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[54] **METHOD AND DEVICE FOR OBTAINING CONTROLLED NUCLEAR FUSION BY MEANS OF ARTIFICIAL PLASMA**

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[51] **Int. Cl.** **G21b 1/02**
[58] **Field of Search** 176/1, 2, 9, 5

[56] **References Cited**

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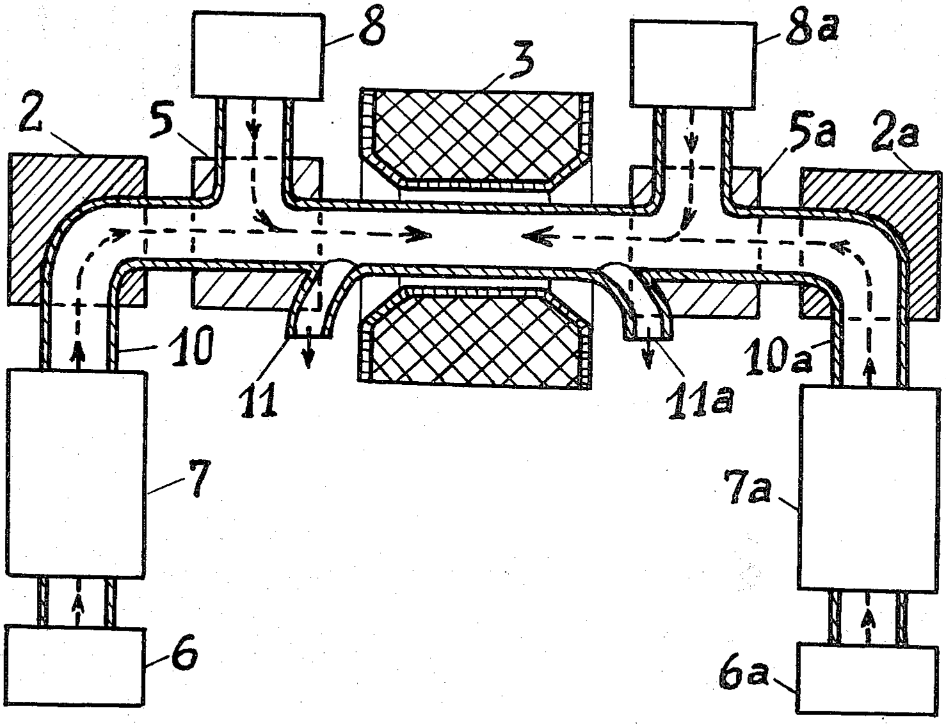
Primary Examiner—Harvey E. Behrend

[57] **ABSTRACT**

For obtaining controlled nuclear fusion, two plasma beams of high density will be formed by blending of previously and separately accelerated atomic ion beams and electrons via deflection magnets, directed against each other with short impulses and combined to a fusion plasma within a reaction space surrounded by a contraction coil. With the axially aligned particle beams a high plasma density of 1^{22} - 1^{24} ions/ccm can be obtained and thus a good efficiency of fusion.

In the drawing, **6**, and **6***a* presents the atomic ion sources and **7**, and **7***a* the atomic accelerators. The atomic ion beams are deflected through magnets **2**, **2***a* and by means of the weaker deflection magnets **5**, **5***a* the electronic beams coming from the electronic accelerators **8**, **8***a* are admixed. The thus formed plasma beams are directed against each other in short periods with limited quantities of particles. A magnetic contraction coil **3** produce the desired high density of the atomic ions. The suction lines **11**, **11***a* maintain a high vacuum in the reaction space.

13 Claims, 7 Drawing Figures



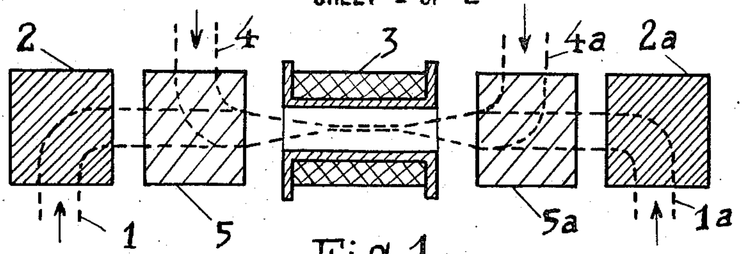


Fig. 1.

