[Second Edition.]

PATENT SPECIFICATION

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COMPLETE SPECIFICATION.

Improvements in and relating to Methods and Apparatus for Effecting Catalytic Reactions between Gases Under Pressure and at High Temperature.

I, STANLEY GORDON SINCLAIR DICKER, Chartered Patent Agent, of 20 to 23, Holborn, London, E.C. 1, a British Subject, do hereby declare the nature of this invention and in what manner the same is to be performed, as communicated to me by Dr. Maria Casale Sacchi, of 73, Piazza SS. Apostoli, Rome, Italy, an Italian Subject, to be particularly described and ascertained in and by the following statement:—

The industrial application of processes based upon catalytic reactions between gases under pressure and at high temperature is carried out by means of a series of apparatus disposed in a closed or open circuit, consisting of *a*) a catalysis apparatus, *b*) a cooler in which the gases issuing from the catalytic apparatus are cooled to a suitable temperature, *c*) a receiver in which are collected the products formed in the catalytic apparatus and condensed in the cooler.

There may also be inserted in the same circuit other apparatus, such as heat exchangers, in which the gas sent to the apparatus of catalysis is heated at the expense of heat from the issuing gases, gas purifiers, etc.

When the apparatus used are disposed in a closed circuit, it is necessary to use a circulating pump or another equivalent device to obtain the circulation of the reacting gases.

Now, according to the object of the present invention, it has been found that it is possible to construct a single apparatus which will accomplish all of the operations which in the closed circuit of apparatus above referred to are performed by the catalysis apparatus, cooler, collector, circulating pump and heat exchanger.

Said apparatus can be constructed in various ways. For instance, in the annexed drawings Figs. 1 and 2 represent the vertical sections of two of the principal methods of execution.

In Fig. 1, referred to in the following description, 1 shows a steel tube able to resist the pressure of the gases contained in the tube itself; said tube is closed at the upper end by the cover 2, and at the lower end by the cover 3. Concentrically to tube 1 is placed tube 4, at the lower end of which is fixed the cone 5, truncated by the flat surface 6 which is provided with a hole 7. Moreover, concentrically to the tube 1 are placed tubes 8, 9, 10 and 11. Tube 8, preferably lined with a thermal insulating material, has the upper end free, while it is closed at the lower end by the truncated cone 12 and by the circular bottom 13, on which the lower end of the tube 11 is welded.

Also 12 and 13, as well as tube 10, to which we will refer below, will be preferably supplied with a thermal insulator. Tube 9 is closed at the lower end by disc 14 bearing in its centre a hole into which is tight fitted tube 11. Tube 10 is free at its lower end. Tube 11 bears at its lower end holes 15 which allow the inside of tube 11 to communicate with the space comprised between 12 and 14.

In the upper part of the apparatus is placed block 16, the annular end 17 of which closes the free space between the upper ends of the tubes 4 and 9; block 16 closes in the upper end also the space between tubes 10 and 11 and is provided with two holes 18 and 18^1 through which pass the thermoelectric couples 19 and 19^1. Moreover, in block 16 there are holes 20 which allow the space comprised between tubes 1 and 4 to communicate with that comprised between tubes 9 and 10. In the circular space enclosed by the tube 11 is fitted the electric heating device 21. In the lower part of the apparatus is disposed, as indicated in the figure, the cone of diffusion 22, formed by special piece 23 supported by cover 3.

In the space comprised between tubes 1 and 4 is placed a cooler of any shape. Said cooler could also occupy a part of the internal space in tube 1 placed below surface 5.

In the figure is shown for this purpose a coil 24 through which flows a cold fluid which enters at 25 and issues from 26.

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It is advisable that the cooler be constructed in such a manner that the gases contained in the space comprised between tubes 1 and 4 should be prevented from coming directly in contact with the internal surface of tube 1. Tube 1 as well as cover 2 could be supplied with cooling devices which may be independent or not of the one situated in the space comprised between tubes 1 and 4.

