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[54] **IRRADIATION APPARATUS**
8 Claims, 6 Drawing Figs.

[52] U.S. Cl. 250/52, 250/106; 198/76
[51] Int. Cl. G01t 7/08
[50] Field of Search .... 250/52, 106, 106 (S), 106 (SC); 198/76X

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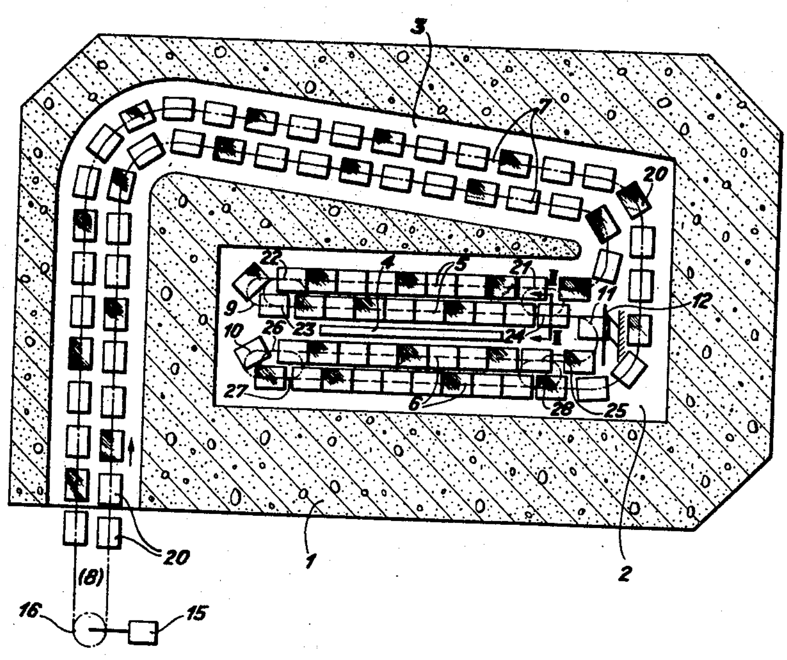
ABSTRACT: The continuous track has individual parallel track sections which are connected together by loops to form a single path for the loads. The conveyors move the loads by means of catches along the track. The loads are transferred at various points from one conveyor to another to change the speed of the loads so as to effect a slow movement of the loads in closely spaced relation past the radiation source.



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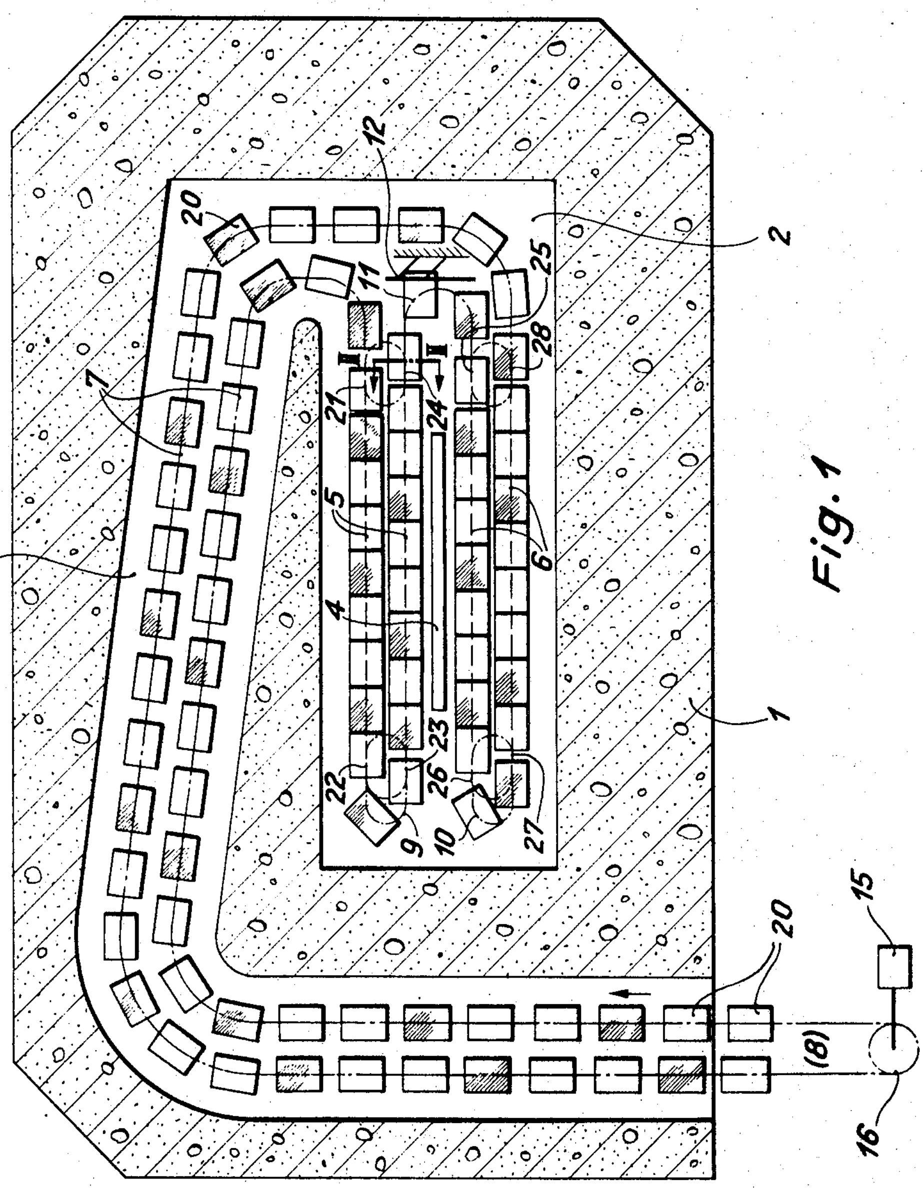

