Form P. Ack. 4.

THE PATENT OFFICE,

No. **13947**

25, SOUTHAMPTON BUILDINGS,

CHANCERY LANE, LONDON, W.C.2.

Date - 9 MAY 1934

Received documents purporting to be the Application and Provisional Specification of L. Szilard

which have been numbered and dated as above,

M. F. LINDLEY,

Comptroller-General.

N.B.—Unless a Complete Specification is left on an Application for a Patent within TWELVE MONTHS from the date of application (or with extension fee, 13 months), the Application is deemed to be abandoned. The investigation as to novelty prescribed by the Patents Acts, 1907 and 1932, is made only when a Complete Specification has been left.
The number and date of this Application must be quoted on the Complete Specification and Drawings (if any), as well as in any correspondence relative thereto.

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Transmut
of element
by fast
particles

Korr.

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PATENTS & DESIGNS ACTS, 1907 to 1932.

PROVISIONAL SPECIFICATION.

(To be furnished in Duplicate.)

[illegible]

(a) Here insert title verbally agreeing with that in the application form.

(a) Transmutation of elements by fast particles; ~~a subject of Hungary and citizen of Germany~~

(b) Here insert (*in full*) name, address and nationality of applicant or applicants as in application form.

(b) I (or We) Leo Szilard Strand Palace Hotel, Strand London W.C.; a subject of Hungary and citizen of Germany

do hereby declare the nature of this invention to be as follows:—

(c) Here begin description of the nature of the invention. The continuation of the specification should be upon wide-ruled paper of the same size as this form, on one side only, with a margin of one inch and a half on the left-hand part of the paper. The specification and the duplicate thereof must be signed at the end and dated (thus): "Dated the day of 19 ."

(c)

(*Y8385) Wt 15367/3534 60,000(4) 11/32 H & Sp Gp 102

Korr.

Transmutation of Elements by Fast Particles.

The invention refers to methods and apparatus adapted for the transmutation of elements, the chief purpose being the production of energy or the storage of energy/and the ~~by means of the~~ production of radio-active bodies. Radio-active bodies are formed if certain light elements are bombarded by protons or diplons. Protons and diplons of 500,000 volts are already effective; but the half period of the resulting radio-active bodies is very short (not exceeding 24 hours) and the efficiency of the process is bad, one of the reasons being the quick dissipation of energy of the slow protons or diplons through their strong ionizing action in matter.

One can produce transmutations more efficiently by bombarding elements with charged particles of a small mass, for instance electrons (or positrons) which in certain cases leads to the liberation of neutrons (uncharged particles of the mass of a proton or multiples thereof), and ~~in~~ other ~~many~~ cases leads direct to the production of a radio-active body. If elements are bombarded by ~~one uses~~ electrons the energy of which does not exceed 10 million volts in most cases radio-active bodies are formed, the neuclear charge of which (the atomic number of which) is one less than that of the bombarded element. After the exposure of an element to the electron bombardment for a/period of time of the order of ~~time short equal~~ ~~to~~ the half period of the radio-active body which is produced one may therefore separate in most cases the newly formed radio-active body by methods of chemical analysis from the original element.

By bombarding a mixture of the elements, excluding Fe, Pb,

with electrons of an energy betwenn 2 and 10 million volts, radio-active bodies are formed in that mixture the half period of some of which exceeds 24 hours; this seems to be the case for As and Cl. By separating the elements of the mixture and observing the decay of activity for each component it is easy to determine the half period of activity for each component, and it is easy to select the element the exposure of which to the fast electrons will lead to a radio active element of a suitable half period.

Figure 1 shows an arrangement suitable to produce radio-active bodies by electron bombardment. 1 is the primary of a transformer, the secondary 2 of which is connected to the points 3 and 4. 3 is connected to the cathode 8 of the ~~mixtury~~ rectifyer tube 5 and to the anode 7 of the rectifyer tube 6. Point 4 is connected to the cathode 9 of the rectifyer tube 10 and to the anode 11 of the rectifyer tube 12. The cathodes 13 and 14 are connected to eachother and to the earth. The anodes 15 and 16 are connected to point 17, and this point is connected to the pole 18 of the impulse generator 20, the pole 19 of which is connected to earth. The impulse generator 20 is built of condensors 21, resistances 22 and spark gaps 23.

This impulse generator is adapted to produce out

intermittent voltage up to 10 million volts, transmitted to the discharge tube 24 through the spark gap 25. 26 is the cathode of the discharge tube the anode 27 of which is connected to the earth. The fast electrons emerge through the metal window 27 (which is the anode as well) and are hitting a body 28 which contains an element that will transmute when exposed to the rays into a radio-active element. This newly formed radio-active element is separated from the element out of which it has been formed by chemical methods, the nuclear charge being decreased and the chemical properties of the new element being that of a left neighbour in the periodical system of the original element. The time of exposure should be of the order of magnitude of the half period of the new element.

All this holds also (mutatis mutandis) for positrons.