Tube 27, which passes through lower cover 3, serves to admit into the apparatus the gases which are to be catalysed. Said tube bears at its lower end a nozzle 28, which, together with special piece 26, forms a true and proper ejector having a diffusion cone 22 and a suction duct 29. The gases to be catalysed reach the nozzle compressed at a pressure higher than the pressure existing in the apparatus, and thus, when entering the apparatus, they expand and part of their potential energy is transformed into kinetic energy, which is utilised by the ejector to cause the circulation of gases within the apparatus itself. By means of a device which does not appear in the drawing, it is possible to displace the nozzle 28 along its axis, thereby varying the position of the nozzle in respect of the diffusion cone. On the inside of the nozzle is a regulating needle which can also be displaced along its axis by means of a special device not shown in the figure. By working these two devices it is possible to vary within the widest possible range the velocity of the circulating gases as well as the ratio between the volume of the gas circulated and the volume of the fresh gases introduced.

As shown in the illustration, the gases coming from the compressor, mixed with a suitable quantity of gases already contained in the apparatus, pass first through the space comprised between surfaces 5 and 12, and then through the spaces comprised between 4 and 8, 8 and 9, and between surfaces 13 and 14. Thence through holes 15 they enter tube 11, in which is placed the electric heating device. The gases leave this space through holes 30 placed in the upper end of tube 11 and then pass through the space comprised between tubes 10 and 11 which contains the catalyst.

Thence the gases pass through the space comprised between tubes 9 and 10, and then, passing through the free space 20, reach the space comprised between 1 and 4 where they are cooled to a suitable temperature by means of the devices above described. During said cooling the products formed are separated and condensed at liquid state, and are collected in space 31 from which they may be extracted by means of pipe 33. The gases are now suctioned through pipe 29 by the entering gases, and are again circulated through the apparatus in the manner described.

It should be observed that between the gases passing through the space comprised between tubes 8 and 9 and the gases passing through the space comprised between tubes 9 and 10 there occurs a heat exchange in consequence of which the latter give their heat to the former. Therefore, tube 9 will by preference be provided with ribs, grooves and so on, which increase its surface.

Tube 4 will likewise be partially or completely provided with ribs etc., since the gases which pass through the space comprised between this tube and tube 1 give a part of their heat to the gases contained in the space comprised between said tube 4 and tube 8.

Fig. 2 shows, as has been said, another manner of construction of the same apparatus which differs chiefly from the preceding one on account of the two metallic blocks 33 and 34, the former placed in the upper, the latter in the lower end, each provided with two sets of holes, as shown in the figure, which put in communication the spaces through which successively pass the gases. The position and the purpose of the two series of holes appears clearly from the figure which is divided in two parts by its axis each showing a section so made as to show one hole of each series.

Figs. 3 and 4 show two different ways of constructing a type of cooler which in practice has proved highly suitable for simultaneously cooling tube 1 and the gases passing in the space comprised between tubes 1 and 4. In the form of construction illustrated in fig. 3, concentrically to tube 1 is placed tube 35 which, though unable to resist the pressure to which it is submitted, can, by reacting elastically to this pressure, transmit the said pressure to tube 1, which must resist the pressure, and follow this tube 1 in its deformations, so that between the contacting surfaces of tubes 1 and 35 there is always a perfect tightness. Along the external surface of tube 35 is a series of grooves through which is caused to flow the cold fluid serving to cool the gases and the tube 1 to suitable temperature. In fig. 4 tube 35 is substituted by the two tubes 36 and 37. In both the types of construction it is advisable that the surfaces in contact with the gases be provided with ribs or grooves. By using coolers of such types any direct contact between gases and the internal surface of tube 1 is absolutely avoided.

In the examples here illustrated the gases flow six times through the upper part of the tube where the reaction and

the heat exchange takes place. However, apparatus can also be constructed in which the gases flow through this space a greater number of times. Likewise, the gases, instead of following the paths indicated in figs. 1 and 2 and which are also indicated schematically in figs. 5 and 8, can follow other paths, for instance, the paths diagrammatically represented in figs. 6 and 7. The constructive forms corresponding to figs. 6 and 7 are not represented in drawing, because they are easy to design on the basis of constructions represented in figs. 1 and 2.

In the types of construction herein above described, it has been shown how the present invention is applied in the case of a synthesis tube containing a series of concentric spaces, the innermost of which contains the electric heating device and is surrounded by an annular space containing the catalyst, the latter being in turn surrounded by other annular spaces. The present invention, however, can be applied equally to synthesis tubes having constructive forms different from the one here employed to describe the object of the present invention.

The advantages obtained using the present apparatus are:

1. Lowering the costs of installation, owing to the facts that the cost of an apparatus of this kind is always smaller than the total cost of the various apparatus which it substitutes, and that the space which it occupies is in practice the same as the space occupied by the synthesis tube in a plant having the same capacity of production.

