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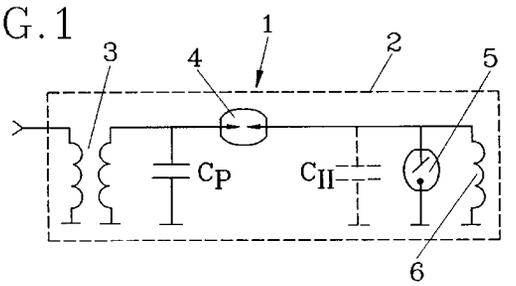
(54) X-ray impulse generator.

(57) The X-ray impulse generator (1) in its grounded metal casing (2), includes a high voltage impulse transformer with coaxial outer primary winding and coaxial inner secondary winding (9), discharge capacitor (C_p), discharge amplifier (4) and X-ray impulse tube (5). The discharge capacitor (C_p) is formed of the casing and the cylinder shaped electrode (14) which is arranged coaxially with this, and which is electrically connected to the secondary winding (9) of the high voltage impulse transformer. In the cylinder shaped electrode (14) a discharge amplifier (4) is arranged, one electrode of which is electrically connected to the cylinder shaped electrode (14), while the other electrode is connected to the high voltage electrode of the X-ray impulse tube (5). Additionally a metal tube and ferrous bars (12) are inserted in the X-ray impulse generator (1). The secondary winding (9) of the impulse transformer is arranged as a helix shaped as envelope, truncated cone, where the narrow end is situated against the cylinder shaped electrode (14). The metal tube is arranged coaxially inside the secondary winding (9) of the impulse transformer and is electrically connected to the high voltage terminal of the secondary winding (9), while the ferrous bars (12) are arranged uniformly round along the cylinder shaped top surface of the metal tube (5).

FIG. 1



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TECHNICAL FIELD OF THE INVENTION

The invention belongs to the field of X-ray technics, or more concrete it belongs to X-ray impulse equipment with energy storage capacitors.

DESCRIPTION OF RELATED ART

Known X-ray impulse generators in the same insulated case are provided with a X-ray impulse tube, a high voltage impulse energy source based on one or two helix generators and discharge amplifier.

Even if they are very compact, such generators have not particular high efficiency.

The known X-ray impulse generator, which contains a X-ray impulse tube, has a discharge capacitor connected to the tube, and the impulse transformer, which through a secondary winding is connected to the discharge capacitor appears as a coaxial construction. The outer primary winding has a form of a solid cylinder, while inner secondary winding has a shape of a helix with truncated cone form.

However, such a generator assumes that one does not use a discharge amplifier, which assures that the duration of the anterior front of the impulses generated by the X-ray radiation and stabilizes the radiation output at the high voltage side of the impulse transformer.

Based on the electrical diagram of the generator, it will be a diagram having a high voltage impulse transformer and there in the circuit of the secondary winding of the transformer discharge capacitor, discharge amplifier and X-ray impulse tube is included.

In a construction such a diagram can be realized as X-ray impulse generator, where in the grounded metal casing a high voltage impulse transformer with coaxial outer primary winding and coaxial inner secondary winding, discharge capacitor, discharge amplifier and X-ray impulse tube is included. To that must be added that the discharge capacitor is formed by the casing and the cylinder shaped electrode, which is situated coaxially with the casing and which is electrically connected to the secondary winding of the impulse transformer. The cylinder shaped electrode includes a discharge amplifier, one electrode of which is electrically connected to the cylinder shaped electrode, and the other electrode is connected to the high voltage electrode of the X-ray impulse tube.

A drawback with the generator known till now is the low efficiency, which is related to those non optimal conditions for conversion and energy transmission to the X-ray tube in the high voltage circuit.

THE OBJECT OF THE INVENTION

The object of the invention is to increase the efficiency of the generator by optimizing the electrical characteristic with the help of constructive means.

SUMMERY OF THE INVENTION

Concerning the invention, the object is obtained through following: The X-ray impulse generator in its grounded metal casing, includes a high voltage impulse transformer with coaxial outer primary winding and coaxial inner secondary winding, discharge capacitor, discharge amplifier and X-ray impulse tube. To that is added that the discharge capacitor is formed by the casing and the cylinder shaped electrode, which is arranged coaxially with this, and which is electrically connected to the secondary winding of the high voltage impulse transformer. In the cylinder shaped electrode a discharge amplifier is arranged, one electrode of which is electrically connected to the cylinder shaped electrode, while the other electrode is connected to the high voltage electrode of the X-ray impulse tube. Additionally a metal tube and ferrous bars are inserted in the X-ray impulse generator.

