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(54) Solvent extraction columns

(57) In pulsed columns for use in solvent extraction processes, e.g. the reprocessing of nuclear fuel, the horizontal perforated plates 9 inside the column are separated by interplate spacers 14 manufactured from metallic neutron absorbing material. The spacer may be in the form of a spiral or concentric circles separated by radial limbs, or may be of egg-box construction. Suitable neutron absorbing materials include stainless steel containing boron or gadolinium, hafnium metal or alloys of hafnium.

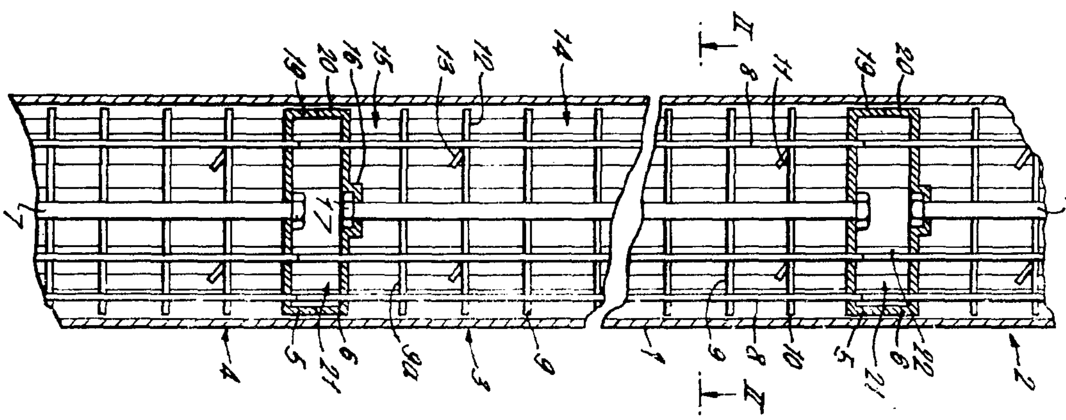

FIG. 1.

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FIG. 4.

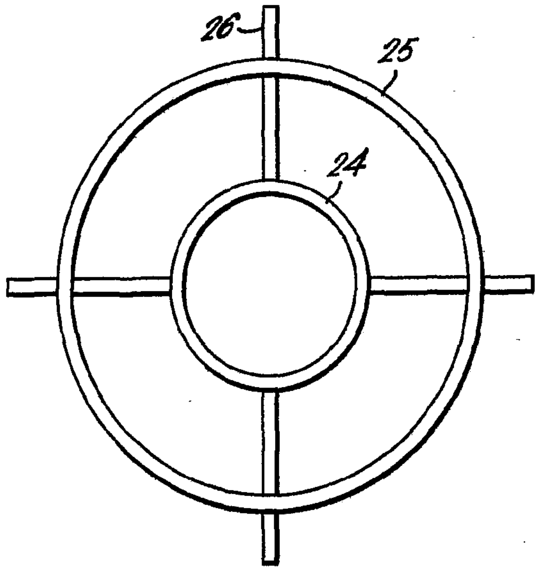

FIG. 1.