2. Greater simplicity of installation, resulting from the elimination of pipings which in the circuits generally employed serve to connect the various apparatus.

3. Greater facility to centralise all the control and regulating devices of a synthesis unit resulting in economy in labour.

Lastly a considerable reduction in the resistance to be overcome in obtaining gas circulation, with consequent saving in power costs necessary to obtain said circulation.

Having now particularly described and ascertained the nature of my said invention, and in what manner the same is to be performed, I declare that what I claim is:—

1. An apparatus for the execution in closed circuit of catalytic reactions between gases under pressure and at high temperature, comprising in a single unit the devices necessary to obtain the heating of the reacting gases, their passage through the catalytic substance, the recovery of a part of the heat from the catalysed gases, the cooling of the gases which have been catalysed, the consequent separation and collection of the products formed, and the continuous circulation of the reacting gases, said circulation being obtained by means of an ejector.

2. Apparatus as claimed in claim 1 formed by a pressure resisting tube containing a series of tubes arranged coaxially with it, the innermost of which contains an electric heating device and is surrounded by the space containing the catalyst, the latter being in turn surrounded by a series of annular spaces so disposed as to form a heat exchanger, characterised by the fact that the outmost of said annular spaces through which the catalysed gases pass after part of the heat which they possess has been recovered, is provided with a cooler which cools the gases to a suitable temperature, causing the separation at liquid state of the products formed which are collected in the space comprised between the lower end of the above referred internal tubes and the lower cover, and in which space is also placed an ejector through which pass the fresh gases supplied to the apparatus.

3. Apparatus as claimed in claims 1 and 2, characterised by the fact that the pressure resisting tube is provided with a device for its cooling.

4. Apparatus as claimed in the preceding claims, characterised by the fact that the upper cover is provided with a device for its cooling.

5. Apparatus as claimed in the preceding claims, characterised by the fact that the simultaneous cooling of the pressure resisting tube and of the catalysed gases is obtained by means of a cooler consisting in a series of grooves in which passes a cold fluid, said grooves being placed along the external surface of a metallic tube lining completely the internal surface of the pressure resisting tube.

6. Apparatus for effecting catalytic reactions between gases under pressure and at high temperature, constructed, arranged and operating substantially as described with reference to the accompanying drawings.

7. The method of effecting catalytic reactions between gases under pressure and at high temperature which employs a single unit of the type substantially as described.

Dated this 29th day of April, 1929.

DICKER, POLLAK & MERCER,
Chartered Patent Agents,
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Agents for the Applicant.