Fig. 1

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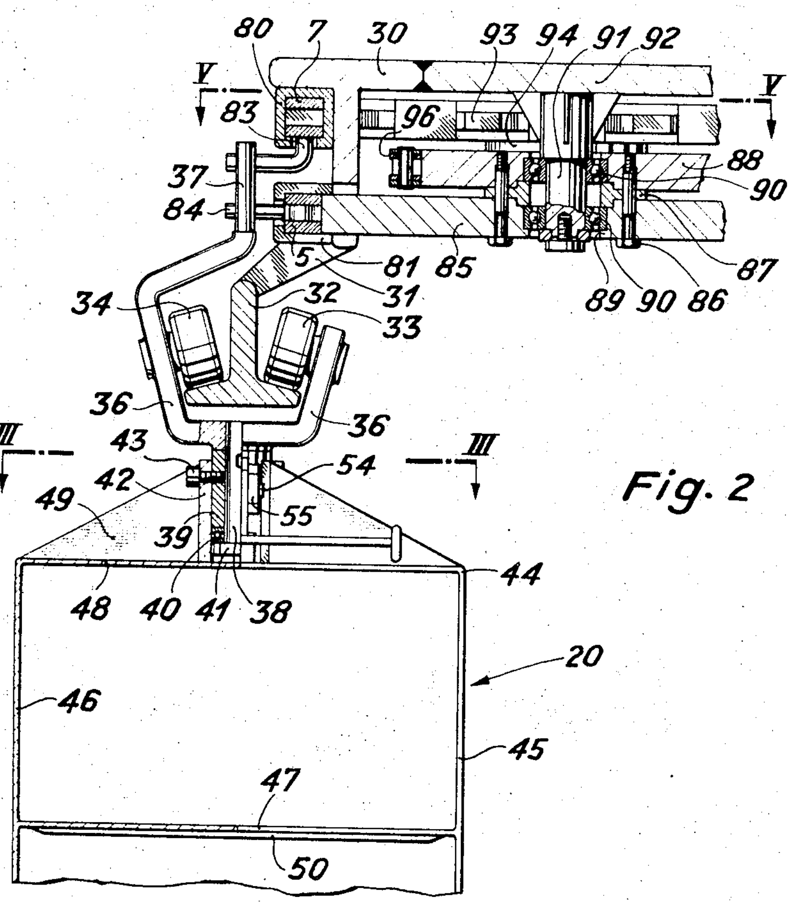