Another type of transmutation produced by electrons, the energy of which need not exceed 10 -20 million volts, is the transmutation caused by neutrons which are produced by bombarding hydrogen or diplogen with such electrons or certain other elements with such electrons. If the body 28 exposed to the fast electrons is surrounded by a thick wall composed of certain elements, for instance As or Br or some of the elements mentioned in the beginning of page 2, radio-active substances are produced by the penetrating radiation (neutrons) emitted by the said body (which is composed of hydrogen or diplogen or other suitable elements) when bombarded by the said electrons. In the thick wall with good efficiency if the thickness

Radio-active elements of very short half periods have only a limited practical use. In order to get a radio-active body of a sufficiently long half period with good efficiency such an element or such ~~ax~~ single isotope of an element will be exposed to the bombarding electrons as will yield a radio-active body of the required properties. In order to avoid waste the time of exposure will not exceed by more than 200% the half period of the product. The radio-active body will be extracted by extracting the elements, the atomic number of which is one lower than the atomic number of the bombarding element.

In order to determine which element should be used for the production of the radio-active body by measurements, which can be easily carried out in every physical laboratory, one has to do the following: one has to bombard one element after the other with neutrons which are for instance liberated from Be through bombardment of alpha particles or diplogen ions. For each element one has to extract after its exposure to the electrons by chemical methods the elements the atomic number of which is by one lower than that of the bombarded element. If the extract is radio-active, emits electrons, and if its half period has a certain value large enough for use for practical purposes, then the original element can be used for our purpose; it will yield when bombarded with electrons with energies between 1 and 10 million volts a radio-active element which, being identical with the radio-active element produced from it through neutrons, can be used for practical purposes while the efficiency ~~in producing the element~~ of the produktion of the radioaktive body with electrons is much better than the efficiency of its production indirectly with neutrons (which in their turn must be produced through bombardment of matter with charged particles). As, Ge, S, lead when bombarded with electrons radio-active bodies of the desired type.

Essential features of the production of radio-active bodies through direct bombardment of elements with electrons, the energy of which ~~is~~/may be between 1 and 10 million volts are the following:

1. The exposure of an element to the electron bombardment for a period of time which is roughly of equal order of magnitude as the half period of the radio-active body which we obtain.

2. The extraction of the elements having an atomic number by one lower than the bombarded element; the extract containing the radio-active body.

3. The exposure of such elements to the electron bombardment, the atomic number of which exceeds by one the atomic number of/those ~~the following~~ radio-active elements: which are produced by neutron bombardment (emit electrons) and the half period of which exceeds 24 hours. Such /radio-active elements are for instance obtained through neutron bombardment from Arsen or Chlor.

The process involved is in many cases the capture of an incident electron and the creation of a neutrino which carries away energy and accordingly the production of the new element occurs more efficiently if the energy of the incident electrons exceeds the energy difference between the old and new element by one or two million volts.

A possible use

An entirely different use of the electrons, the energy of which need not exceed 10 million volts, is the liberation of neutrons from bombarded elements. If hydrogen, diplogen, triplogen (hydrogen of the atomic weight three) and other suitable elements are bombarded by electrons, neutrons are liberated in two different ways. In the case of hydrogen, diplogen and triplogen the whole nucleus may be transformed into a neutron having roughly the respective masses of the mass of a proton, its double, and its treble. In the cases of diplogen, triplogen and other elements the nucleus may break up into two parts or more, one of the parts at least being a neutron.

Figure 2 shows an example. 30 is the positive end of a discharge tube. 31 are electrons with energies between 1 and 20 million volts. 32 is a substance emitting neutrons when bombarded by the said electrons. 33 is a thick wall between 10 and 100 cm thickness exposed to the neutrons emitted by 32.

By exposing a thick wall 33 built of chlorine (or a compound thereof) or Arsen (or a compound thereof) etc. radio-active bodies are produced, the half period of which is sufficiently large to make them useful for practical purposes. (This holds for 32 emitting neutrons the mass of which is roughly equal to the mass of the proton).

For the following paragraphs ~~it will be immaterial whether~~ the neutrons emitted by a source 40 ~~are~~ can be assumed to be produced ~~as described in Figure 2 or whether they are produced in some other way for instance~~ either by the bombardment of Be with Helium or Diplogen accelerated by electrical fields or by the bombardment of Diplogen with Diplogen ions accelerated by electric fields or in some other way. These paragraphs deal with methods to increase the efficiency of the transmutation caused by neutrons by the use of elements which "multiplicate" the number of neutrons or "transform" their mass.