Furthermore, the secondary winding of the impulse transformer is arranged as a helix shaped hollow, truncated cone, where the narrow end is situated against the cylinder shaped electrode. The metal tube is arranged coaxially inside the secondary winding of the impulse transformer and is electrically connected to the high voltage terminal of the secondary winding, while the ferrous bars are arranged uniformly around the cylinder shaped top surface of the metal tube.

These characteristics correspond to the claim 1 in the set of claims.

The entire use of the characteristics according to claim 1, assures that the efficiency of the generator increases, this due to the combination of mentioned embodiment of the secondary winding of the impulse transformer and the relation ship "metal tube - ferrous bars", which increases the discharge capacity of the generator, and which in turn results in an increase of the energy, which is transferred to the X-ray tube.

It must be observed that usage of ferrites in impulse transformers, for instance to increase the induction of the winding, as such is known.

Nevertheless, according to the inventors opinion, at this time exists an additional effect, an increase of the discharge capacity occurs as a result of the increase of the capacity of transformer connection, which again is a result of the connection of the ferrous bars to the potential. Moreover, the use of just bars, instead of usual rings, makes it possible to eliminate the drawbacks of the magnetic field, which is characteristic for rings.

Introduction of the help induction between the casing of the generator and the second electrode of the discharge amplifier around the X-ray tube and its high voltage electrode also contributes to increase the efficiency of the generators, thanks to that the potential of the second electrode of the discharge amplifier has firm connection to null at the moment the discharge capacitor of the generator is charged. It

makes it possible to not produce superfluous parasite capacity between the high voltage electrode of the X-ray tube and the casing of the generator, a superfluous capacity, which delays/reduces amplitude of the high voltage pulse, which acts on the X-ray tube and results in reduced radiation output.

The characteristic of claims 4 and 5 assures the most advantageous conditions for realizing the effect, which is referred to in connection with the characteristics of claim 1.

From the constructive design point of view the characteristics of claims 6 to 8 solve the problem of the radiation safety of the generator in a rational way.

The positioning of the second screen, according to claim 8, contributes to levelling the electrical field, due to the material in the frame of the help inductance, which increases the electrical resistance of this component while the generator is operating.

BRIEF DESCRIPTION OF THE DRAWINGS

The principal point of this invention is described through the drawings, in which:

Fig. 1 shows the electrical diagram of the impulse generator.

Fig. 2 shows a cross-section through the generator.

Fig. 3 shows a diagram disclosing the principle of the mutual coil of the primary and secondary windings of the impulse transformer.

Fig. 4 shows how the cross-section along A-A through "metal tube - ferrous bars" look like.

Fig. 5 shows the equivalent capacitance diagram of the connection "casing - help induction - X-ray tube".

DETAILED DESCRIPTION OF THE EMBODIMENT

The X-ray impulse generator 1, in its grounded metal casing 2 is provided high voltage impulse transformer 3, discharge capacitor C_P, discharge amplifier 4, X-ray impulse tube 5 and help induction 6.

The parasite capacitance between the high voltage electrode / anode / X-ray tube 5 and the casing 2 is designated with C_{II}. The generator 1 acts from a common charge block, in which a commutating discharger and a charge capacitor are included (e.g. see 4 or 5). This charge block is connected to the primary winding 3 of the impulse transformer.

The impulse transformer 3 includes an outer primary winding shaped as a flat helix 7, which is arranged on the frame 8, e.g. of plexiglass, and is connected to the charge block (not shown). It further contains a coaxial inner secondary winding 9 that is arranged in helix having form of a hollow, truncated cone and is arranged on the corresponding frame 10, for example of plexiglass. The inner secondary winding includes a metal tube 11, which is electrically connected to the high voltage end of the secondary winding 9; and situated according to the "close packing" principle around the metal tube, there are ferrous bars 12, which are enclosed by a holder 13.

