(12) UK Patent Application (19) GB (11) 2 007 480 A

(21) Application No 7840785
(22) Date of filing 17 Oct 1978
(23) Claims filed 17 Oct 1978
18 Jan 1979
(30) Priority data
(31) 43719/77
(32) 20 Oct 1977
(33) United Kingdom (GB)
(43) Application published
16 May 1979
(51) INT CL²
G21F 1/00
H01J 35/16
ic classification
C1A 9C1Y 9C2

(54) **Radiation shielding**

(57) Shields for equipment in which ionising radiation is associated with high electrical gradients, for example X-ray tubes and particle accelerators, incorporate a radiation-absorbing metal, as such or as a compound, and are electrically non-conducting and can be placed in the high electrical gradient region of the equipment. Substances disclosed include dispersions of lead, tungsten, uranium or oxides of these in acrylics, polyesters, PVC, ABS, polyamides, PTFE, [illegible]

ERRATUM

SPECIFICATION NO 2007480A

Page 3, line 2, *after* CLAIMS *Start New Paragraph insert*

1. An electrically non-conducting shield for electrical equipment that produces ionising radiation, which shield incorporates a radiation-absorbing metal and is shaped to lie within the region of high electrical gradient in the equipment adjacent to the radiation-producing components thereof.

2. A shield according to claim 1, forming an evacuable enclosure for the radiation producing components.

3. A shield according to claim 1 or 2, formed of a moulded cast or otherwise shaped matrix of an epoxy resin or other plastics material incorporating the radiation absorbing metal in particulate form, as such or as a non-conducting compound.

4. A shield according to any one of claims 1 to 3, in which the radiation-absorbing metal is tin or a metal of higher atomic number.

5. A shield according to any one of claims 1 to 3, in which the radiation-absorbing metal is tungsten or a metal of higher atomic number.

6. A shield according to any one of claims 1 to 3, in which the radiation absorbing metal is lead, as litharge or in other form.

7. A shield substantially as herein described and shown in Figs 1 and 2 or Fig. 3 of the accompanying drawings.

8. Ionising-radiation producing electrical equipment when provided with a radiation shield as claimed in any preceding claim.

New claims or amendments to claims filed on 18 January 1979

Superseded claims 1 to 8

New or amended claims:-

THE PATENT OFFICE
24 September 1979

Bas 71332/14

GB 2 007 480 A

SEE ERRATA SLIP ATTACHED

(12) UK Patent Application (19) GB (11) 2 007 480 A

(21) Application No 7840785
(22) Date of filing 17 Oct 1978
(23) Claims filed 17 Oct 1978
18 Jan 1979
(30) Priority data
(31) 43719/77
(32) 20 Oct 1977
(33) United Kingdom (GB)
(43) Application published
16 May 1979
(51) INT CL[2]
G21F 1/00
H01J 35/16
(52) Domestic classification
H5R 1C
H1D 32 50 9C1A 9C1Y 9C2
9CX 9CY
(56) Documents cited
GB 811819
GB 439904
GB 420438
GB 379801
GB 374722
GB 280636
(58) Field of search
H5R
(71) Applicants
Lintott Engineering Ltd.
Foundry Lane,
Horsham,
Sussex,
RH13 5PY.
(72) Inventor
Derek Aitken
(74) Agents
Phillips & Leigh

(54) **Radiation shielding**

(57) Shields for equipment in which ionising radiation is associated with high electrical gradients, for example X-ray tubes and particle accelerators, incorporate a radiation-absorbing metal, as such or as a compound, and are electrically non-conducting and can be placed in the high electrical gradient region of the equipment. Substances disclosed include dispersions of lead, tungsten, uranium or oxides of these in acrylics, polyesters, PVC, ABS, polyamides, PTFE, epoxy resins, glass or ceramics. The material used may constitute an evacuable enclosure of the equipment or may be an external shield thereof.

