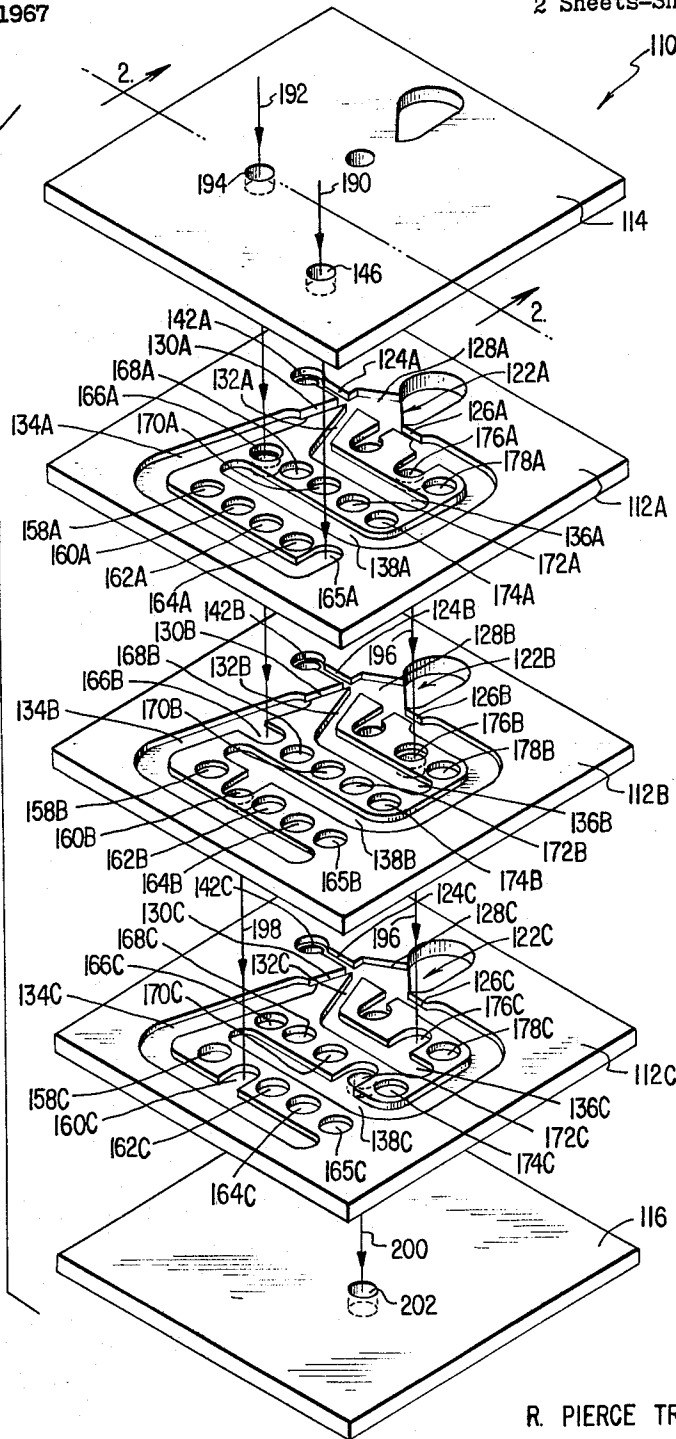
3,495,604

INTEGRAL FLUERIC ELEMENT AND MANIFOLD PLATE AND METHOD
OF STACKING A SERIES OF SUCH PLATES AND FLUID
COUPLING THE SAME

Filed Sept. 22, 1967

2 Sheets-Sheet 1

FIG. 1



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2 Sheets-Sheet 2

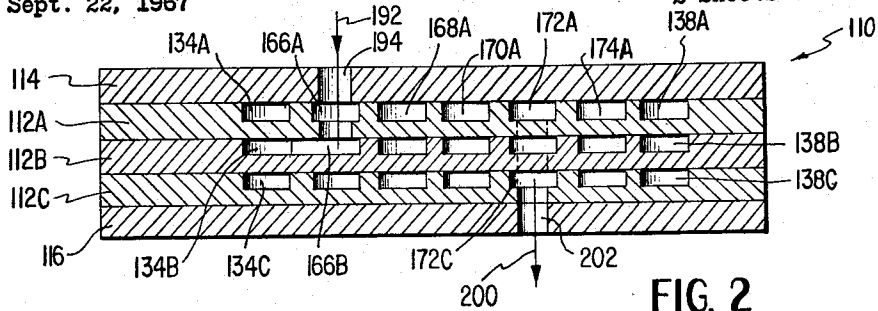


FIG. 2

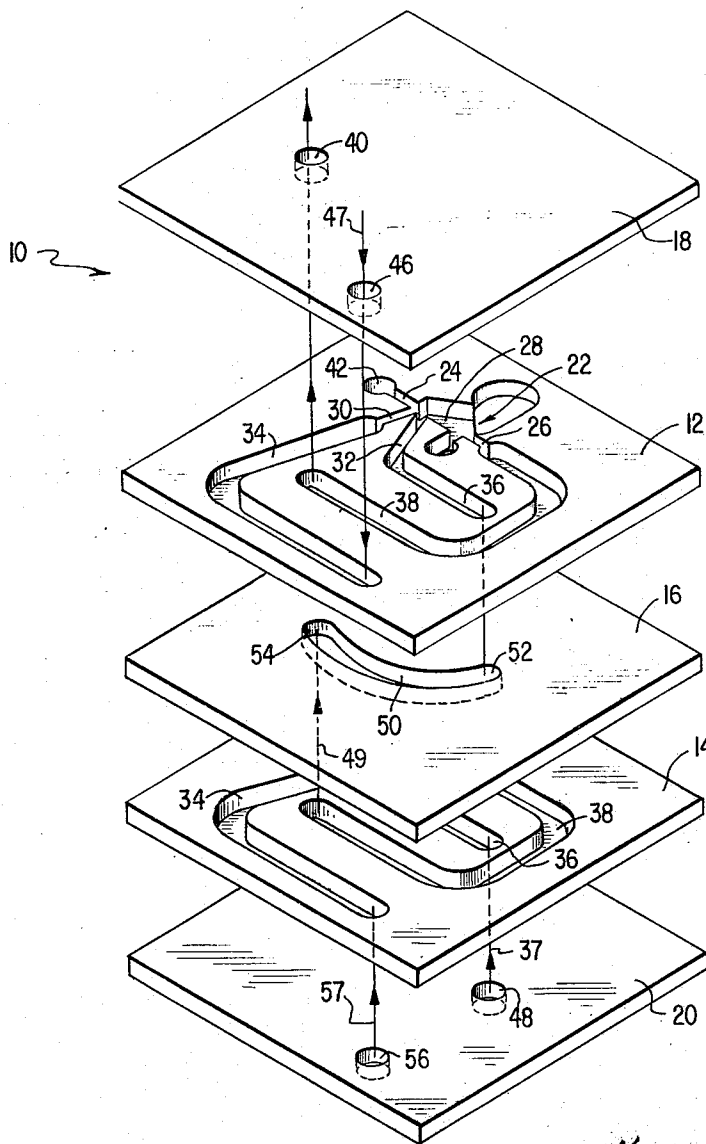


FIG. 3
(PRIOR ART)

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INTEGRAL FLUERIC ELEMENT AND MANIFOLD PLATE AND METHOD OF STACKING A SERIES OF SUCH PLATES AND FLUID COUPLING THE SAME

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6 Claims

ABSTRACT OF THE DISCLOSURE

An integral flueric element and manifold plate comprising a formed flueric element section defined by a configured recess, and an adjacent manifold section including separate elongated manifold passages in the form of recesses having one end fluid connected to the flueric element carried by said plate, and a series of adjacent isolated recesses within the plate. A series of plates form a stacked array with lateral notches coupling selected isolated recesses to the elongated manifold passages, and holes completed through the plate thickness at selected isolated recesses to establish plate-to-plate fluid connections.