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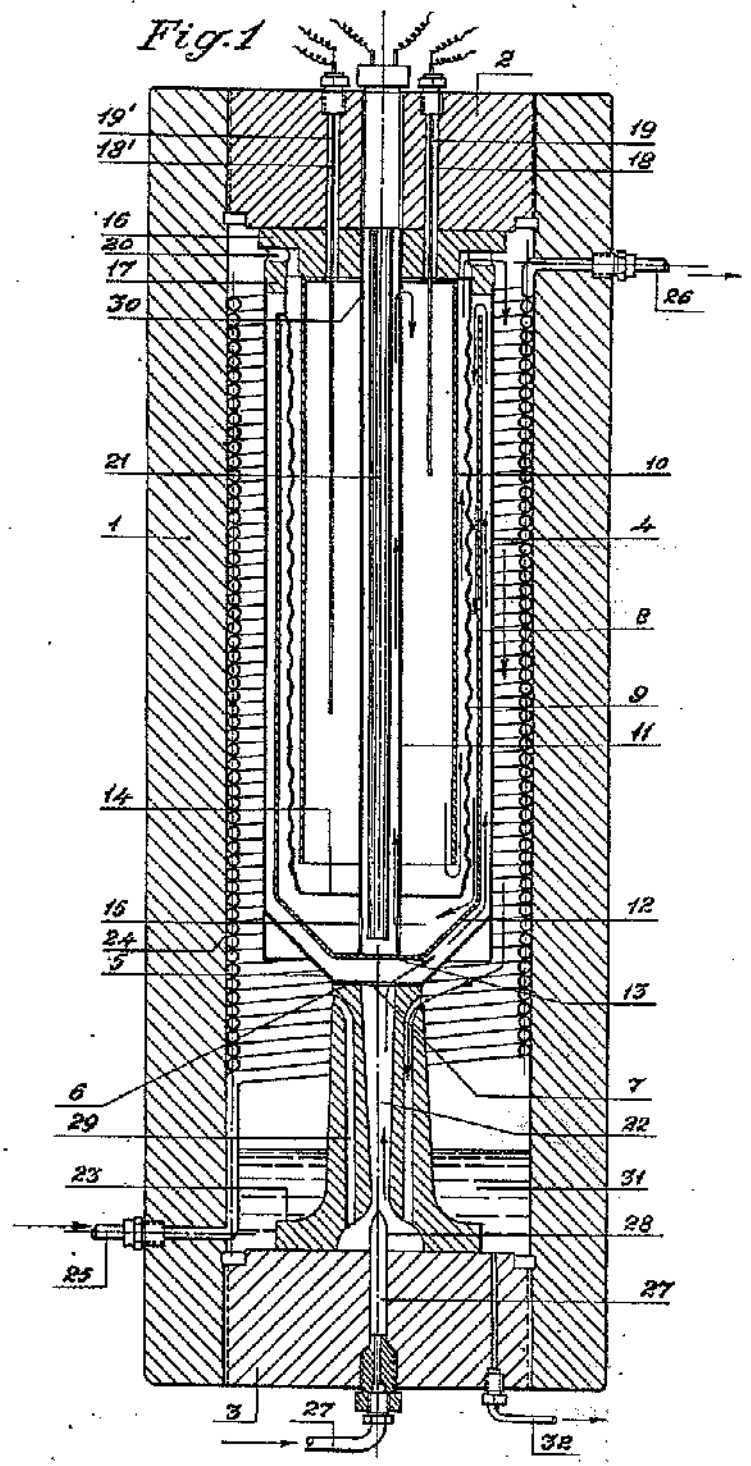
SHEET 1

[This Drawing is a reproduction of the Original on a reduced scale]