Figure 3 shows an example of the transforming action which leads to chain reactions. 40 is the source of neutrons emitting neutrons of the simple mass (roughly the mass of a proton). These neutrons strike the layer "A" and liberate there neutrons of the double mass. The layer "A" can consist of diplogen or diplogen compound or other suitable elements. It can be thin or thick (between 10 to 100 cm). Neutrons of the double mass when penetrating ~~striking~~ the layer "B" (which can again be either thin or 10 to 100 cm. thick) liberate there neutrons of the simple mass. The layer "B" can be built of an element which yields simple neutrons when bombarded by diplogen, for instance, Lithium 7 or Be9 (or diplogen itself!) or some other suitable element. The simple neutrons liberated in the layer "B" penetrate ~~strike/ one of~~ the layers "A", liberate there double neutrons (neutrons of the double mass) which again ~~strike~~ liberate simple neutrons in one of the layers "B". We have a chain reaction. If the length of the chain is very long the total bulk of the material involved will be very lagge, the linear dimensions increasing approximately with the square root of the number of the links in the chain and reaching eventually 30 metres or more. The energy liberated in the process can be either used directly or an element can be exposed to the neutrons which will be transformed into a radio-active body eventually to be used as accumulator of energy by making use of the energy stored for driving machines. The process involved in layer "A" canfor instance be the following: neutrons of the simple mass strike diplogen nuclei atoms, and the two of them tr transmute into a proton and a neutron of the double mass. The process involved in the layer "B" if this layer is built of Lithium 7 may be a neutron of the double mass striking a Lithium atom and the two of them transmuting into a neutron of the simple mass, a Helium atom and a Hydrogen atom of the mass and two other elements of the total mass 8 and the total charge 3. The process involved in the layer "B", if this layer too consists of diplogen is may be the following: a neutron of the double mass strikes a diplogen atom and the two of them transmute into a hydrogen atom of the mass 3 and a neutron of the simple mass.

Figure 4 shows another example. A third layer "C" is exposed to the neutrons emerging from the source 40. Neutrons striking atoms in the layer "C" liberate neutrons in "C" and the same is the case for the neutrons ~~liberated in~~ coming from one of the layers "B". For instance neutrons are liberated by fast neutrons from some of the heaviest isotopes of some of the heavier elements, also from Diplogen. A chain reaction combined with the multiplying action of layer "C"

Sz.

$$E_2 \cong E_1^2 \frac{1}{mc^2 \times 900}$$

leads to a very large amplifying factor.

Essential features are:

1. The exposure of a substance "C" to a neutron source in which neutrons are liberated and the total number of neutrons thereby increased; the amount of the exposed substance "C" being at least sufficient to surround the source in a thickness of 10 to 100 cm if pure and in the solid or liquid state.

2. The exposure of a substance "A" from which neutrons of a multiple mass are liberated by the neutrons of the simple mass.

3. The exposure of a substance "B" (which can in certain cases be the substance "A" itself) to the neutrons of the multiple mass which liberate in "B" neutrons of the simple mass.

4. The combination of the chain reaction (2 and 3) with the multiplying action (1).

5. The exposure of elements whibh are transformed into radio-active bodies by neutrons to the neutrons arising from the processes 1 to 4.

A very different type of transmutation from the hitherto discussed type arises when elements are bombarded by electrons, the energy of which is sufficient to transmit to a body of the mass of a proton, a momentum, so that the energy corresponding to this momentum should be above one million volt. If the energy of the electron is for instance between 20 and 100 million volts the maximum energy E_2 transmitted to a body of the mass of a proton in a collision with such an electron is approximately given by the following formula:

$$E_2 \cong E_1^2 \frac{1}{mc^2 \times 900}$$

In this formula E_2 is the energy transmitted to the heavy particle, E_1 is the energy of the electron, mc^2 is the energy corresponding to the mass of the electron (about 500,000 volts). For an electron energy of E = 50 million volts for instance this formula gives a transmitted energy of E_2 = 5 million volts. If certain elements are bombarded with electrons the energy of which is between 20 and 100 million volts we can get transmutation for instance the liberation of neutrons by breaking up the nucleus into two or more parts. This is for instance the case for diplogen breaking up into a proton and a neutron and for the heaviest isotopes of certain heavier elements. The ionisation losses of the electron suggest the use of the lightest possible elements for sake of efficiency. If elements are broken up by electrons the energy of which does not exceed 10 million volts as discussed in the first part of this description the total charge of the parts is by one lower than the atomic number of the bombarded element. Here, however, we are dealing with break-ups in which the electron need not be captured the total charge of the parts into which a nucleus breaks up may therefore be equal to the nuclear charge of the original element.

Electrons, the energy of which exceed 20 million volts can be produced by leading the electrons very often around an iron core which is magnetised by alternating current. One can reach 20 million volts if the electrons are accelerated during one half cycle, and can reach much more if the electrons are accelerated during several half cycles.

Essentialfeatures are:

1. The production of radio-active bodies by means of electrons which are fast enough to disrupt nuclei without ~~xxx~~ being captured, having an energy above 20 million volts, suitable elements being bombarded by electrons above 20 million volts.

2. The liberation of neutrons from diplogen or other suitable elements by such electrons.

Transmutation of Elements by Fast Particles.