BACKGROUND OF THE INVENTION**Field of the invention**

This invention relates generally to pure fluid devices, and more particularly to an integral flueric element and manifold plate and a method of forming a stacked array of flueric elements which eliminate the need for separate manifold plates in such arrays.

Description of the prior art

Flueric elements have, to some extent, replaced conventional electronic devices in both complex control systems and computers. The flueric element normally performs and amplifier function since the control stream, which is introduced at right angles to the main power stream, is generally small compared to the main stream in fluid volume. Interaction between the control stream or streams and the power stream normally occurs in an amplifier or interaction chamber with fluid being selectively diverted from one outlet passage to another as a result of control stream interaction. Flueric devices therefore require, in addition to the interaction chamber and an inlet for the power stream, a plurality of outlet passages and normally a plurality of control passages fluid coupled to the interaction chamber, generally at right angles to the path of the power stream through said chamber.

The physical construction of a flueric element normally involves a laminate structure including outer sheets or plates acting to sandwich a configured intermediate sheet or plate. The plates may be formed of metallic, plastic, glass ceramic or glass ceramic material with the outer plates normally sealed to the intermediate plate by such means as adhesives and the like. The plates are formed with suitable passages and apertures. The individual flueric elements are then fluid coupled together to form multi-element system circuitry in much the same manner as the electrical circuits involve electrically coupling a great number of electrical or electronic components.

In the past, in an attempt to form a highly compact flueric system, individual flueric elements in planar form and carried by separate plates, were stacked, but fluid separated by interspersed manifold plates. The manifold plates are selectively apertured for the express purpose of

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making suitable fluid connections between the passages of a flueric element carried by one plate and passages of the next succeeding flueric element carried by a succeeding plate of the stacked array. The employment of separate manifold plates in between each flueric element plate has eliminated the need for flexible tubing or other means for making the necessary connection between the flueric elements making up the system. However, this necessitates designing manifolds with specific configurations of passages, apertures and the like, to insure the proper connection of a fluid signal from one flueric element to another succeeding flueric element. This is particularly true where the fluid system employed flueric elements which are different in design and function.

SUMMARY OF THE INVENTION

It is therefore an object of this invention to provide an improved method of fluid coupling a plurality of flueric elements carried by individual plates forming a stacked array, which completely eliminates the need for separate manifold plates.

It is another object of this invention to provide an improved flueric circuit in the form of a stacked plate array wherein each plate carries integrally formed flueric elements and manifold sections, which requires minimum structural modification to achieve selected fluid connections between the stacked plates and to the flueric elements carried thereby.

It is a further object of this invention to provide an improved method of forming a stacked array of flueric elements which may be easily and selectively fluid coupled within an appropriate flueric circuit at minimum expense, with maximum speed, and maximum operational reliability.

In general, the present invention is directed to an improved, integral flueric element and manifold plate for use in a stacked array which completely eliminates the need for separate manifold plates. Each plate has a formed flueric element section defined by a configured recess partially through the plate from one surface only, and a manifold section including separate elongated manifold passages in the form of recesses, partially through the plate from one surface only, and having one end fluid connected to the flueric element carried by the plate, and a series of isolated circular recesses within the plate, partially therethrough and from one surface thereof.

The present invention is further directed to the method of fluid coupling the manifold passages of one plate to manifold passages in adjoining plates to place the flueric elements of a stacked array of plates in fluid coupling circuit relationship. The method of fluid connection involves forming transverse notches between the normally isolated circular recesses and the manifold passages adjacent thereto within the same plate, and completing holes completely through the plate thickness for selected circular isolated recesses to establish plate-to-plate fluid connection.

BRIEF DESCRIPTION OF THE DRAWING

Other objects of this invention will be pointed out in the following detailed description and claims and illustrated in the accompanying drawings which disclose by way of example the principle of the invention and the best mode which has been contemplated in applying the principle.