Fig. 1



Fig

Fig. 2

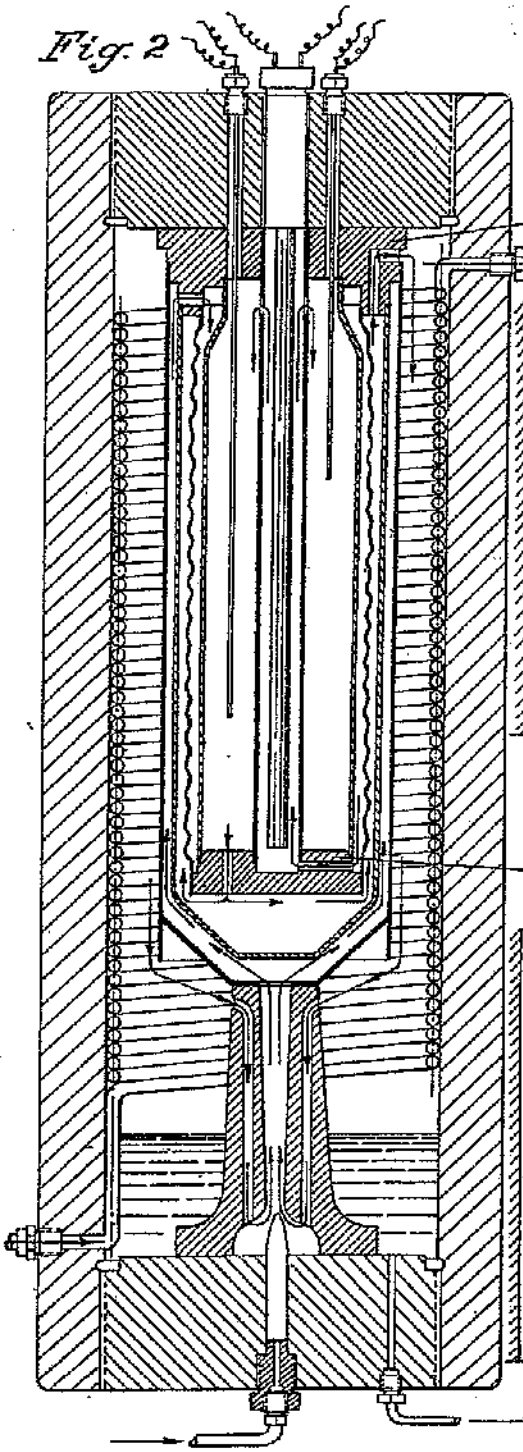


Fig. 7

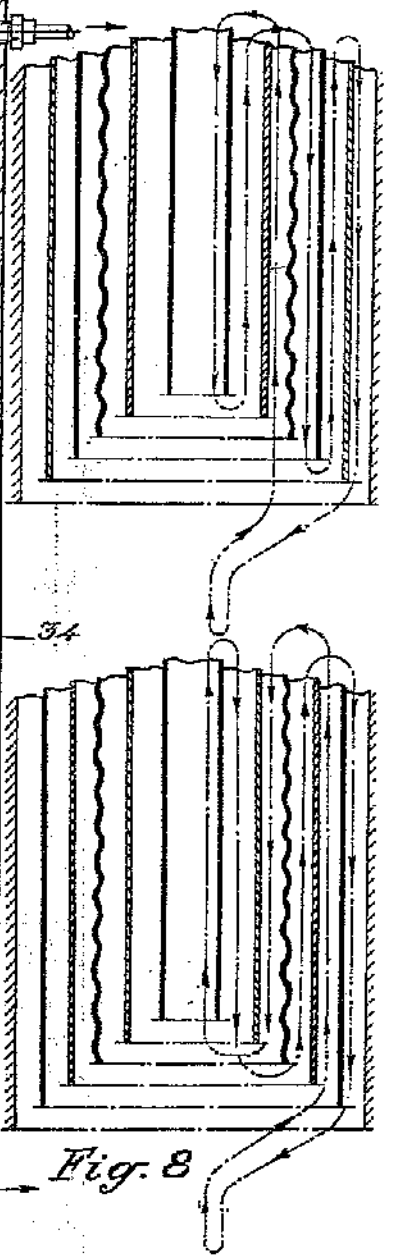


Fig. 8

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4 SHEETS

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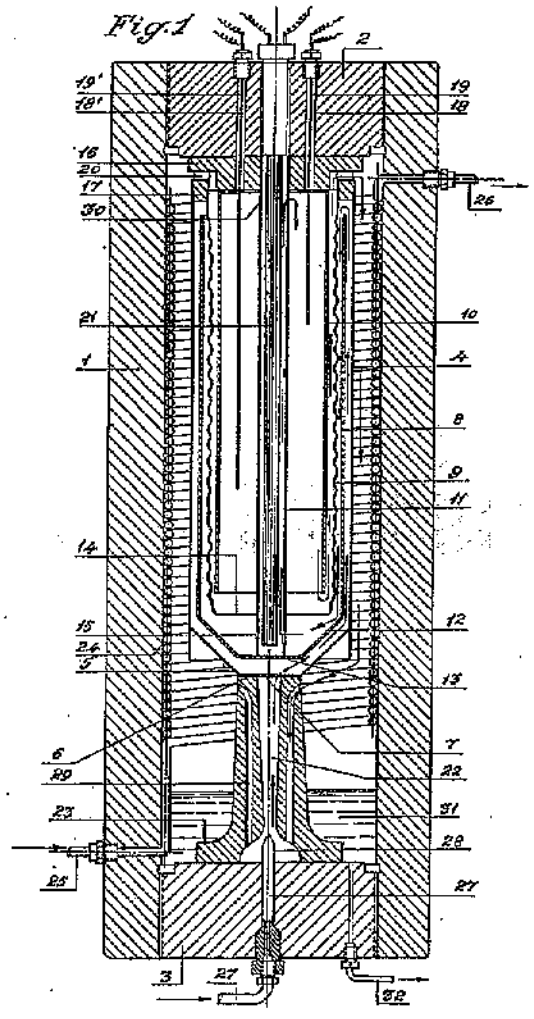
SHEET 1