The invention refers to methods and apparatus adapted for the transmutation of elements, the chief purpose being the production of energy or the storage of energy and the production of radio-active bodies. Radio-active bodies are formed if certain light elements are bombarded by protons or diplons. Protons and diplons of 500,000 volts are already effective; but the half period of the resulting radio-active bodies is very short (not exceeding 24 hours) and the efficiency of the process is bad, one of the reasons being the quick dissipation of energy of the slow protons or diplons through their strong ionising action in matter.

One can produce transmutations more efficiently by bombarding elements with charged particles of a small mass, for instance electrons (or positrons) which in certain cases leads to the liberation of neutrons (uncharged particles of the mass of a proton or multiples thereof), and in many cases leads to the production of a radio-active body. If one uses electrons the energy of which does not exceed 10 million volts in most cases radio-active bodies are formed, the neuclear charge of which (the atomic number of which) is one less than that of the bombarded element. After the exposure of an element to the electron bombardment for a period of time of the order of the half period of the radio-active body which is produced one may therefore separate in most cases the newly formed radio-active body by methods of chemical analysis from the original element.

By bombarding a mixture of the elements

with electrons of an energy between 2 and 10 million volts, radio-active bodies are formed in that mixture the half period of some of which exceeds 24 hours; this seems to be the case for As and Cl. By separating the elements of the mixture and observing the decay of activity for each component it is easy to determine the half period of activity for each component, and it is easy to select the element the exposure of which to the fast electrons will lead to a radio active element of a suitable half period.

Figure 1 shows an arrangement suitable to produce radio-active bodies by electron bombardment. 1 is the primary of a transformer, the secondary 2 of which is connected to the points 3 and 4. 3 is connected to the cathode 8 of the rectifyer tube 5 and to the anode 7 of the rectifyer tube 6. Point 4 is connected to the cathode 9 of the rectifyer tube 10 and to the anode 11 of the rectifyer tube 12. The cathodes 13 and 14 are connected to eachother and to the earth. The anodes 15 and 16 are connected to point 17, and this point is connected to the pole 18 of the impulse generator 20, the pole 19 of which is connected to earth. The impulse generator 20 is built of condensors 21, resistances 22 and spark gaps 23.

This impulse generator is adapted to produce intermittant voltage up to 10 million volts, transmitted to the discharge tube 24 through the spark gap 25. 26 is the cathode of the discharge tube the anode 27 of which is connected to the earth. The fast electrons emerge through the metal window 27 (which is the anode as well) and are hitting a body 28 which contains an element that will transmute when exposed to the rays into a radio-active element. This newly formed radio-active element is separated from the element out of which it has been formed by chemical methods, the nuclear charge being decreased and the chemical properties of the new element being that of a left neighbour in the periodical system of the original element. The time of exposure should be of the order of magnitude of the half period of the new element.

All this holds also (mutatis mutandis) for positrons.

Another type of transmutation produced by electrons, the energy of which need not exceed 10 million volts, is the transmutation caused by neutrons which are produced by bombarding hydrogen or diplogen ~~with such electrons~~ or certain other elements with such electrons. If the body exposed to the fast electrons is surrounded by a thick wall composed of certain elements, for instance As or Cl or ~~any~~ some of the elements mentioned in the beginning of page 2, radio-active substances are produced by the penetrating radiation (neutrons) emitted by the said body (which is composed of hydrogen or diplogen or other suitable elements) when bombarded by the said electrons. in the thick wall with good efficiency if the thickness

Radio-active elements of very short half periods have only a limited practical use. In order to get a radio-active body of a sufficiently long half period with good efficiency such an element or such an single isotope of an element will be exposed to the bombarding electrons as will yield a radio-active body of the required properties. In order to avoid waste the time of exposure will not exceed by more than 200% the half period of the product. The radio-active body will be extracted by extracting the elements, the atomic number of which is one lower than the atomic number of the bombarding element.

In order to determine which element should be used for the production of the radio-astive body by measurements, which can be easily carried out in every physical laboratory, one has to do the following: one has to bombard one element after the other with neutrons which are for instance liberated from Be through bombardment of alpha particles or diplogen ions. For each element one has to extract after its exposure to the electrons by chemical methods the elements the atomic number of which is by one lower than that of the bombarded element. If the extract is radio-active, emits electrons, and if its half period has a certain value large enough for use for practical purposes, then the original element can be used for our purpose; it will yield when bombarded with electrons with energies between 1 and 10 million volts a radio-active element which, being identical with the radio-active element produced from it through neutrons, can be used for practical purposes while the efficiency in producing the element with electrons is much better than the efficiency of its production indirectly with neutrons (which in their turn must be produced through bombardment of matter with charged particles). As, Ge, S, lead when bombarded with electrons radio-active bodies of the desired type.

Essential features of the production of radio-active bodies through direct bombardment of elements with electrons, the energy of which may be between 1 and 10 million volts are the following:

1. The exposure of an element to the electron bombardment for a period of time which is roughly of equal order of magnitude as the half period of the radio-active body which we obtain.