FIGURE 1 is an exploded, perspective view of a plurality of integral flueric element and manifold plates with plate-to-plate and internal fluid connections formed by the improved method of the present invention.

FIGURE 2 is a sectional, elevational view of the plates as a stacked array, taken along about lines 2—2 of FIGURE 1.

FIGURE 3 is an exploded, perspective view of an array of flueric elements including fluid connections formed by prior art technique.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring first to FIGURE 3 of the drawing, there is shown a typical prior art construction employing a stacked array 10 of flueric elements including appropriate flueric element plates 12 and 14 separated by a manifold plate 16 which act in conjunction with outer cover plates 18 and 20 to form a conventional sandwich structure. Plates 12 through 20 are suitably coupled by adhesive means or are otherwise bonded to prevent fluid escape between their planar contacting surfaces. The plates, which may be formed of metallic, plastic, glass ceramic and glass ceramics or like material, are configured by relieving or cutting out portions of the plates partially or completely therethrough to provide the passages, channels, openings, apertures or other means for fluid coupling the main power stream to the flueric element carried by plates 12 and 14 and for coupling a control stream to such elements. Identical flueric elements 22 are carried by element plates 12 and 14 in this case. They comprise NOR devices including a main or power stream inlet passage 24 and an inline outlet passage 26 on the opposite side of interaction chamber 28. A pair of spaced control passages 30 and 32 are provided on the same side of the interaction chamber 28. Suitable elongated manifold passages 34, 36 and 38 are coupled respectively to control passages or ports 30 and 32 and outlet passage 26. Flueric element plates 12 and 14 are identically formed by conventional duplicate manufacturing processes involving stamping, etching or otherwise forming the passages partially or completely through the plate thickness.

Representative fluid circuit connections are made to flueric element plates 12 and 14 through the various ports or openings carried by outer cover plates 18 and 20, while the internal connections are made by the separate manifold plates such as plate 16, and specifically curved, elongated slot 50. In this respect, the bottom cover plate 20 is provided with a circular aperture or opening 48 which is axially aligned with the end of elongated slot 36, and thus delivers a control fluid signal 37 to control port 32 of the flueric element carried by flueric element plate 14. Naturally, a separate opening (not shown) from a source (not shown) in cover plate 20 directs power stream fluid to power stream inlet 24 of the flueric element carried by plate 14. In like manner, aperture 56 delivers a control stream signal 57, from a source (not shown) to the elongated manifold control passage 34 within flueric element plate 14.

Intermediate manifold plate 16 employs curved elongated passage 50 which achieves, as indicated by arrow 49, fluid connection between manifold outlet passage 38 carried by flueric element plate 14 and manifold control passage 36 carried by the upper flueric element plate 12. At the same time aperture 40 within cover plate 18 acts as an outlet passage since it is fluid connected to outlet manifold passage 38 within flueric element plate 12. Further, a second aperture 46 carried by the upper plate 18 provides fluid connection for an inlet control signal 47 to manifold passage 34 and flueric element control channel 30 of plate 12. The power stream for flueric element 22 of flueric element plate 12 passes from circular port 42 through the inlet passage 24 into the interaction chamber 28. In this respect, the power stream for the flueric element of plate 12 may also originate at the lower cover plate 20 using a common vertical passage formed through plates 14 and 16 (not shown).

Further, as characteristic of known, multiple plate flueric arrays, it is necessary to provide, intermediate of the flueric element plates, completely separate and distinct manifold plates such as plates 16 for suitably connecting the outlet passage of one flueric element carried by one

plate to an inlet passage or control port of the next succeeding flueric element carried by an adjacent plate. In this case, central manifold plate 16 is shown as having an irregular or curved elongated manifold passage 50 having one end 52 which terminates generally in line with manifold passage 36 carried by flueric element plate 12. The opposite end 54 of the manifold passage 50 terminates in a position so as to overlie manifold passage 38 carried by flueric element plate 14. The manifold passages such as passage 50 carried by plate 16 must be so configured in form that they will not inadvertently fluid couple manifold passages within the flueric element plates other than those desired. The requirement of careful control and positioning of the manifold passages, within the individual manifold plates becomes readily apparent when one envisions the positions occupied by the respective passages when the plates 18 through 20 are sandwiched together to completion of the assembly in the form of a stacked array. This is even further complicated when the stacked array includes a series of element plates, interspersed by manifold plates, in which the elements for the given plates vary greatly in configuration and number of channels.