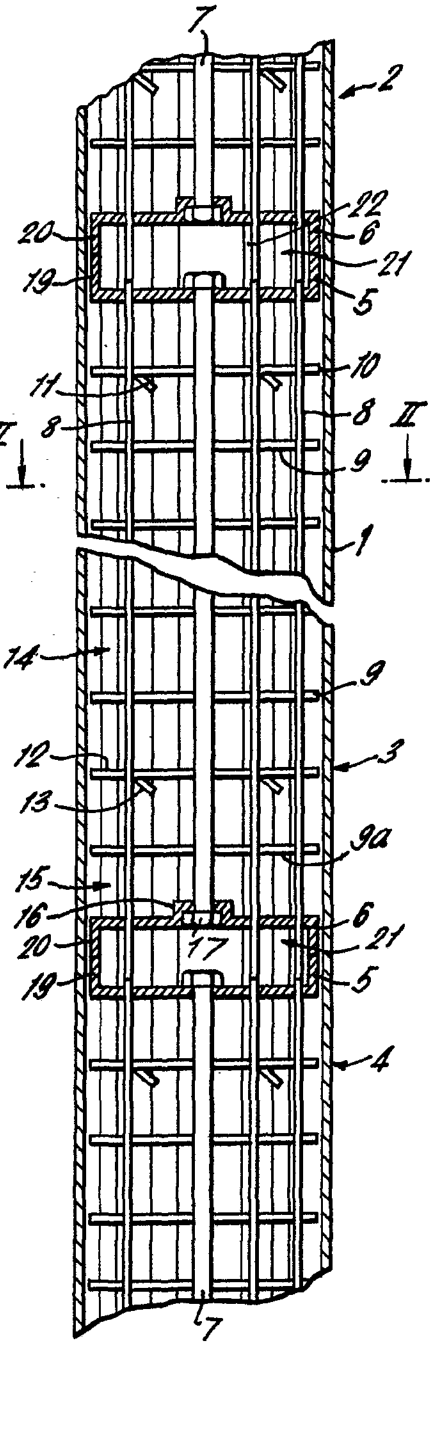

FIG. 5.

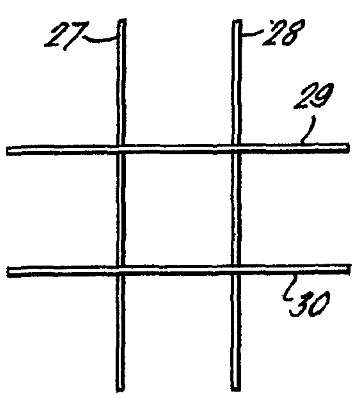

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FIG. 2.