GB 2 007 480 A

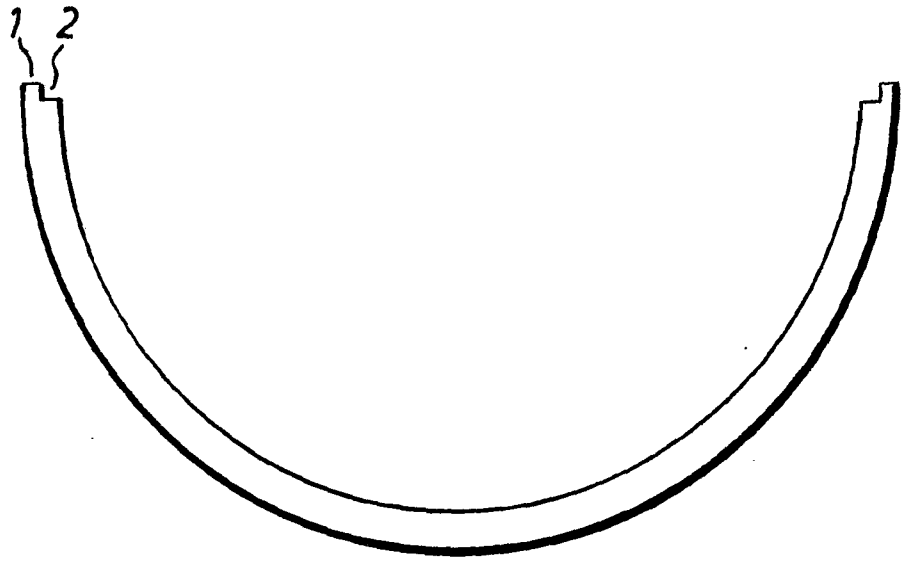

FIG. 1

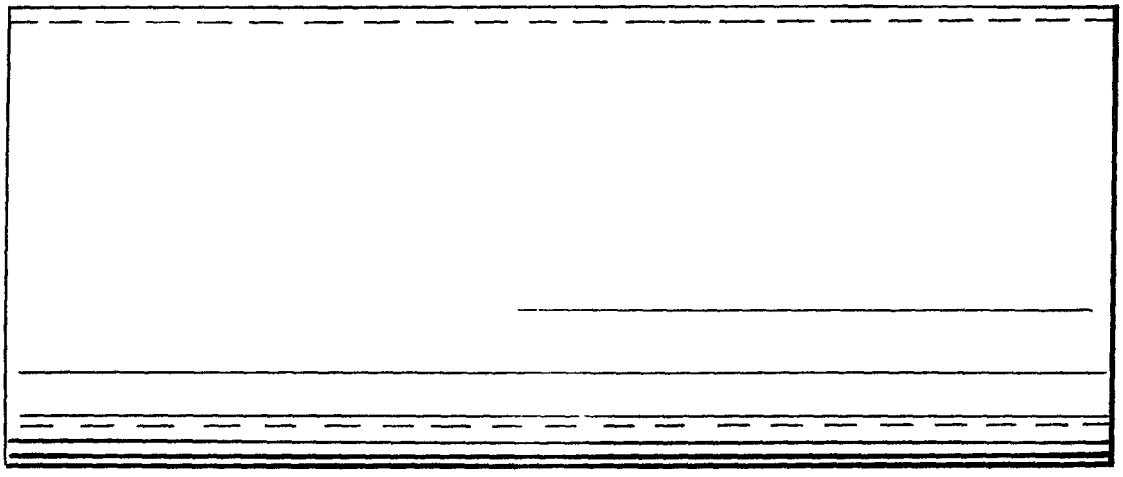

FIG. 2

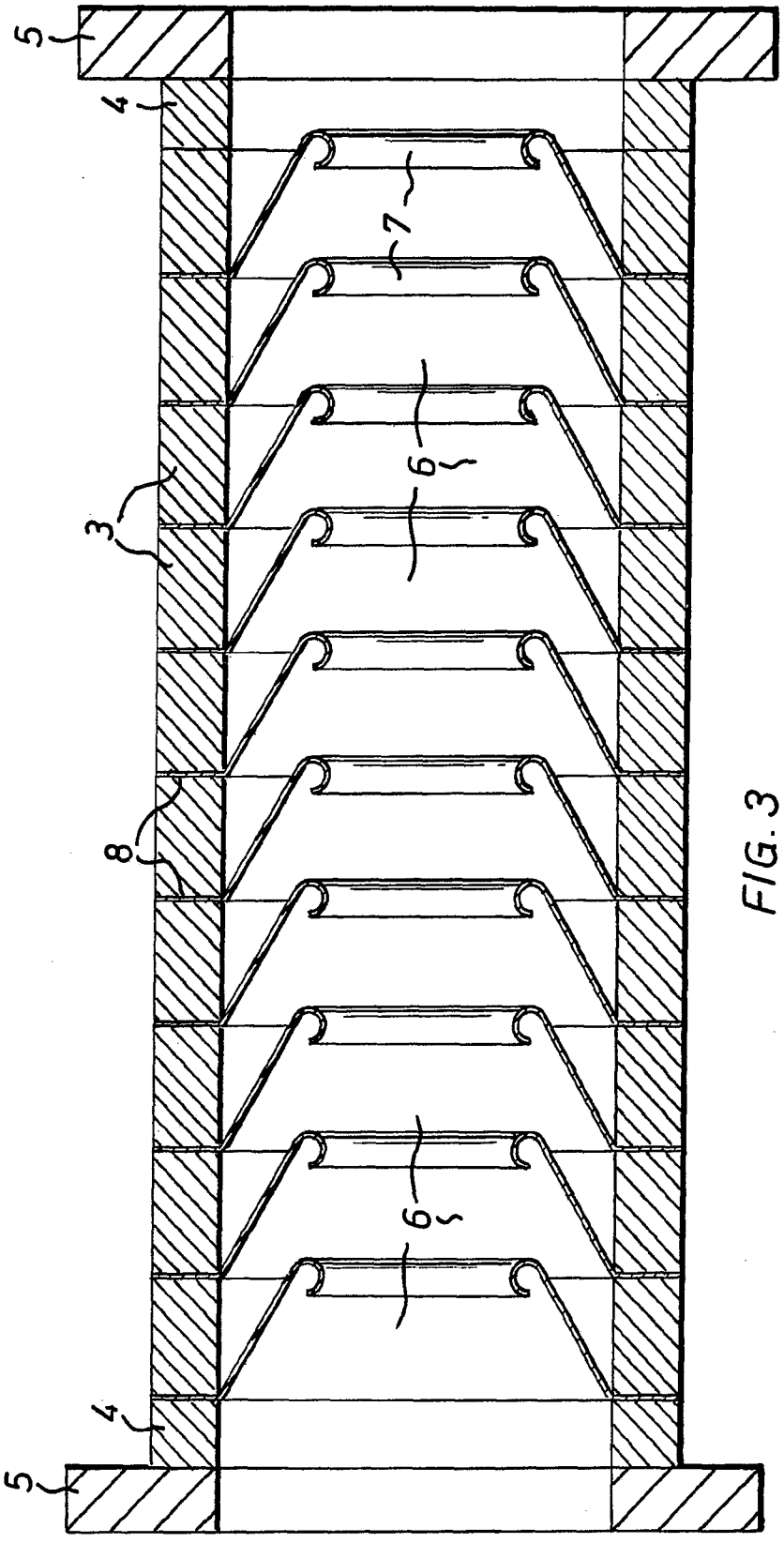

FIG. 3

SPECIFICATION

Radiation shielding

The invention relates to radiation shields, particularly for equipment in which the production of radiation is associated with high electrical gradients. Commercial ion beam or electron beam equipment, where the accelerator tubes give rise to high radiation levels, is of this kind.

Conventional shielding of lead sheeting or concrete, spaced from the radiation source, is often very expensive in the cost of materials or in elaborate fabrication, and may also make equipment excessively bulky or heavy.

Our concept is to make shielding that is electrically non-conductive and can therefore be placed in equipment close to the radiation source where the electric field strength is high. Both the bulk of the equipment and the amount of shielding material required can be greatly reduced by this means, without loss of protection.

The invention accordingly provides an electrically non-conducting shield for electrical equipment that produces ionising radiation, which shield comprises a radiation-absorbing metal and is shaped to lie within the region of high electrical gradient in the equipment adjacent to the radiation-producing components thereof. The metal, even where used in an insulating matrix, is preferably in the form of an electrically non-conducting compound, and the invention extends both to the shields and to equipment incorporating them.

Such shields may be made separately and used with equipment in which the radiation producing components are enclosed by other means, such as the conventional glass envelope, or may themselves form an evacuable enclosure.

Any radiation-absorbing metal may be used, but the absorptive power of metals increases rapidly with atomic number and heavy metals are desirable, preferably of atomic number 50 or more (tin and metals above it) and advantageously of atomic number 74 or more (tungsten and metals above it.)