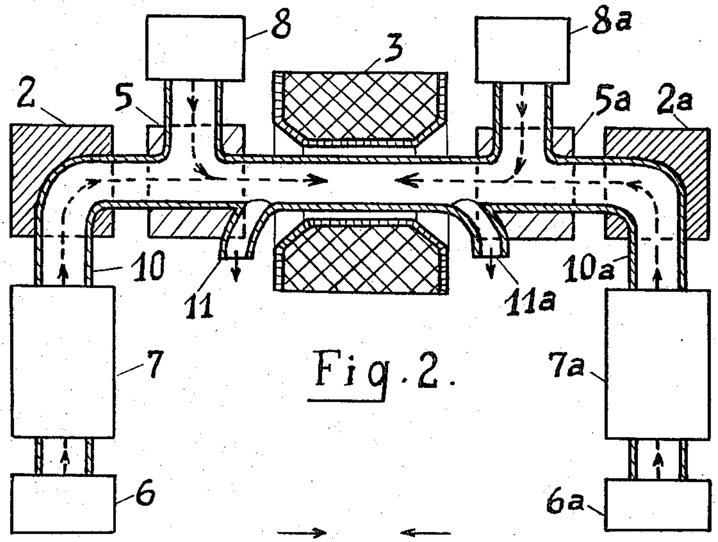


Fig. 2.

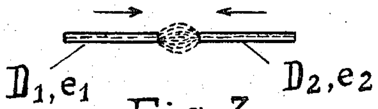


Fig. 3.

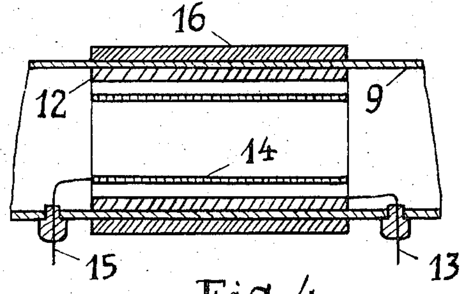


Fig. 4.

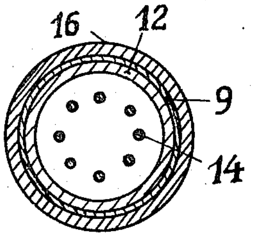


Fig. 5.

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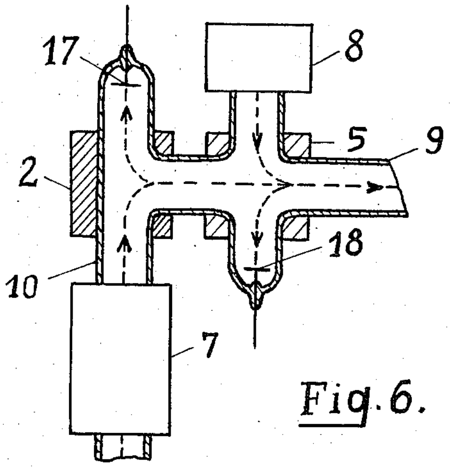

Fig.6.

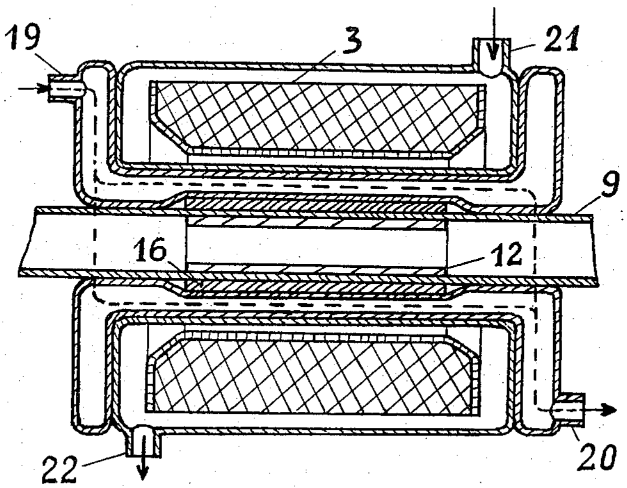

Fig.7.

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METHOD AND DEVICE FOR OBTAINING CONTROLLED NUCLEAR FUSION BY MEANS OF ARTIFICIAL PLASMA

The present invention concerns a method for obtaining controlled nuclear fusion by means of artificial plasma produced by the combination of previously accelerated atomic ions and electrons, applying beams of atomic ions travelling in opposite directions. Furthermore the present invention provides for the device necessary for the practical application of said method. According to the invention beams of atomic ions and electrons are combined via different deflection magnets, the beams of atomic ions passing through both magnets, the electron beam, on the other hand, passing only through one weaker magnetic field. Prior to the collision the plasma beams thus produced are contracted to ion densities of the orders 10^{22} to 10^{24} or more ions/ccm by means of magnetic fields of increasing electric field strength due to the avoidance of radial velocity components of the ion flux movement and are thus led together in limited packets (i.e., short pulses of electric current).