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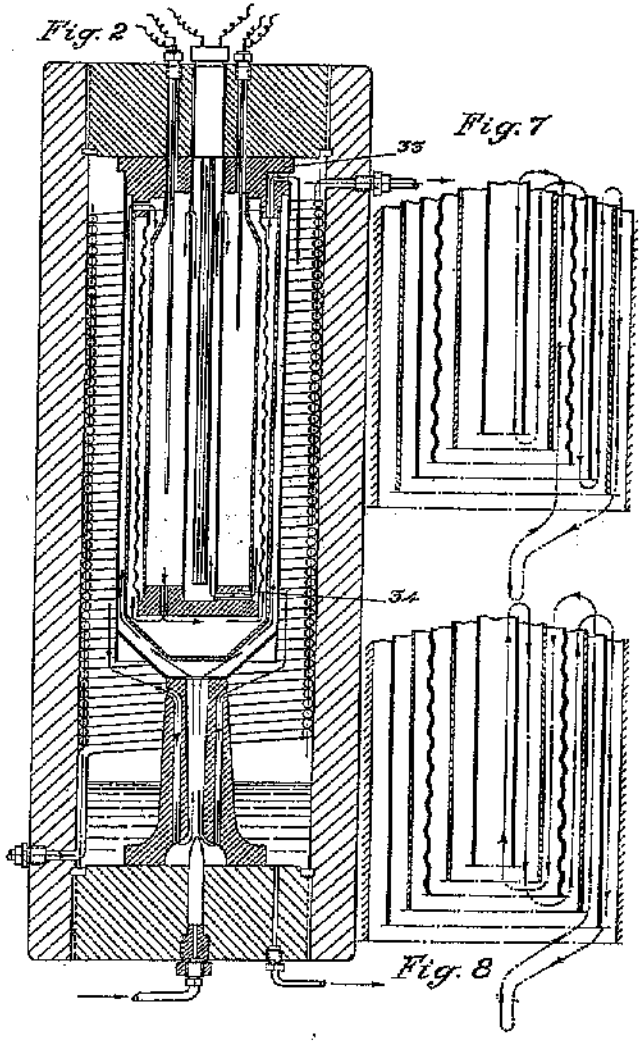