The present invention employs for the first time integral flueric element and manifold plates in which the need for separate manifold plates between flueric element plates is completely eliminated. The applicability of the present invention to complicated flueric element systems may be readily appreciated by contrasting the stacked array of FIGURE 3 with the stacked array of FIGURE 1. Of course, the stacked array of FIGURE 1 employs only three flueric elements, one to a plate, merely to show the present invention in its simplest form. The array 110 comprises the integral flueric element and manifold plates of identical configuration, indicated by numbers 112A, 112B and 112C. These are sandwiched together by cover plates 114 and 116 to form a stacked flueric element assembly which completely eliminates the need for separate manifold plates between flueric element plates, while at the same time allowing selective coupling of fluid passages between the various flueric elements to form a desired circuit arrangement. It is further noted that plates 114 and 116 of the FIGURE 1 assembly are identical to the outer cover plates 18 and 20 forming the prior art assembly of FIGURE 3.

The flueric element and manifold plates 112A, 112B and 112C are characterized by having both the flueric element sections, the elongated manifold passage sections, and adjacent, isolated through passage locations formed as recesses within the individual plates. This allows interchangeability and alignment of specific function areas, requiring minimum recess configuration changes to effect the desired, selective fluid coupling within each plate and between stacked plates depending upon circuit requirements. In this respect, plate 112A includes flueric element 122A including power stream inlet 124A, in line outlet 126A, at the opposite end of the interaction chamber 128A, with control ports 130A and 132A positioned adjacent and to one side of the interaction chamber. There is provided, in like manner to the flueric element plates of the FIGURE 3 prior art device, elongated manifold passages such as passage 134A coupled to control port 130A, manifold passage 136A coupled to control port 132A, and fluid outlet passage 138A coupled to flueric element outlet 126A.

Unlike the prior art devices, the elongated manifold passages are provided with a series of normally fluid isolated, but adjacent recesses, in this case circular in form, which lie adjacent the manifold passages. This allows selective coupling of these recesses to elongated manifold passages carried by plates either above and/or below a given plate. It is noted further that the isolated circular recesses, are positioned intermediate the elongated manifold passages such that they may be selectively coupled to a manifold passage on either side. For instance, with respect to plate 112A, there are provided manifold cir-

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cular recesses 158A, 160A, 162A, 164A and 165A which lie between elongated manifold passages 134A and 138A. Likewise, circular recesses 166A, 168A, 170A, 172A and 174A lie between elongated manifold passages 138A and 136A with circular recess 166A also lying adjacent manifold passage 134A. Circular recesses 176A and 178A are normally formed intermediate of manifold passages 136A and 138A on the opposite side of the series starting with recess 166A.

Therefore, one important aspect of the present invention is allowing fluid connection between the isolated recesses and the elongated manifold passageway by removal of a portion of the plate material forming a barrier between these areas. For instance, with respect to normally isolated recess position 165A it is noted that a wall between manifold passage 134A and this recess has been removed or notched to achieve lateral fluid communication. Further, with respect to recess area 176A, the wall between this recess and its associated manifold passage 138A has been removed to achieve fluid communication at this point. The cooperation between the lateral wall removal step and the oriented position of opening 146 carried by plate 114 and recess 165 may be easily appreciated. A control fluid signal readily passes through opening 146 on cover plate 114 to recess area 165A. With the side wall of this recessed area removed, fluid connection is achieved to associated manifold passage 134A and control channel 130A. The remaining integral fluieric element and manifold plates 112B and 112C are similarly provided with identical fluieric element and manifold sections by configured recesses in like manner to plate 112A. Like numerals represent like recess areas. Again, it is assumed that the bottom or lower cover plate 116 carries a suitable circular opening or port for delivering power stream fluid from a source (not shown) through bottom cover plate 116 to inline, vertical passages 142C, 142B and 142A to provide the necessary power stream requirements for the three fluieric elements 122A, 122B and 122C.