2. The extraction of the elements having an atomic number by one lower than the bombarded element; the extract containing the radio-active body.

3. The exposure of such elements to the electron bombardment, the atomic number of which exceeds by one the atomicnumber of those radio-active elements: which are produced by neutron bombardment (emit electrons) and the half period of which exceeds 24 hours. Such radio-active elements are for instance obtained through neutron bombardment from Arsen or Chlor.

The process involved is in many cases the capture of an incident electron and the creation of a neutrino which carries away energy and accordingly the production of the new element occurs more efficiently if the energy of the incident electrons exceeds the energy difference between the old and new element by one or two million volts.

An entirely different use of the electrons, the energy of which need not exceed 10 million volts, is the liberation of neutrons from bombarded elements. If hydrogen, diplogen, triplogen (hydrogen of the atomic weight three) and other suitable elements are bombarded by electrons, neutrons are liberated in two different ways. In the case of hydrogen, diplogen and ériplogen the whole nucleus may be transformed into a neutron having roughly the respective masses of the mass of a proton, its double, and its treble. In the cases of diplogen, triplogen and other elements the nucleus may break up into two parts or more, one of the parts at least being a neutron.

Figure 2 shows an example. 30 is the positive end of a discharge tube. 31 are electrons with energies between 1 and 20 million volts. 32 is a substance emitting neutrons when bombarded by the said electrons. 33 is a thick wall between 10 and 100 cm thickness exposed to the neutrons emitted by 32.

By exposing a thick wall 33 built of Chlorine (or a compound thereof) or Arsen (or a compound thereof) etc. radio-active bodies are produced, the half periód of which is sufficiently large to make them useful for practical purposes. (This holds for 32 emitting neutrons the mass of which is roughly equal to the mass of the proton).

For the following paragraphs it will be immaterial whether the neutrons emitted by a source 40 are produced as described in Figure 2 or whether they are produced in some other way for instance by the bombardment of Be with Helium or Diplogen accelerated by electrical fields or by the bombardment of Diplogen with Diplogen ions accelerated by electric fields. These paragraphs deal with methods to increase the efficiency of the transmutation caused by neutrons by the use of elements which "multiplicate" the number of neutrons or "transform" their mass.

Figure 3 shows an example of the transforming action which leads to chain reactions. 40 is the source of neutrons emitting neutrons of the simple mass (roughly the mass of a proton). These neutrons strike the layer "A" and liberate there neutrons of the double mass. The layer "A" can consist of diplogen or diplogen compound or other suitable elements. It can be thin or thick (between 10 to 100 cm). Neutrons of the double mass when penetrating the layer "B" (which can again be either thin or 10 to 100 cm. thick) liberate there neutrons of the simple mass. The layer "B" can be built of an element which yields simple neutrons when bombarded by diplogen, for instance, Lithium 7 or Be9 (or diplogen itself!) or some other suitable element. The simple neutrons liberated in the layer "B" penetrate one of the layers "A", liberate double neutrons (neutrons of the double mass) which again liberate simple neutrons in one of the layers "B". We have a chain reaction. If the length of the chain is very long the total bulk of the material involved will be very lagge, the linear dimensions increasing approximately with the square root of the number of the links in the chain and reaching eventually 30 metres or more. The energy liberated in the process can be either used directly or an element can be exposed to the neutrons which will be transformed into a radio-active body eventually to be used as accumulator of energy by making use of the energy stored for driving machines. The process involved in layer "A" canfor instance be the following: neutrons of the simple mass strike diplogen ~~nuskex~~ atoms, and the two of them ~~gx~~ transmute into a proton and a neutron of the double mass. The process involved in the layer "B" if this layer is built of Lithium 7 may be a neutron of the double mass striking a Lithium atom and the two of them transmuting into a neutron of the simple mass, ~~x Lithium atom and a hydrogen atom of the mass~~ and two other elements of the total mass 8 and the total charge 3. The process involved in the layer "B", if this layer too consists of diplogen ~~in~~ may be the following: a neutron of the double mass strikes a diplogen atom and the two of them transmute into a hydrogen atom of the mass 3 and a neutron of the simple mass.

Figure 4 shows another example. A third layer "C" is exposed to the neutrons emerging from the source 40. Neutrons striking atoms in the layer "C" liberate neutrons in "C" and the same is the case for the neutrons liberated in one of the layers "B". For instance neutrons are liberated by fast neutrons from ~~xxxx xx~~ the heaviest isotopes of/some of the heavier elements. ~~X~~ chain reaction combined with the multiplying action of layer "C" leads to a very large amplifying factor.

Essential features are:

1. The exposure of a substance "C" to a neutron source in which neutrons are liberated and the total number of neutrons thereby increased; the amount of the exposed substance "C" being sufficient to surround the source in a thickness of 10 to 100 cm if pure and in the solid or liquid state.

2. The exposure of a substance "A" from which neutrons of a multiple mass are liberated by the neutrons of the simple mass.