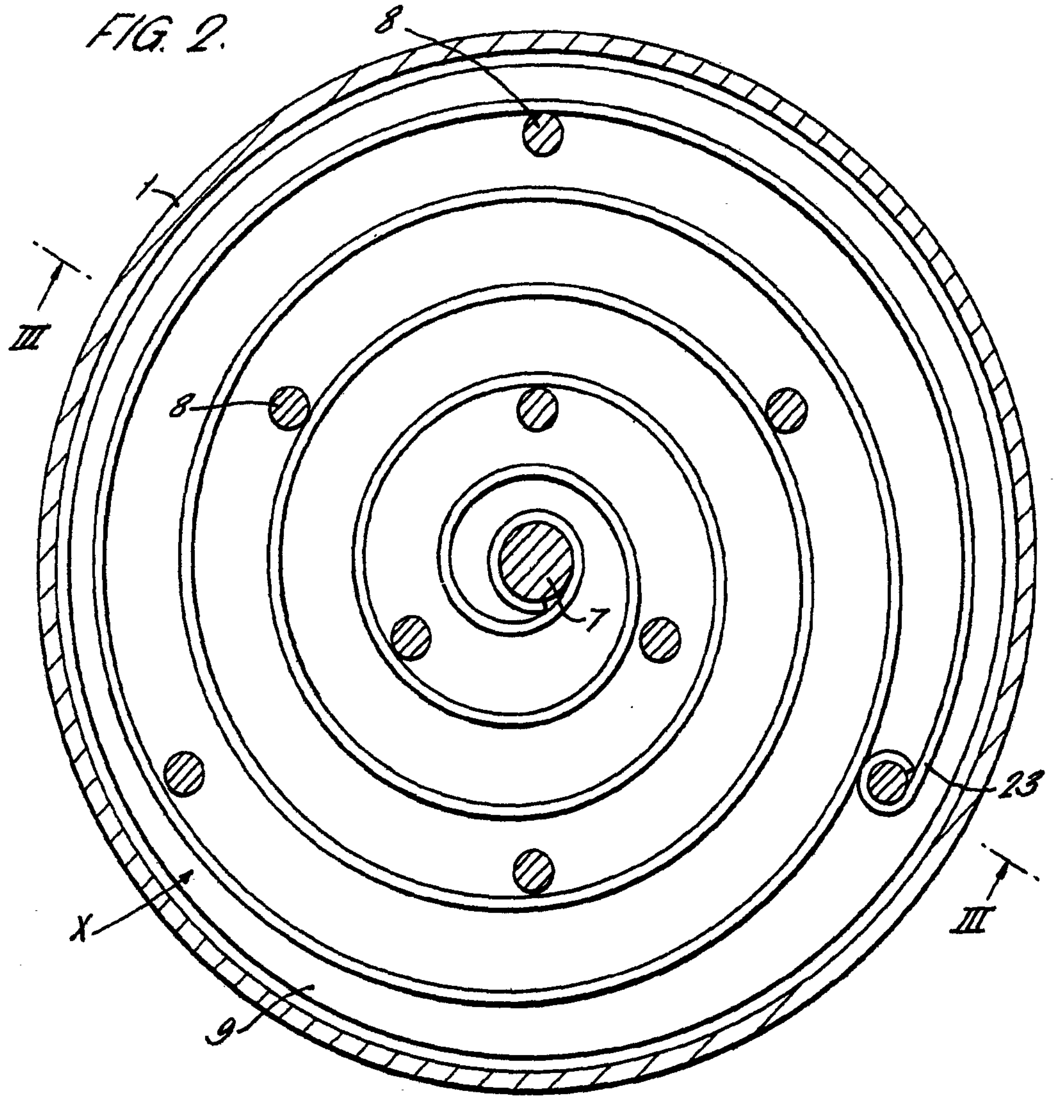
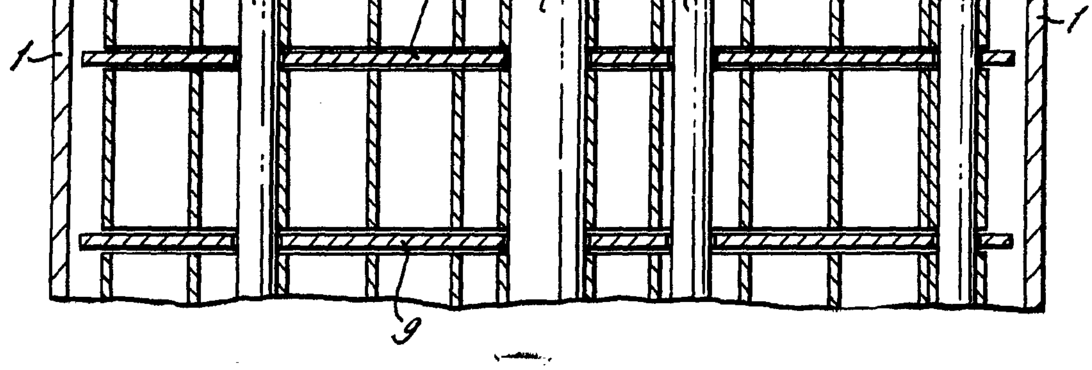


FIG. 3.



SPECIFICATION

Solvent extraction columns

This invention relates to pulsed columns used in solvent extraction processes associated with the nuclear industry and particularly to pulsed columns used in the solvent extraction processes involved in the reprocessing of irradiated nuclear fuel material to separate re-usable nuclear fuel material from fission products.

One form of pulsed columns used in reprocessing plants for irradiated nuclear fuel material comprises a vertical tube containing perforated horizontal plates. The liquid in the column is caused to pulse which forces the discontinuous phase through the apertures in the plate forming bubbles. The pulsing causes the bubbles to be forced through holes in successive plates as they work their way up or down the column. The plates in the columns are spaced apart and are fixed in position by means of the tie rods and are separated by interplate spacers.