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Fig. 3

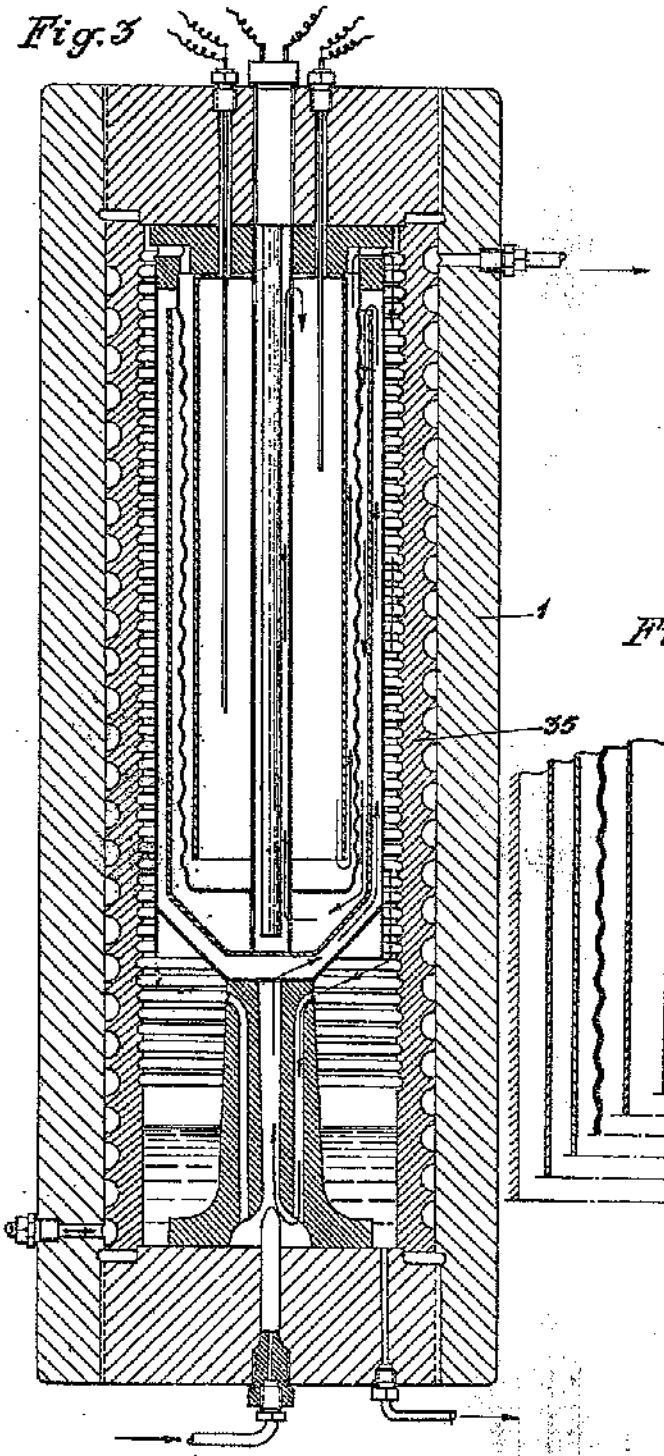


Fig. 6

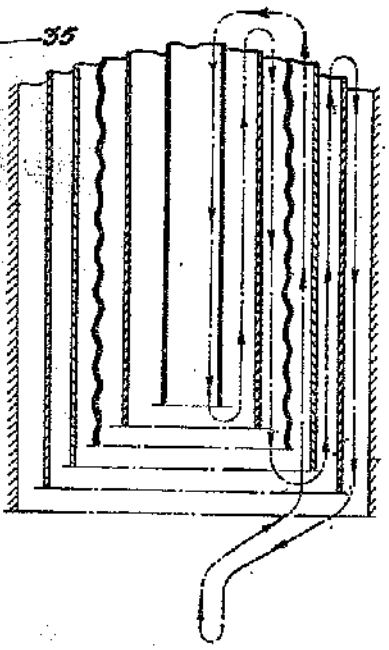


Fig. 4

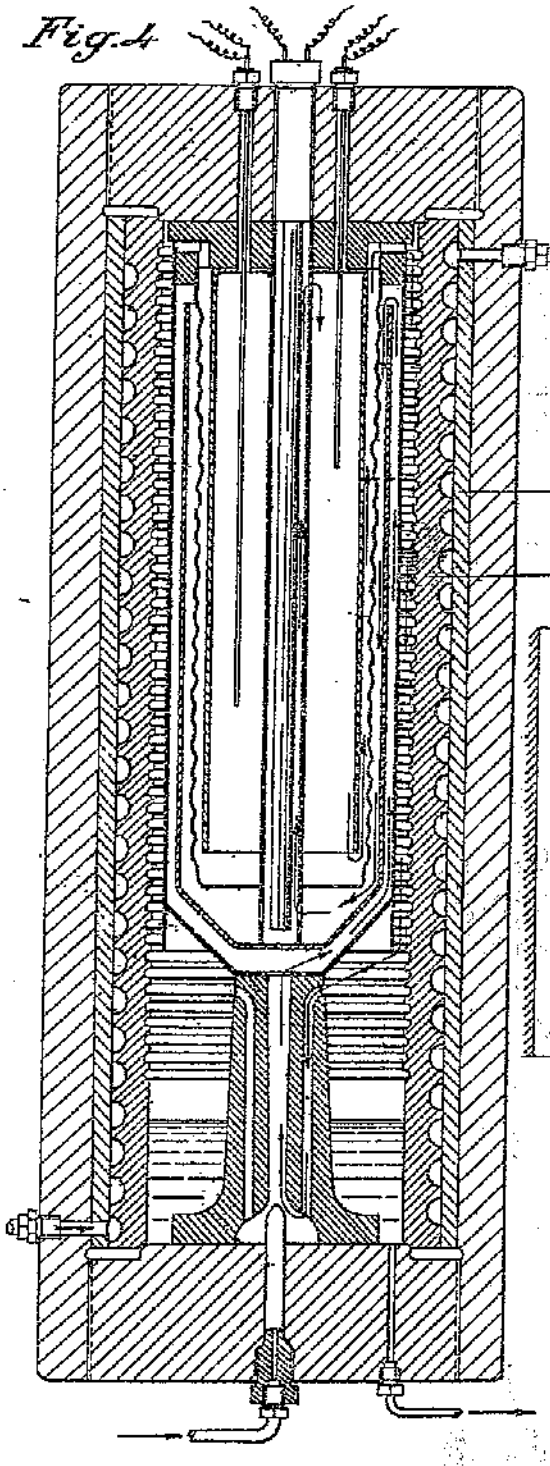
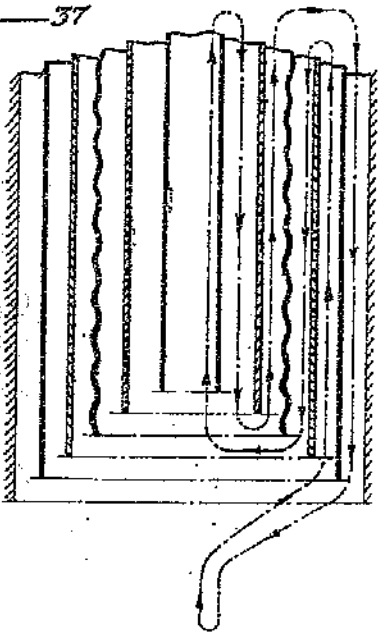