3. The exposure of a substance "B" (which can in certain cases be the substance "A" itself) to the neutrons of the multiple mass which liberate in "B" neutrons of the simple mass.

4. The combination of the chain reaction (2 and 3) with the multiplying action (1).

5. The exposure of elements which are transformed into radio-active bodies by neutrons to the neutrons arising from the processes 1 to 4.

A very different type of transmutation from the hitherto discussed type arises when elements are bombarded by electrons, the energy of which is sufficient to
body of the mass of a proton, so that
transmit to a/~~[illegible]~~ a momentum/the energy corresponding to ~~which~~ this momentum should be above one million volt. If the energy of the electron is for instance between 20 and 100 million volts the maximum energy transmitted to a body of the mass of a proton in a collision with such an electron is approximately given by the following formula:

In this formula E is the energy transmitted to the heavy particle, E is the energy of the electron, mc is the energy corresponding to the mass of the electron (500,000 volt). For an electron energy of E - 50 million volts for instance this formula gives a transmitted energy of E - 5 million volts. If certain elements are bombarded with electrons the energy of which is between 20 and 100 million volts we can get transmutation for instance the liberation of neutrons by breaking up the nucleus into two or more parts. This is for instance the case for diplogen breaking up into a proton and a neutron and for the heaviest isotopes of certain heavier elements. The ionisation losses of the electron suggest the use of the lightest possible elements for sake of efficiency. If elements are broken up by electrons the energy of which does not exceed 10 million volts as discussed in the first part of this description the total charge of the parts is by one lower than the atomic number of the bombarded element. Here, however, we are dealing with break-ups in which the electron need not be captured the total charge of the parts into which a nucleus breaks up being therefore equal to the nuclear charge of the original element.

Electrons, the energy of which exceed 20 million volts can be produced by leading the electrons very often around an iron core which is magnetised by alternating current. One can reach 20 million volts if the electrons are accelerated during one half cycle, and can reach much more if the electrons are accelerated during several half cycles.

Essentialfeatures are:

1. The production of radio-active bodies by means of electrons which are fast enough to disrupt nuclei without ~~auk~~ being captured, having an energy above 20 million volts, suitable elements being bombarded by electrons above 20 million volts.

2. The liberation of neutrons from diplogen or other suitable elements by such electrons.

Nr 3.

In dieser Anm. ist ~~[illegible]~~ nicht defi-
niert so, dass K, U, Th, etc.
explizite nur als unstabile
Elemente auftreten würden. —
Es sind keine dublett Ketten
genannt. — Wärme-theil nicht
ordentlich. — ~~Neutronen bzw. Nega-
tone~~ Negative Protonen Erzeu-
gung nicht ordentlich. —

4/4

Goldhaber gespräch

über Be + hν(?) am

25n ~~14~~ Juni - 34.

~~14 Juni~~

Betrifft Beryllium

TELEPHONE:
TEMPLE BAR 8080 (15 LINES)
TELEGRAMS:
"LUXURY, RAND, LONDON."
CODE:
WESTERN UNION.

STRAND PALACE HOTEL,
STRAND, W.C.2.
LONDON.

Houtermanns Bemerkung über Kettenreaktionen 22.6.-34

im Blackett Coll. —

(Freiburg)

Sz.

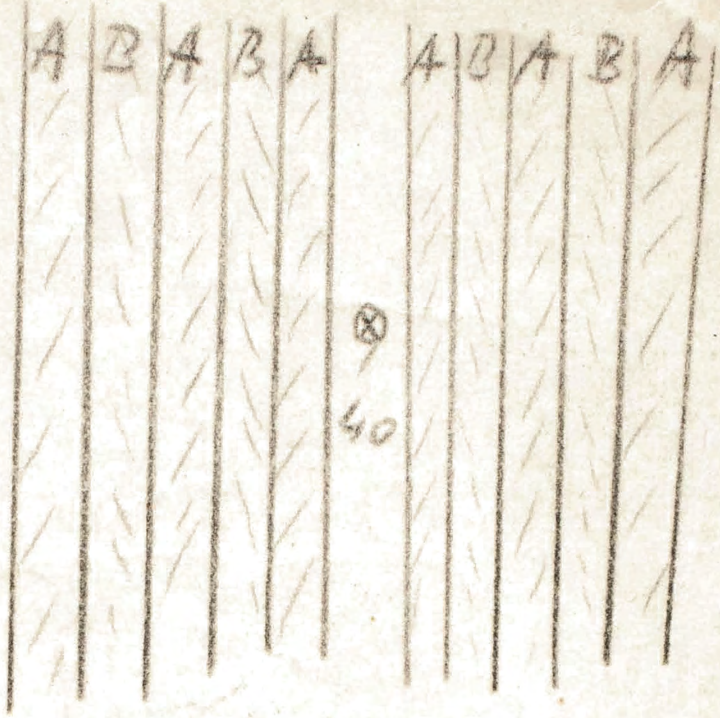

Fig 3.