In a plant for reprocessing spent oxide nuclear fuel material which contains larger amounts of fissile material than the fuel from earlier nuclear power stations greater criticality control has to be exercised. Criticality control can be achieved by restriction of vessel geometry or by limitation of the mass or concentration of fissile material present. To achieve the reprocessing capacity required by modern nuclear power programmes, larger diameter columns are required. In these larger diameter columns criticality control is achieved by careful control of the mass or concentration of fissile material. Because the larger diameter columns would not be safe by their geometry alone from criticality excursion in the event of a failure in the mass concentration control system which permitted a build-up of fissile material, other means of criticality control must be provided if the larger diameter columns are to achieve the safety standard expected in the nuclear industry.

According to the present invention a pulsed column for use in solvent extraction processes, comprises a vertical tube containing vertically spaced perforated horizontal plates, the horizontal plates being separated by interplate spacers manufactured from metallic neutron-absorbing material.

In a preferred embodiment the interplate spacers are formed of steel containing alloyed boron. The alloyed boron may be enriched with B^{10} to increase the neutron absorbing capacity of the spacer and hence increase the maximum concentration of fissile material which can be safely handled by the column. Up to 1% by weight of boron having the natural abundance of isotopes may be incorporated into the stainless steel. Stainless steel containing enriched boron (90% B^{10}) is more effective than stainless steel containing natural boron and as little as 0.1% by weight of enriched boron in the stainless steel may give the required neutron absorbing capacity.

Other metallic neutron absorbing materials which may be used to manufacture the interplate spacers include stainless steels containing gadolinium, hafnium metal or hafnium alloys.

The interplate spacer may be in the form of a spiral, in the form of concentric rings separated by radial limbs or in the form of flat plates welded together in an egg-box construction.

The invention will be illustrated by the following description given by way of example only which has reference to the accompanying drawings in which:

Figure 1 is a cross-sectional view of a part a pulsed column for use in a solvent extraction process for the reprocessing of irradiated nuclear fuel material to separate re-usable nuclear fuel material from fission products,

Figure 2 is a cross-sectional view taken along the line II—II of Figure 1,

Figure 3 is an enlarged cross-sectional view of a pulsed column taken along the line III—III of Figure 2, and

Figures 4 and 5 are plan views of alternative forms of interplate spacers.

The pulsed column shown in Figure 1 has a cylindrical outer casing 1. Within the casing 1 are located sub-assemblies 2, 3, 4 which are mounted vertically within the casing 1 to form the packing of the pulsed column. Each sub-assembly has upper and lower end members 5, 6 connected together by a central tie rod 7 and nine minor tie rods 8. The tie rods 7, 8 may be connected to the end members 5, 6 by nuts or by welding. Regularly spaced along the tie rods are apertured horizontal nozzle plates 9 made of stainless steel. The apertures in the nozzle plates 9 (which have been omitted from the Figures for clarity) are punched through the plates and these apertures form the nozzles. The free area of the nozzle plates 9 comprises about 22% of the total area of the plate. In a typical plate of 12 inch diameter the apertures are $^{3}/_{16}''$ holes punched on a $^{3}/_{8}''$ triangular grid over the whole area of the plate. Each plate 9 has larger apertures drilled through it of slightly larger diameter than the tie rods 7, 8 which pass through these larger apertures. Adjacent the upper end member 5 of each sub-assembly is a louvre plate 10 having six louvres 11 cut out of the plate and bent so as to extend downwardly from the plate. A similar louvre plate 12 having louvres 13 is located at the opposite end of the sub-assembly and is spaced from the lower end member 6 by a plate 9*a* which is identical with the plates 9 described above. The louvre plates 10, 12 ensure adequate mixing of the liquids passing through the column. The plates 9 in the column are separated by interplate spacers of metallic neutron absorbing material. The spacers are indicated generally by the reference numeral 14 in Figure 1 and described in more detail hereinafter with reference to Figures 2 to 5. The plate immediately above each spacer 14 rests on the upper surface of the spacer. The central portion of the spacer 15 immediately adjacent the lower end member 6 of each sub-assembly is cut away to fit round the boss 16 in the lower end member 6 which houses a nut 17 which connects the central tie rod 7 to the end member. The spacers 18 immediately below the louvre plates 10, 12 are cut away so as to be clear of the louvres 11, 13.