Fig. 5



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SHEET 3

Fig. 3

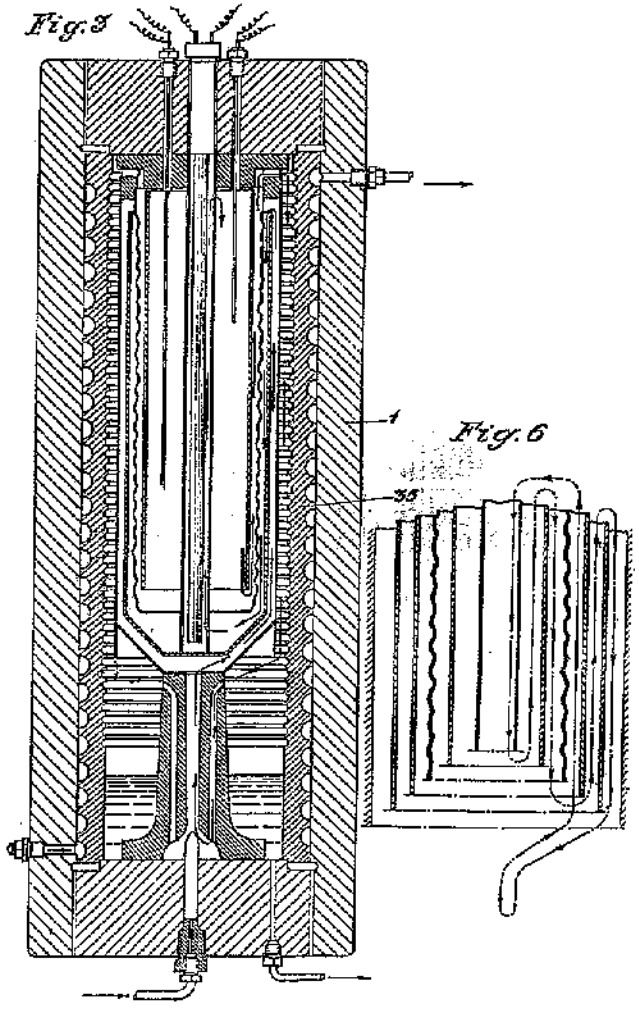


Fig. 6

SHEET 4

Fig. 4

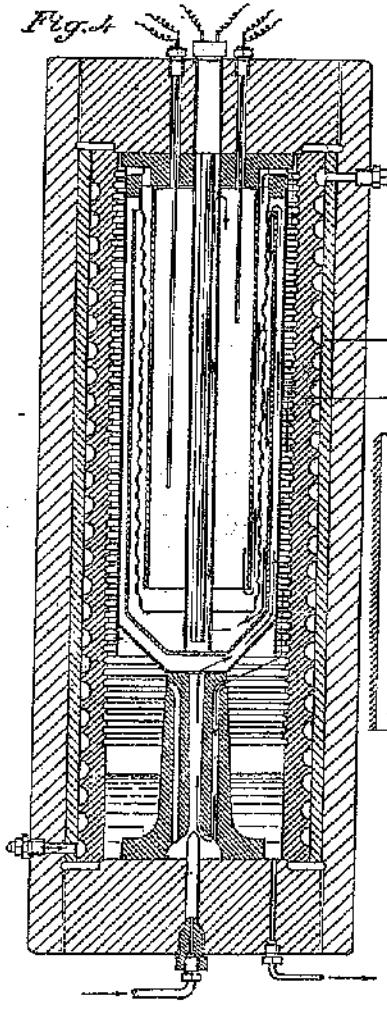
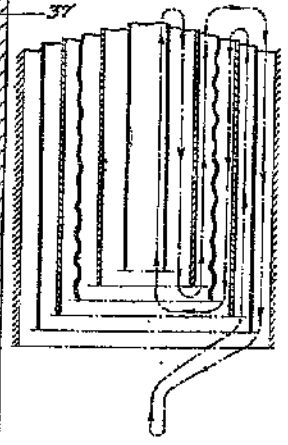


Fig. 5



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