In order to obtain controlled nuclear fusion it is necessary to provide the atomic ions with velocities sufficing for overcoming the Coulomb barrier. As far as deuterium ions (deuterons) are concerned this is the case in an ordinary plasma of 100 million ° K. According to the equation $e \cdot V = K \cdot T$ this corresponds to ion velocities of 10 keV (1 eV corresponds to a temperature velocity of about 7,730 ° K). So far fusion temperature has been attempted to be reached mainly by means of pulsating discharges of current, plasma shocks, etc. Considering Maxwell's distribution of temperature velocity, however, the fusion plasma also has to be kept in a stable position for a certain period of time (cca 1 second), i.e., it has to be enclosed by an arrangement, so that the fastest of the atomic ions of the temperature movement on all sides may collide in accordance with the mean value. However, considerable problems have to be faced in achieving fusion temperature and in maintaining the fusion plasma over a sufficient length of time with a sufficiently high plasma density and yield.

Apparently two factors are chiefly responsible for the instability of heavily contracted plasma columns, namely, side effects of the hot plasma on the colder gaseous atmosphere surrounding it, and the tendency of the plasma to reduce its density on account of the movement of temperature on all sides, which is manifested in an enormous expansion pressure.

The present invention avoids these difficulties. Artificial plasma is produced in a vacuum, thus eliminating the side effects. By avoiding a movement of temperature on all sides and applying an exclusive axial ion velocity in two plasma beams travelling in opposite directions, a primary radial velocity component being avoided, high and highest plasma densities may be obtained by means of relatively weak electromagnetic field strengths. Owing to the fact that all atomic ions of the beams virtually possess the same velocity, which is produced by one accelerator in each case, also the reaction time necessary in the case of ordinary plasma with a general temperature movement, i.e., Maxwell's distribution of temperature velocity, is no longer required, that is to say, the necessity of enclosing the plasma. Atomic ions and electrons are accelerated separately to an appropriate extent each and form plasmas each. Only the collision of these two contracted artificial plasmas triggers of the fusions.

The accompanying drawings will provide a more detailled explanation of the present invention.

FIG. 1 illustrates the principle of the method invented;

FIG. 2 schematically shows an example of the practical application of the present invention;

FIG. 3 serves to explain the fusion process invented;

FIGS. 4 and 5 show details of an appropriate device for obtaining the energy produced;

FIG. 6 offers a schematic explanation of another variety of the device invented;

FIG. 7 schematically shows an example of the reaction chamber of the device invented.

According to FIG. 1 the beams of atomic ions **1**, **1***a*, stemming from ion sources (canal ray tubes) and subsequent accelerators, which are not shown here, are directed against each other after having been deflected by magnetic fields from magnetic poles **2**, **2***a* and meet within the contraction field of a magnetic coil **3**. Prior to the combination of the ion beams the electron beams **4**, **4***a* are added, which also come from accelerators not shown here, via the deflection magnets **5**, **5***a*, which leads to the formation of artificial plasma beams. The combined beams of atomic ions and electrons are preferably of the same or of similar cross sections and particle densities (electron energy might be somewhat higher) so that in the nascent plasma the space charge is either compensated (quasi neutrality) or negative and the mutual Coulomb repulsion of atomic ions in the beams is offset. Thus the nascent plasma contracts itself (self pinch) and is subsequently further contracted by the fields of the magnetic coil **3** enclosing the area of reaction. The deflection fields of magnetic poles **2**, **4** (and **2***a*, **4***a*, respectively) for beams of atomic ions and electrons are of the same direction each so that the antipole particles are added from opposite sides in each case; in case of different directions they might be added from the same side. Beams of atomic ions and electrons possess approximately the same velocity, i.e., electronic energy may be substantiall below the atomic energy. Electron velocity may preferably also be somewhat greater than the ion velocity. The beams of atomic ions **1** and **1***a* also pass through the deflection fields for the electrons **4** and **4***a* respecively, a fact which in calculating the paths of the ion beams **1** and **1***a* and the field strenghts of the deflection magnets **2** and **2***a* should be taken into consideration; the fields of the electron deflection magnets (poles **5**, **5***a*), however, which may be much weaker, do not have a decisive effect upon the ion beams, which are deflected only to a small extent since they possess a far greater amount of energy when moving at the same speed. Within the area enclosed by coil **3** the fusion reactions take place. For this purpose the beams of atomic ions and plasma respectively have to penetrate each other to a certain degree which depends on the ion density obtained through contraction as well as on the degree of ion acceleration. It is to be suggested to use atomic ion energies ranging from a few keV to a maximum of about 100 keV, the field strength of the field of contraction (coil **3**) amounting to 10^3 to 10^4 Gauss. Considering an effective collision cross section of 0.03 barn (i.e., 0.03. 10^{-24} cm^2) at 100 keV and an ion density ranging from 10^{22} to 10^{24} ions or more/ccm the reaction path may be less than 1 m (e.g., $^{-}$ m in the case of 10^{24} ions/ccm if all energy is made use of).