The shielding is conveniently made in moulded or cast form, either by dispersion of the radiation absorbing material in an insulating and bonding plastics matrix such as an epoxy resin, or by ceramics techniques, using for example ceramics or glasses containing lead oxide.

Alternqtively the radiation absorbing material may be a loose or lightly bonded non-conducting fill within a shell of plastics, glass or other material. The exact method of incorporating the radiation absorbing material is unimportant, provided it is present and the shield as a whole is non-conducting.

Where shielding is moulded or cast, the radiation absorbing material content is preferably the maximum within workability limits, well known in themselves in both the plastics and ceramics arts. The state of subdivision of the materials is also largely a matter of convenience in moulding or casting operations.

Lead is the most convenient radiation absorbing metal on grounds of cost and effectiveness, and lead monoxide (litharge) is a particularly suitable form in which to use it, in view of high density and ready availability in convenient form, as sold for paint pigment. Alternatives are however tungsten, particularly in oxide form, or, where maximum absorptive power in minimum volume is required, uranium, conveniently as depleted uranium oxide.

When a plastics matrix is used, selection may be made from many plastics of suitable electrical properties, as determined by the specific application and well known in themselves in electrical equipment. Acrylics, polyesters, polyvinyl chloride, ABS (acrylonitrile-butadiene-styrene), polyamides and polytetrafluoroethylene are all suitable, shaped by sintering, injection moulding, extruding or other suitable means, but we prefer the well known epoxy resins used in electrical equipment for insulating purposes.