In order to achieve the desired circuit relationship between the fluieric elements carried by each adjacent plate, it is only necessary to complete a desired lateral connection by notching a side wall between a circular recess area and a selected manifold passage, for inner plate connections and complete the removal of plate material at any selected circular recess to achieve plate-to-plate fluid interconnection.

As previously indicated, a fluid control stream indicated by arrow 190 passes through cover plate opening 146 to recess 165A whereupon, due to the lateral wall removal, fluid passes directly through manifold passage 134A to control port 130A associated with fluieric element 122A. A second control stream signal passes as indicated by arrow 192 through circular opening or aperture 194 on plate 114 which is aligned with isolated recess 166A carried by plate 112A. The fluid control signal is not intended to control fluieric element 122A, but rather fluieric element 122B carried by the second plate 112B. Thus, a hole is completed through annular recess 166A, such that the fluid signal stream 192 passes to recess area 166B. Further, the wall between the recess 166B and control passage 134B is removed so that control signal 192 enters interaction chamber 128B through control port 130B to affect operation of fluieric element 122B. Meanwhile, the power stream passing through interaction chamber 128A in plate 112A passes into manifold passage 138A. This passage is blocked except for the lateral removal of the side wall between the passage and annular circular recess 176A. Further, a hole is formed in this recess through the thickness of the plate 112A so as to provide an axial passage to aligned circular recess 176B of plate 112B. Further, the side wall surrounding this recess has not been deleted, but the opening formed by the recess has been completed through the thickness of plate 112B to form a second axial through passage to deliver the out-

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put of fluieric element 122A, identified as output signal 196, to the normally isolated recess 176C of plate 112C. A portion of the side wall associated with this recess has been removed to fluid connect recess 176C to manifold passage 136C for delivering the same as a control signal to control port 132C associated with fluieric element 122C.

Further, referring back to plate 112B, it is noted that the power stream passing through the fluieric element 122B, under normal circumstances passes through outlet port 126B into manifold passage 138B. In this case, the side wall has been removed between normally isolated circular recess 160B in this passage, and further, a hole including this recess has been completed through the thickness of plate 112B to pass the outlet fluid indicated by arrow 198 to normally isolated circular recess 160C formed within plate 112C. A portion of the side wall of this recess has been removed in plate 112C to fluid connect the recess to the elongated manifold passage 134C, thereby delivering the fluid 198 as a control signal to fluieric element 122C since it passes through control port 130C and enters interaction chamber 128C. With the power stream entering port 124C to interaction chamber 128C, in the absence of control signals at ports 130C and 132C, the main power stream will pass through inline outlet 126C into outlet manifold passage 138C. Normally isolated annular recess 172C has its side wall removed to allow fluid communication between its recess and the manifold passage 138C. In addition, within recess 172C, a hole has been completed through the thickness of the plate 112C to form an axial fluid communication path to cover plate 116. In this respect, aperture 202 in plate 116 receives fluieric element outlet signal indicated by arrow 200 which is then passed to an end device (not shown).