The ferrous bars 12 used, should preferably be made of material, whose magnetic characteristic is at the temperature range (diapason). This relates to the heat, which is released when the generator is operating, and with the lack of saturation in strong magnetic impulse field. Ferrites, e.g. marked 700 NMS, satisfy these requirements.

The primary and secondary windings 7, 9 of the impulse transformer 3 have wounds in the direction where the voltage is subtracted in the interspace of the high voltage end of the secondary winding 9 and primary winding 7. The principle of a corresponding winding is shown in fig. 3.

Into the tube 11 is inserted a cylinder shaped electrode 14, which together with the grounded casing 2 of the generator forms the discharge capacitor C_P. Inside the cylinder formed electrode 14 a discharge amplifier is arranged, whose first electrode 15 is electrically connected (for instance in front of the construction) to the cylinder shaped electrode 14, while the second electrode 16 is electrically connected (in front of the construction) to needle anode 17 of the X-ray impulse tube 5. The X-ray impulse tube 5 is arranged with a disc shaped grounded cathode 18, which operates based on the effect of explosive emission of the electrons.

The help inductance 6 with frame 19 of e.g. plexiglass, is made as a helix having truncated cone form, which encloses the bar of the needle anode 17 of the X-ray tube 5 from the discharge zone to the second electrode 16 of the discharge amplifier 4.

The X-ray impulse generator can be provided with two screens 20 and 21 for X-ray radiation bundle, which screen off the back hemisphere of the radiation distribution in relation to the direction of the efficient radiation, generated by the generator 1.

The first screen 20 is arranged between the X-ray tube 5 and the help inductance 6. The second screen 21, which supports the first screen along the back hemisphere "solid/spatial angle", can be made as an inner and/or outer lead case of the cylinder shaped aluminium electrode 14. Obviously, unlike the outer, the inner case requires less material.

In a second embodiment, the screen 22 has shape of a hood, which encloses the part of the help inductance 6, which is arranged in the same side as the discharge amplifier 4, which contributes to levelling the electrical field on the plexiglass of the frame 19 of the induction 6.

Attachment element of the miner parts of the generator are not shown on the drawings as being insignificant in relation to the tasks, which are solved by the invention.

The X-ray impulse generator operates according

to the following.

When impulse voltage from the discharge block (not shown) is initiated, the impulse transformer 3 charges the discharge capacitor C_P. After reached voltage alternation for the discharge amplifier 4, the high voltage impulse from the capacitor C_P reaches the high voltage electrode/anode 17 of the X-ray tube and causes an explosive electron emission from the edge of the cathode 18. When the acceleration is caused by the electrical field of the tube 5, the electrons are decelerated on the anode 17, and as a result X-ray radiation impulse is produced.

Insertion of the relation of "metal tube 11 ferrous bars 12" causes the secondary side of the impulse transformer 3 equivalent to the capacitor diagram to assume the shape which is shown in the upper part of fig. 5, i.e. the same as transformer without ferrous bars 12 on the potential metal tube 11 (at the bottom of fig. 5) the middle winding capacitor of the secondary winding 9 (along the diagonal) has an additional end on the metal tube 11.

In the shown embodiment of the generator, such a solution, made it possible to increase the secondary capacitance of the transformer 3 from 15 pF to 25 pF. When this capacitance is added to C_P, the energy portion which at discharge is transferred to the X-ray tube 5, is thereby increased.

At later inspection of the effect of the help induction 6 on the function of the generator 1, one should be observant to the resultant equivalent capacitance diagram in connection with "bar-anode 17 - induction 6 - grounded metal casing 2", which is shown at the top of fig. 6, is identical to the diagram shown in the upper part of fig. 5. Just as well it is so that such diagram is formed on other basis, which one can see at the lower part of similar diagram in figs. 5 and 6.

The insertion of help induction 6 makes connection to the earth for the potential of the second electrode of the discharge amplifier 4 at the same moment that the discharge capacitance Cp of the generator 1 is charged, and dose not make it possible to produce superfluous parasite capacitance C_{II} between the windings of the help induction 6.

The effect of the radiation protection achieved through usage of the screens 20 and 21 or 22 of the generator 1 are obvious and do not need further description.

In the realized embodiment of the generator at a voltage of 150 kV an efficiency rate of 35% is obtained, which gives a total increase of 12-15% of the efficiency rates typical for impulse equipment of type IRA, ARINA, MIRA etc.