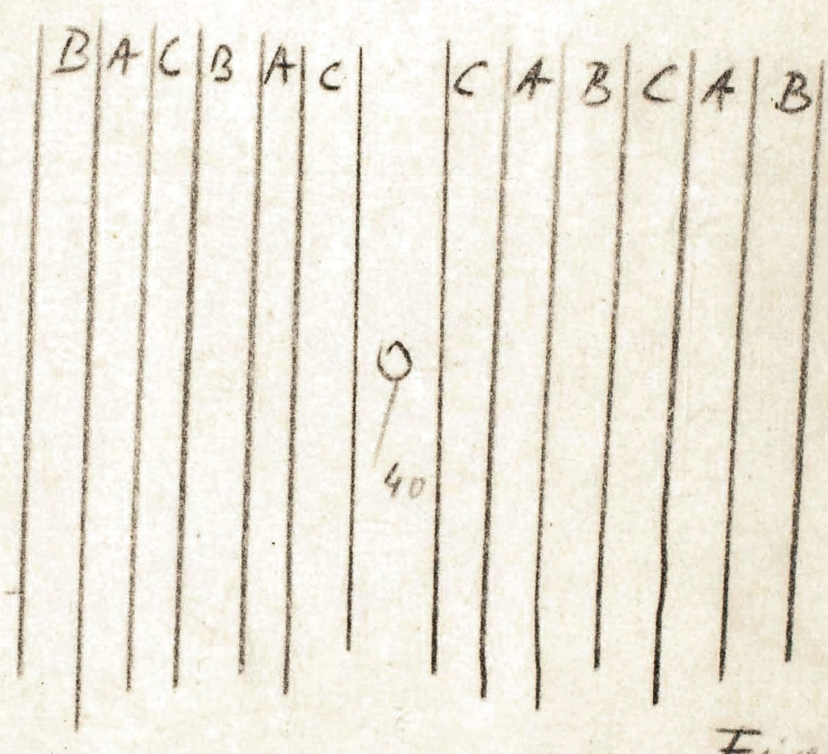

Fig 4.