Several sub-assemblies are stacked vertically inside the outer casing 1 provide the pulsed column. The end members 5, 6 of each sub-assembly have apertures (not shown) to allow liquid to pass from one sub-assembly to the next and have an outwardly extending annular flange 19, 20 around their periphery. When the sub-assemblies are stacked in the column the upper edge of the flange 19 on the upper end member 5 of one sub-assembly contacts the lower edge of the flange 20 of the lower end member 6 of the sub-assembly immediately above it leaving a space 21 between the end members 5, 6 enclosed by the flanges 19, 20. The minor tie rods 8 extend through the lower end member 6 and into the space 21. Packing 22 of a metallic neutron absorbing material is provided in the space 21.

Referring now to Figures 2 and 3 the interplate spacers are illustrated in more detail. The drawings show the central tie rod 7 and the minor tie rods 8 and the nozzle plate 9. The apertures in the nozzle plate are not shown. The interplate spacer 14 is shown as a spiral strip one end of which is wrapped round the central tie rod 7. To facilitate manufacture of the spiral the central tie rod may be displaced a small amount from the central axis of the plates 9. The spiral is produced by spirally winding a strip of neutron absorbing material such as stainless steel containing up to 1%, for example 0.5% boron by weight. The outer end 23 of the strip is shaped so as to fit round one of the outer minor tie rods 8. The outer coil of the spiral is circular about the central axis of the sub-assembly from the point X to its outer end 23. To assemble the sub-assembly the tie rods are fitted to one of the end members and spacers and plates are placed on the tie rods alternatively. The spacers and plates are a sliding fit on the tie rods and are not mechanically connected to each other. When the required number of plates and spacers have been fitted the other end member is fitted and the tie rods connected to it.

The spirally wound spacer 14 described above is the preferred form because it is relatively simple to manufacture. Two other forms are illustrated in Figures 4 and 5. The form shown in Figure 4 has two concentric rings 24, 25 of neutron absorbing material and four radial limbs 26, of the same material joining the rings together. To construct this spacer the radial limbs 26 have to be welded to the rings 24, 25.

The other forms of spacer has four flat plates 27, 28, 29, 30 welded together to form an egg-box construction as shown in Figure 5. Both these alternative forms of spacer require welding during their manufacture and they are therefore more difficult to fabricate than the preferred spiral spacer.

CLAIMS

1. A pulsed column for use in solvent extraction processes comprising a vertical tube containing vertically spaced perforated horizontal plates, the horizontal plates being separated by interplate spacers manufactured from metallic neutron-absorbing material.

2. A pulsed column as claimed in claim 1 wherein the metallic neutron-absorbing material is stainless steel containing alloyed boron, stainless steel containing gadolinium, hafnium or hafnium alloys.

3. A pulsed column as claimed in claim 2 wherein the metallic neutron-absorbing material is stainless steel containing up to 1% by weight of boron having the natural abundance of isotopes.

4. A pulsed column as claimed in claim 3 wherein the metallic neutron-absorbing material is stainless steel containing boron in which 90% of the boron present is the isotope of atomic mass 10.

5. A pulsed column as claimed in any one of the preceding claims wherein the interplate spacers are in the form of a spiral.

6. A pulsed column as claimed in any one of claims 1 to 4 wherein the interplate spacers are in the form of concentric rings separated by radial limbs.

7. A pulsed column as claimed in any one of claims 1 to 4 wherein the interplate spacers are formed by flat plates welded together in an egg box construction.

8. A pulsed column for use in solvent extraction processes substantially as hereinbefore described with reference to the accompanying drawings.

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