LIST OF DESIGNATION SIGNS

1	Generator
2	Casing
3	Transformer (primary winding)
4	Discharge amplifier
5	Impulse tube
6	Help induction
7	Helix
8	Frame
9	Secondary winding
10	Frame
11	Metal tube
12	Bar
13	Holder
14	Cylinder shaped electrode
15	First electrode
16	Second electrode
17	Needle electrode
18	Cathode
19	Frame
20	First screen
21	Second screen
22	Screen
C_P	Discharge capacitor
C_{II}	Parasite capacitor

Claims

1. A X-ray impulse generator (1), which in its grounded metal casing (2) is arranged with a high voltage impulse transformer (3) with coaxial outer primary winding and coaxial inner secondary winding (9), discharge capacitor (C_P), discharge amplifier (4) and X-ray impulse tube (5), the discharge capacitor (C_P) consists of the casing (2) and a cylinder shaped electrode (14) which is arranged coaxially with this, and which is electrically connected to the secondary winding (9) of the high voltage impulse transformer, in the cylinder shaped electrode (14) a discharge amplifier (4) is arranged, one electrode (15) of which is electrically connected to the cylinder shaped electrode (14), while the other electrode (16) is connected to the high voltage electrode of the X-ray impulse tube (5),
characterized in,
that a metal tube (5) and ferrous bars (12) are inserted in the X-ray impulse generator (1),
that the secondary winding (9) of the impulse transformer is arranged as a helix shaped hollow, truncated cone, where the narrow end is situated against the cylinder shaped electrode (14), while the metal tube (5) is arranged coaxially inside the secondary winding (9) of the impulse transformer and is electrically connected to the high voltage terminal of the secondary winding (9), while the ferrous bars (12) are arranged uniformly around the cylinder shaped top surface of the metal tube (5).

2. A X-ray impulse generator (1) according to claim

1,
characterized in,
that a help induction (6) is inserted, made as a helix in a form of hollow, truncated cone, where one end of the helix is electrically connected to the second electrode of the discharge amplifier (4), while the other end is connected to the grounded casing (2), whereby the helix extends from the second electrode of the discharge amplifier (4) in the direction of corresponding end of the casing (2) and encloses the X-ray tube (5) and its high voltage electrode.

3. A X-ray impulse generator (1) according to claims 1 and 2,
characterized in,
that the primary winding (3) of the impulse transformer is formed as a flat helix,
that the direction of the primary and secondary winding (3, 9) of the helix is based on the subtraction of a voltage in an interspace of high voltage end of the secondary winding (9) and corresponding end part of the primary winding (3).

4. A X-ray impulse generator (1) according to any of claims 1 to 3,
characterized in,
that the ferrous bars (12) are made of a material whose magnetic characteristics is at wide temperature range (diapason), and which is without saturation in strong magnetic impulse field.

5. A X-ray impulse generator (1) according to any of claims 1 to 4,
characterized in,
that the ferrous bars (12) are distributed around the circumference of the metal tube according to "close packing" principle.

6. A X-ray impulse generator (1) according to any of claims 1 to 5,
characterized in,
that in the generator (1) at least one screen is inserted for X-ray radiation in a back hemisphere zone with respect to the direction distribution of effective radiation bundle produced by the generator (1).

7. A X-ray impulse generator (1) according claims 2 and 6,
characterized in,
that two screens (20, 21) are arranged, one (20) around the X-ray tube (5), between this and help induction (6), while the second screen (21) is arranged around the help induction (6) at the same side as the second electrode of the discharge amplifier (4).

8. A X-ray impulse generator (1) according claims 2 and 7,
characterized in,
that the second screen (21) is arranged surrounding the help induction (6) in the same side of the second electrode (16) of the discharge amplifier (4) reaches the first screen (20) is arranged.