The accelerated plasma beams are preferably directed against each other by impulses, i.e., abruptly. The high vacuum vessel enclosing the arrangement is not shown in FIG. **1** for reasons of simplicity.

FIG. **2** offers a further explanation of the apparatus used. It shows schematically the cases of the ion sources **6** and **6***a* with the subsequent accelerators **7, 7***a* and the electron source and accelerator units **8, 8***a*, which resemble Braun tubes. Here, the contraction magnet **3** enclosing reaction tube **9** is made to supply field strength through an increasing electromagnetic field strength which at the outset slowly increases towards the field of reaction. The connections **10, 10***a* located before or after the accelerators may have a diameter of e.g., 10 to 20 cm or more, the same holds true for part **9** in the reaction zone, however, it may also be a little less there. Within the area of reaction the plasma contracts itself to form a slim tube, i.e., it is of small cross cut with high particle density. On the side of the area of reaction there is a tube **11** and preferably also a symmetrical tube **11***a* in addition for the evacuation of the system. Pumps for achieving a maximum vacuum should be in constant operation, the bring about the operating vacuum and remove remaining reaction products.

According to FIG. **3** two plasma columns D_1, e_1 and D_2, e_2, which have been heavily contracted by magnetic action and which have been produced according to the method explained in FIG. **1** in an apparatus as is shown in FIG. **2**, collide frontally, so that the atomic ions, owing to the high plasma density, may encounter fusion pulses after having travelled a short distance and little scattering occurs. The electrons added to the atomic ions are preferably a little faster or are put in a little earlier, which leads to the formation of an electron cloud at the point of collision of the ion packets emitted, which may further support the fusion of atomic ions. Also additional electrons enclosed at the side of the magnetic field of coil **3** and rotating within the area of reaction may favor fusion, however, the electrons present in the plasmas may suffice to support the fusion. As long as atomic ions and electrons move at high speeds (which either equal or exceed the thermic speeds at thermic dissociation) they can hardly combine to form atoms, i.e., the cannot recombine; this is possible only after slowing the down. Owing to the high plasma density and the discontinuous emission little scattering of atomic ions occurs, the high plasma density also favors a so-called tunnel effect, i.e., the reduction of atomic energy necessary to overcome the Coulomb barrier. According to theory particle energy has to suffice to achieve an approach up to a distance of 10^{-13} cm, at which point the Coulomb repulsion ceases to exist and the great nuclear force becomes effective, i.e., apparently a change in the structure of the atomic ions takes place in the course of which a nucleus is formed out of the two nuclei.

FIGS. **4** and **5** schematically show an appropriate arrangement for the purpose of obtaining energy. A layer **12**, e.g., a graphite layer (graphite cylinder tube) is attached to the inner wall of the reaction tube which absorbs radiation energies of all kinds and which also becomes positively charged by protons if protons are produced in the course of the reaction, thus supplying electric current via a leakage **13**. It may also become charged through scattered atomic ions. In order to hold back scattered electrons a grid-like electrode with a positive potential may be placed before this wall electrode **12**, which consists e.g., of cylindrically arranged graphite rods **14** with a lead **15.**

Protons result from the fusion of deuterium ions and tritium and an energy release of 4.08 MeV. As known, protons and tritium trigger off further reactions in the course of which also ^3He and ^4He emerge as well as neutrons ($P + D = {}^3He + 5.5$ MeV, $T + D = {}^4He + N + 17.6$ MeV, etc.). The deuterium fusion may also directly supply ^3He ($D + D = {}^3He + N + 3.27$ MeV). Therefore a direct fusion of deuterium ions into stable helium (^4He) should be sought to be achieved, with no production of protons or neutrons and with an energy release of 23.8 MeV.

An expansion inducing a Maxwell temperature movement, which is due to come about in the reaction chamber after the collision of the plasma columns unless only short electric impulses (plasma packets) are applied, is prevented by the discontinuous emittance. The emittance of particle packets is known through modern impulse method.