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3 p 4

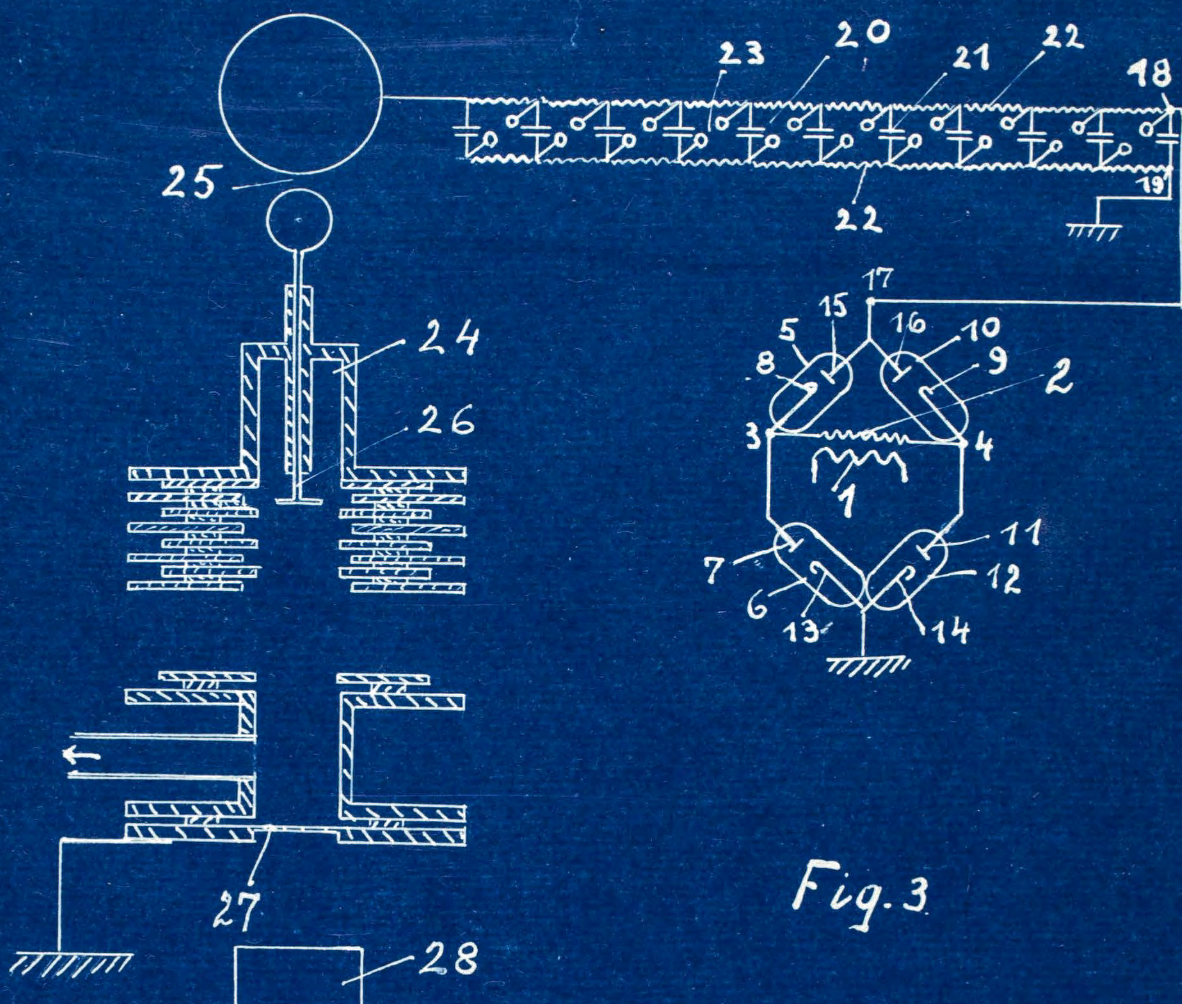

Fig. 3

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1

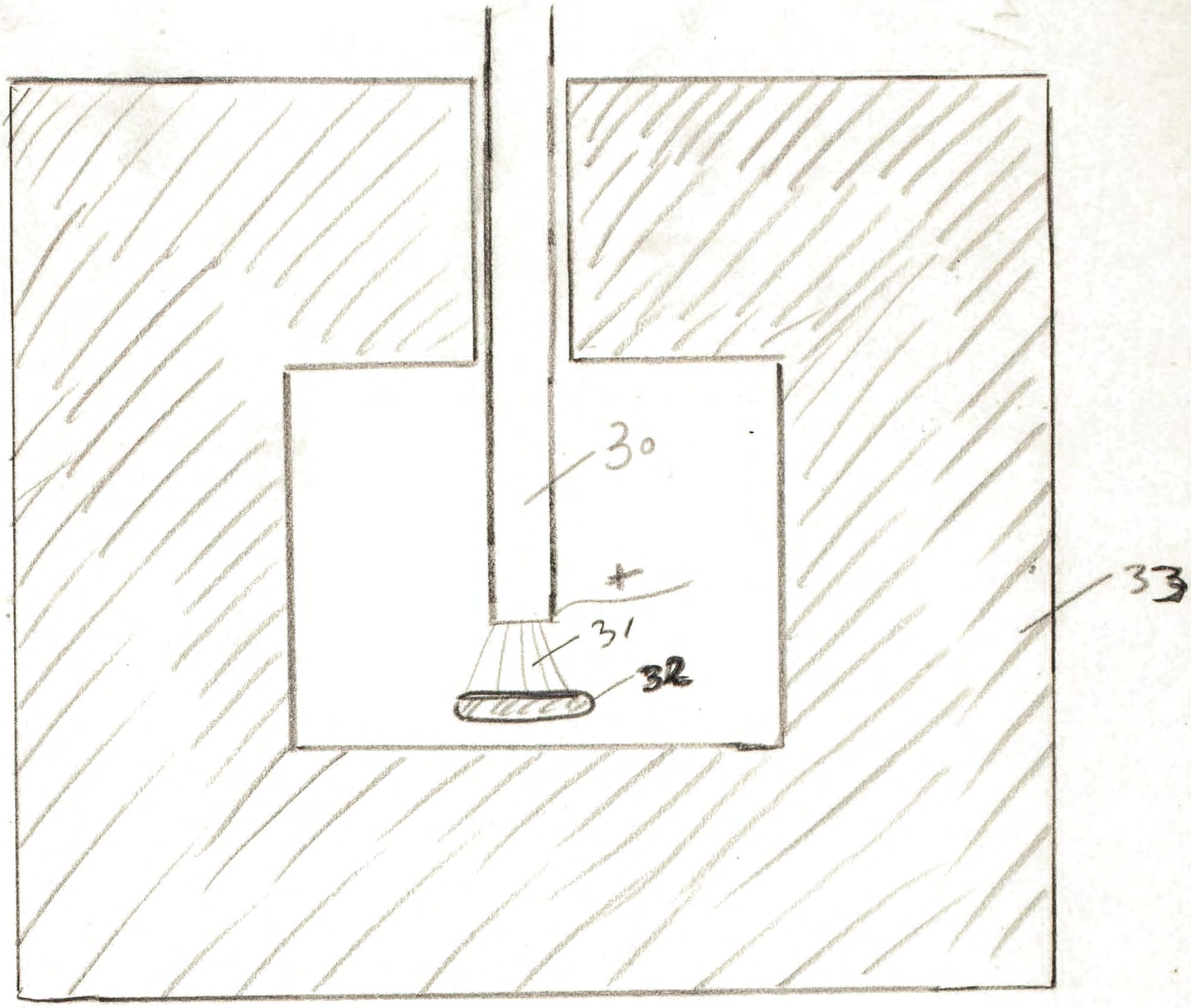

Fig 2.

9th May

2