FIG.1

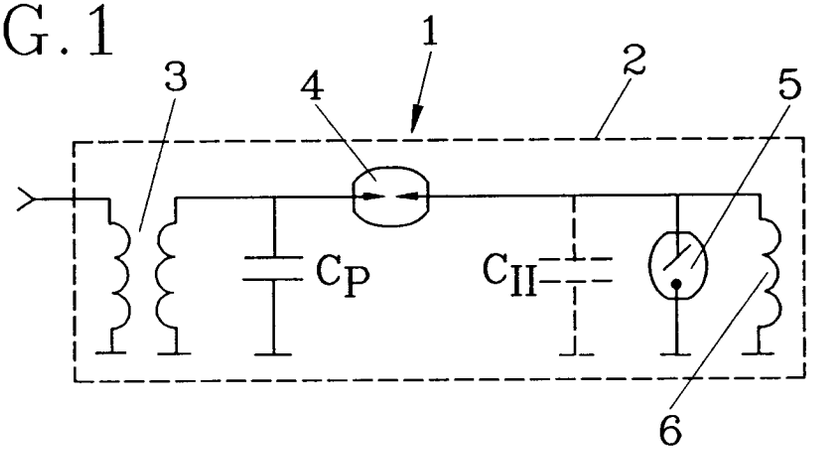


FIG.2

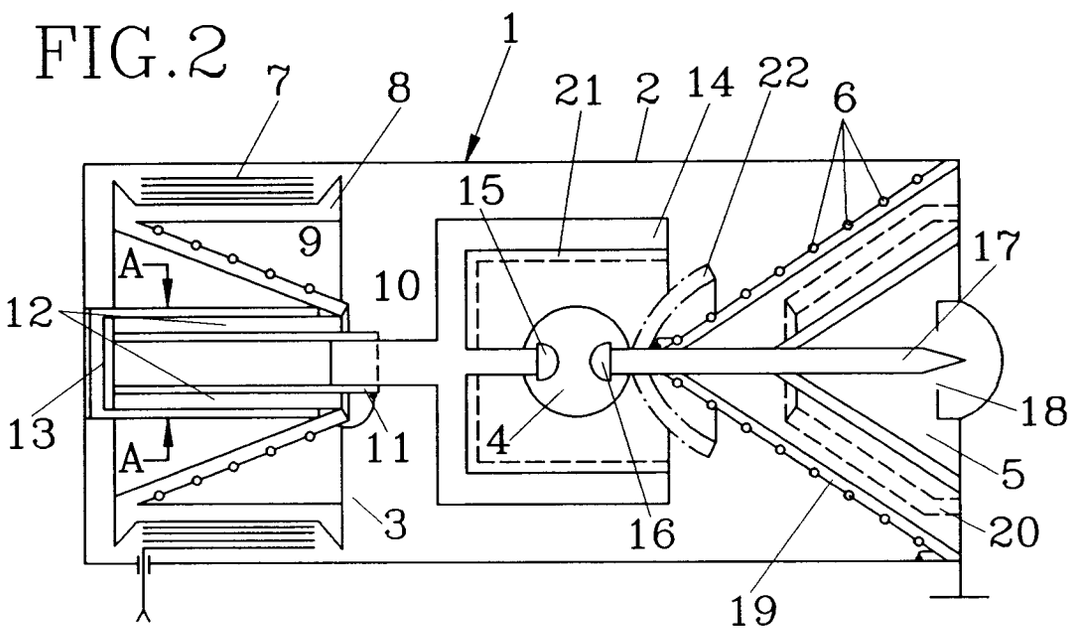


FIG.3

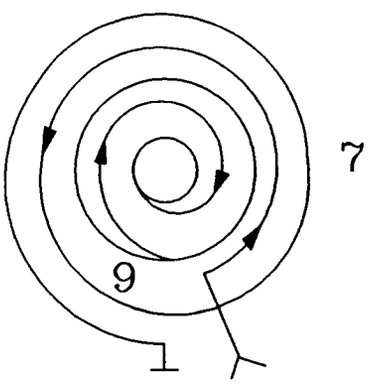


FIG.4

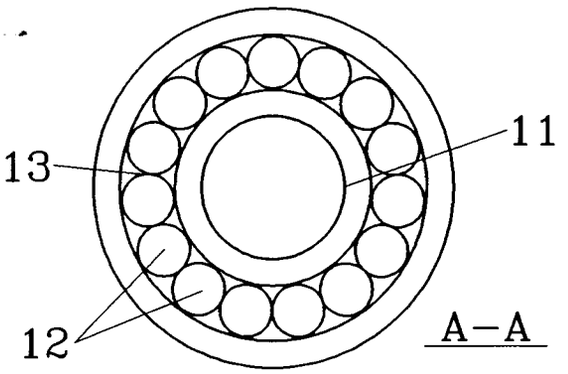


FIG.5

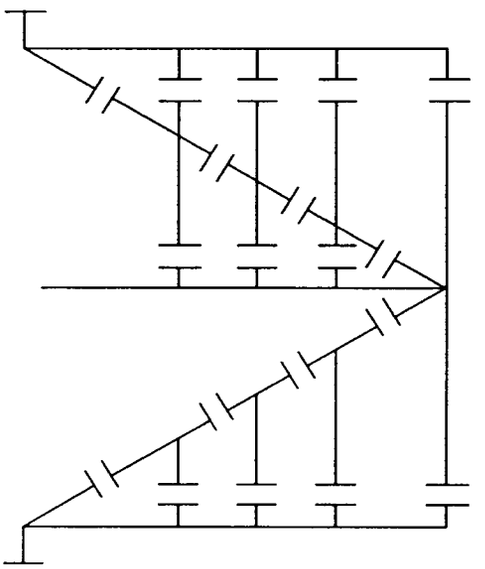
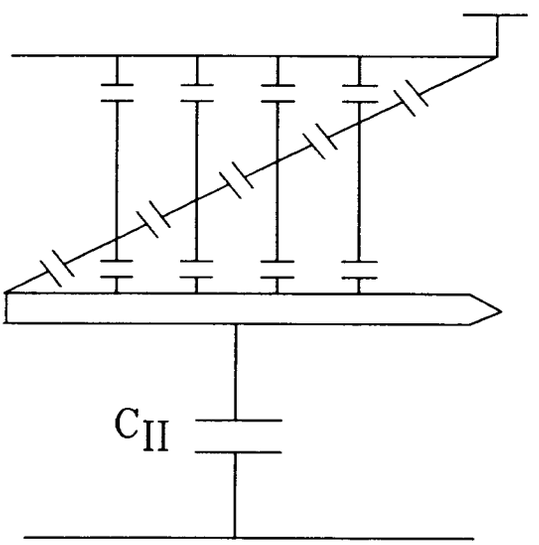


FIG.6



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EUROPEAN SEARCH REPORT

Application Number
EP 94 85 0188

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	INSTRUMENTS AND EXPERIMENTAL TECHNIQUES., vol.25, no.5, 1 September 1982, NEW YORK US pages 1256 - 1258 A.S. EL'CHANINOV ET AL. 'A COMPACT PULSED X-RAY MACHINE RITA-150' * the whole document *	1	H05G1/06 H05G1/24
A	INSTRUMENTS AND EXPERIMENTAL TECHNIQUES., vol.15, no.2, 1 March 1972, NEW YORK US pages 535 - 536 N.V. BELKIN ET AL. '"QUANTUM" MINIATURE NANOSECOND X-RAY PULSE GENERATOR' * the whole document *	1	