In FIGS. **4** and **5**, reaction tube **9** is lined in addition by a layer **16** of a high density material, e.g., lead, platinum, tungsten, or an appropriate alloy, designed to complete the radiation absorption by graphite layer **12.**

A further application of the present invention is shown in FIG. **6.** In order to prevent the loss of energy stemming from accelerated particles which perhaps have escaped collision and are not scattered, and to prevent these accelerated particles from uncontrollably hitting the vessel wall in an undesired manner special electrodes have been designed according to FIG. **6** to capture these particles. The remaining primary electric energy may be obtained from these electrodes by means of circuits, e.g., between these electrodes and the point of departure of the particles. According to FIG. **6** the remaining fast atomic ions reach the above-mentioned electrode **17** via polar field **2** and, together with the ion source, can form a circuit (**6***a* in FIG. **2**), whereas surplus fast electrons are lead to electrode **18** via polar field **5** and may form a circuit e.g., with the electron source (**8***a* in FIG. **2**). If necessary, it might also be possible to establish a circuit between electrodes **17** and **18.**

FIG. **7** schematically shows a detail of the device invented, namely an example of the reaction chamber. In this case the reaction tube **9** with the inner layer **12** and the outer layer **16** has two cooling jackets. The inner cooling jacket with feed pipe **19** and outlet **20** may be used to make use of the thermal reaction energy for the purpose of power production, the outer jacket with feed pipe and outlet **21, 22** is designed above all to cool the magnetic coil **3** and to protect it against damage. Layer **12** preferably consists of graphite, layer **16** of a high density and appropriately heat resisting alloy.

In its practical application the present invention is not limited to the examples shown here. Magnetic fields, e.g., may be replaced by other devices capable of combining and concentrating atomic ions and electrons into high density plasma beams.

I claim:

1. A method for obtaining controlled nuclear fusion by means of artifical plasma, formed by leading together atomic ions and electrons, characterized by the fact that atomic ion beams (**1, 1***a*) after they have been previously accelerated via deflection magnets (**5**, **5***a*) are admixed with previously and separately accelerated electronic beams (**4**, **4***a*), and thus formed plasma beams of high density are are directed against each other within a magnetic contraction (**3**).

2. A method according to claim **1**, wherein the beams of atomic ions (**1**, **1***a*) are deflected by a magnetic deflection field (**2**, **2***a*) and are made to pass through another, weaker field (**5**, **5***a*) designed to deflect and add the electron beam (**4**, **4***a*).

3. A method according to claim **1**, wherein ion densities ranging from 10^{22} to 10^{24} or more ions/ccm are applied by means of magnetic contraction, space charge being compensated and radial velocity components of the ion movement being avoided.

4. A method according to claim **1**, wherein the axial velocity of the plasma electrons is greater than the velocity of the atomic ions.

5. A method according to claim **1**, wherein the electron beams are emitted earlier than the beams of atomic ions.

6. A method according to claim **1**, wherein the electric current of the electrons exceeds the current of the ions, which results in a negative space charge.

7. A method according to claim **1**, wherein the plasma beams produced pass through a magnetic field with a field strength of increasing contracting property until the zone of fusion is reached.

8. A method according to claim **1**, wherein the beams of atomic ions, which combined with electrons form plasmas, are directed against each other in short current impulses.

9. A device for obtaining controlled nuclear fusion, wherein the sources of atomic ions (**6**, **6***a*) with accelerators (**7**, **7***a*) and electron sources with accelerators (**8**, **8***a*) are symmetrically arranged so as to form a reaction chamber, the reaction chamber being enclosed by a magnetic coil (**3**) and mixing magnets (**5**, **5***a*) for the purpose of mixing the beams of atomic ions and electrons into plasma beams.

10. A device according to claim **9**, wherein a layer (**12**) is attached the vessel wall (**9**) for the purpose of obtaining energy which is capable of absorbing both radiation energy and charges and which is provided with a junction in order to conduct positive charges for the supply of electric current (**13**).

11. A device according to claim **10**, wherein grid-like electrode arrangements in front of the layer (**12**) which possess a positive potential for the absorption of scattered electrons.

12. A device according to claim **9**, wherein additional electrodes (**17**, **18**) are provided for capturing charged particles that have evaded collision, for the purpose of retrieving unused electric energy of charged particles.

13. A device according to claim **9**, wherein the reaction chamber with the energy absorption arrangement (**9**, **12**, **16**) is enclosed by two systems of vessels serving the purpose of letting off heat, the inner system (**19**, **20**) designed to take over thermal energy and the outer one (**21**, **22**) to protect the contraction coil (**3**).

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