The accompanying drawings are given as specific examples of components, and in them:

Figures 1 and 2 show one half of an X-ray tube shield in end and side view respectively;

Figure 3 shows an accelerator tube in longitudinal section.

The X-ray tube shield is 19.9 inches (50.5 cm) long by 15.4 inches (39.2 cm) diameter and 0.625 inches (1.59 cm) thick, and is made in moulds lined with a sheet of melamine resin for each shield, to give a good exterior finish. The moulded shield is machined along the mating flanges 1 and 2 for the counterpart half-shield to give a perfect fit.

The mix used is the following:

45 parts by weight finely divided lead monoxide (litharge) paint pigment
6.75 parts by weight resin
2 parts amine hardener

The resin is a Bisphenol-A based material and the hardener is a polyamine, the properties being the following:

1. PROPERTIES OF THE RESIN:

Designation	DOBECKOT 605 (Dr. Beck & Co.) (Trade Mark)
Type of material	Solvent free modified epoxy resin

Appearance	Clear light straw liquid
Viscosity at 20°C	1,000 cps.
Flash point	>100°C.
Epoxy equivalent	200 ± 20
Specific Gravity at 20°C	1.11

2. PROPERTIES OF THE HARDENER:

Designation	*HARDENER 762 BE2* (Dr. Beck & Co.)
Type of Material	Polyamine
Appearance	Blue liquid
Viscosity at 20°C.	80 cps.
Flash point	>100°C.
Specific Gravity at 20°C.	0.97

3. PROPERTIES OF THE RESIN/HARDENER MIX AS SUCH:

Viscosity at 20°C.	800 cps
Usable Pot life at 20°C	30 minutes
at 30°C.	20 minutes
at 40°C.	10 minutes
Gel Time at 100°C.	3 minutes
Cure at 120°C.	30 - 60 minutes

4. ELECTRICAL PROPERTIES (CURED RESIN AS SUCH):

Electric Strength BSS 2782 Part 2 1965 Method 201 C	1000 volts/mil
Volume Resistivity BSS 2782 Part 2 1965 Method 202 A	1×10^{15} ohm cm
Surface Resistivity BSS 2782 Part 2 1965 Method 203 A	8×10^{14} ohm cm
Permittivity	2.5
Dielectric Loss Angle (Tan δ)	0.010
Shrinkage %	0.5

Shields as made with the litharge based mix have excellent electrical properties with a volume resistivity better than 10^{12} ohm cm and an electric strength of approx. 30 MV/*m*. A test sample of the material 1 cm in thickness reduces the intensity of 150 KV X-rays from a commercial tube by a factor of 600, and the shields are thus readily capable of reducing radiation levels below permitted maxima, for example 0.25 mil-lirads/hour in the U.S.A.

Suitable amounts of other metal compounds for making up mixes as above are readily calculated from their density. Amounts which may be used in substitution for the 45 parts of litharge are for example (by weight):

PbO_2	-	44.2 parts
PbF_2	-	38.9 parts
UO_2	-	51.7 parts
UN	-	67.5 parts
WO_2	-	57.1 parts

An example of a shield which is in fact the vacuum enclosing envelope of the radiation source is shown in Figure 3. It consists of a number of rings 3 of the litharge-based mix given above interposed between the metal electrodes of a graded accelerator tube. The tube is of a design used in commercial ion implanters for silicon chips, and is schematically shown, without electrical connections or details of the end rings 4 and metal end flanges 5 by which the tube is mated into the vacuum system of the implanter. The electrodes 6 are of flanged frusto-conical form with the smaller, inner ends 7 rolled and the flanges 8 reaching the surface of the shield, for electrical connections. They are made of aluminium, or for steeper electrical gradients

titanium.

CLAIMS

1. An electrically non-conducting shield for electrical equipment that produces ionising radiation, which shield incorporates a radiation-absorbing metal and is shaped to lie within the region of high electrical gradient in the equipment adjacent to and forming an evacuable enclosure for the radiation producing components.

2. A shield according to claim 1, formed of a moulded cast or otherwise shaped matrix of an epoxy resin or other plastics material incorporating the radiation absorbing metal in particulate form, as such or as a non-conducting compound.

3. A shield according to claim 1 or 2, in which the radiation-absorbing metal is tin or a metal of higher atomic number.

4. A shield according to claim 1 or 2, in which the radiation-absorbing metal is tungsten or a metal of higher atomic number.

5. A shield according to claim 1 or 2, in which the radiation absorbing metal is lead, as litharge or in other form.

6. A shield substantially as herein described and shown in Figures 1 and 2 or Figure 3 of the accompanying drawings.

7. Ionising-radiation producing electrical equipment when provided with a radiation shield as claimed in any preceding claim.

Printed for Her Majesty's Stationery Office, by Croydon Printing Company Limited, Croydon Surrey, 1979
Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.