A	INSTRUMENTS AND EXPERIMENTAL TECHNIQUES., vol.14, no.3, 1 May 1971, NEW YORK US pages 919 - 920 E.A. ABRAMYAN 'GENERATOR FOR PRODUCING POWERFUL PULSES OF ELECTRON BEAMS AND X RADIATION' * the whole document *	1	
A	DE-B-12 99 082 (SPETSIALNOE KONSTRUKTORSKOE BJURO RENTGENOVSKOI APPARATURY) * column 1, line 34 - line 54 * * column 1, line 68 - column 2, line 63 *	1	TECHNICAL FIELDS SEARCHED (Int.Cl.6) H05G H01J
A	US-A-4 070 579 (J.L.D. BREWSTER) * column 1, line 51 - column 3, line 23; figures 1,2 *	1	
A	US-A-3 681 604 (D.L. CRISWELL ET AL.) * column 1, line 53 - column 2, line 55 * * column 3, line 28 - column 5, line 58; figures 1-4 *	1,5	

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	25 January 1995	Horak, G

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	GB-A-2 119 610 (NAUCHNO-ISSLEDOVATELSKY INSTITUT INTROSKOPII) * page 1, line 4 - line 86 * * page 1, line 98 - page 2, line 44; figures 1,2 * -----	1	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

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