The simple but effective manner of achieving both plate-to-plate, and inner plate fluid connection on a selective basis with minimum modification of a standard, identically configured plate may be best seen by reference to FIGURE 2 which is a sectional elevation of the assembly 110. Circular opening 194 in cover plate 114 is shown as being axially aligned with normally isolated circular recess 166A carried by integral fluieric element in manifold plate 112A and normally isolated circular recess 166B carried by plate 112B. Annular recess 166A is shown with a hole completed through the thickness of plate 112A, while the lateral side wall between recess 166B and manifold passage 134B of plate 112B has been removed to allow fluid connection between cover plate port 194 and manifold passage 134B in the manner previously described. Likewise, the power stream passing into outlet manifold passage 138C of plate 112C passes from this plate, through normally isolated circular recess 172C and an axial hole so as to fluid connect the manifold passage 138C to signal outlet port 202 carried by cover plate 116, the signal being identified by arrow 200.

In manufacturing the individual, identical fluieric element and manifold plates, for the many circular isolated recesses, the bottom wall of these recesses may be suitably weakened so as to allow the bottoms to be "knocked out" by means of a simple mechanical blow similar to the method of manufacturing electrical outlet boxes in which openings in the walls may be achieved by knocking out weakened wall sections. Further, if the plates are made from plastic, simple rotary tools may be employed for achieving lateral fluid inner plate connection by removing side wall ports prior to assembly. Thus by selectively cutting notches and holes a single mass-produced plate can be used to satisfy all element and manifold requirements interposed by the fluieric circuitry. While we have described the invention as being applied to plates carrying identical fluieric elements configured as in "NOR" devices having a pair of adjacent control inlet ports 130A-132A, for instance, the fluieric element sections themselves may be so configured as to be provided with removable wall sections for allowing fluid connection of one, two, three, four or more control passages, to the

interaction chamber, and at the same time allowing selective coupling of the interaction chamber to two or more fluid outlets by the same lateral wall removal or notching technique.

While the invention has been particularly shown and described with reference to a preferred embodiment, it will be understood by those skilled in the art that the foregoing and other changes in form and detail may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. An integral fluoric element and manifold plate for multiple plate stacking and fluid interconnection, said plate comprising:

a formed fluoric element section defined by a configured surface recess, and a manifold section including at least one separate elongated manifold passage in the form of a configured surface recess and a series of isolated surface recesses adjacent said manifold passages to facilitate selective lateral coupling thereto by removal of side wall portions between selected recesses and said manifold passages and completion of holes, axially through the plate thickness for plate-to-plate fluid coupling.

2. The plate as claimed in claim 1 wherein said manifold and said elongated manifold passage recess and said series of isolated recesses project from the same surface of said plate.

3. The integral fluoric element and manifold plate as claimed in claim 1 wherein said isolated surface recesses are circular in configuration.

4. The integral fluoric element and manifold plate as claimed in claim 1 wherein, at least two of said separate elongated manifold passages have portions extending parallel to but spaced from each other, and said series of isolated surface recesses are positioned intermediate of said elongated manifold passage portions to allow selective lateral fluid coupling between any one of said isolated surface recesses and either of said manifold passage portions.

5. A method of forming an improved fluoric element stacked array comprising the steps of:

stacking a plurality of integral fluoric element and manifold plates of identical configuration in face abutting relationship, with each plate including a formed fluoric element section defined by a configured surface recess and a manifold section including sepa-

rate elongated manifold passages in the form of configured surface recesses and a series of isolated surface recesses adjacent said manifold passages; notching the side wall of said isolated surface recess to selectively couple the same to respective manifold passages; and completing holes axially through selected isolated surface recesses to establish plate-to-plate fluid connections therebetween.

6. The method of forming a stacked array of fluoric elements in circuit completing relationship comprising the steps of:

forming a plurality of identical, integral, fluoric element and manifold plates including axially aligned, formed fluoric element sections defined by a configured surface recess and axially aligned manifold sections adjacent thereto, including a plurality of separate elongated manifold passages in the form of configured surface recesses and a series of axially aligned, isolated circular surface recesses adjacent said manifold passages, and positioned therebetween; selectively removing side wall portions between selected circular isolated surface recesses and said manifold passages; and completing holes through said plate thickness at selected isolated surface recesses to establish plate-to-plate fluid connections.

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SAMUEL SCOTT, Primary Examiner

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