Fig. 2

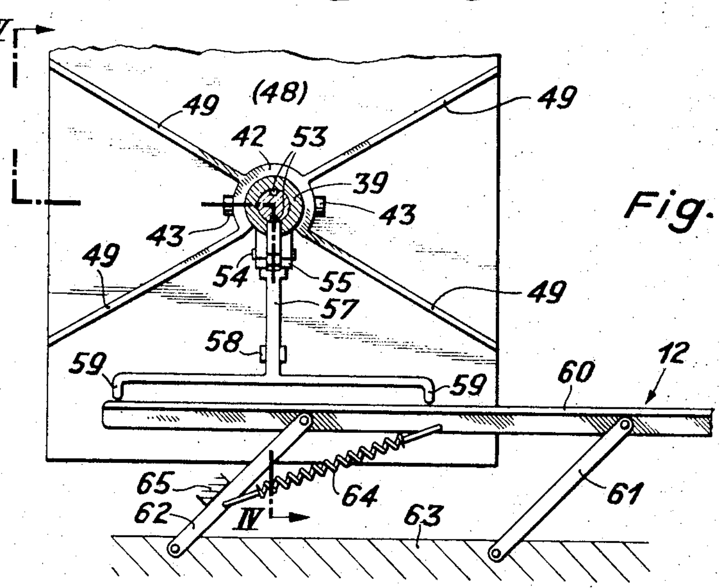

Fig. 3

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Fig. 4

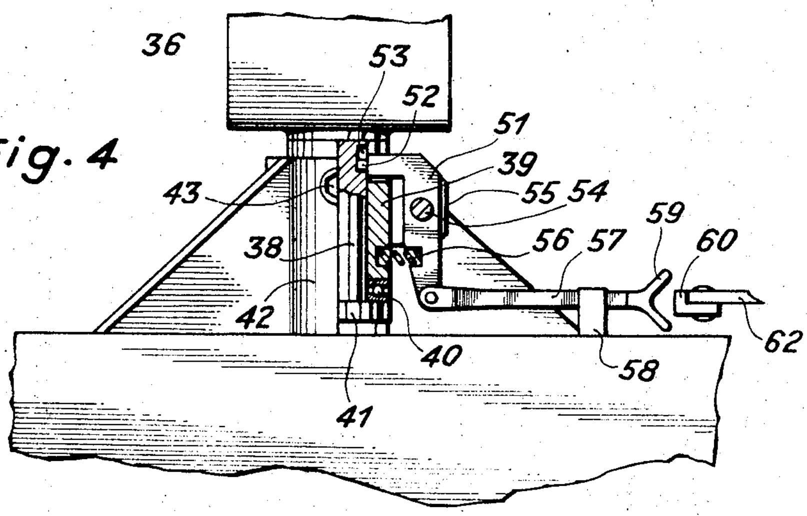


Fig. 5

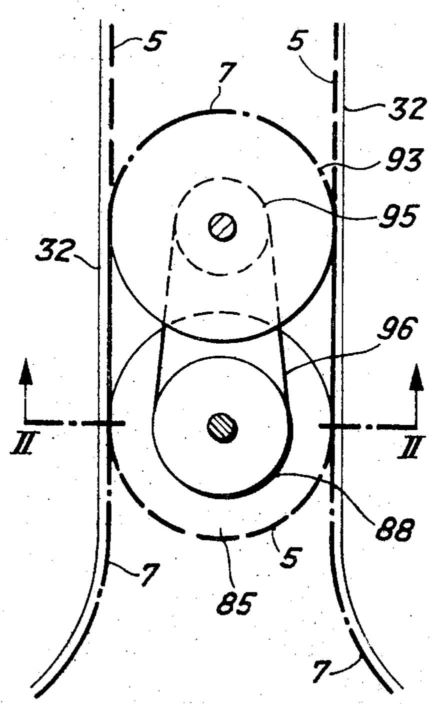
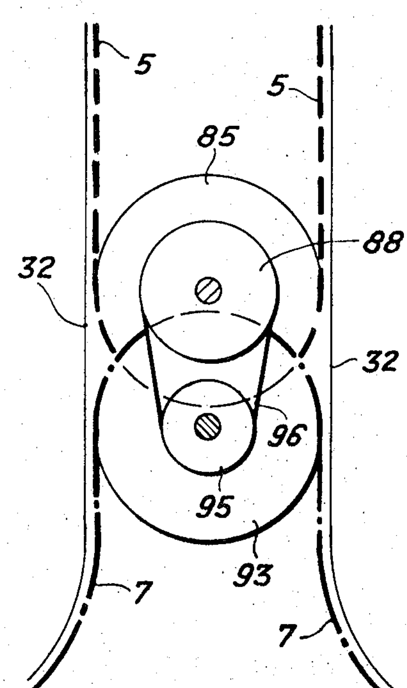


Fig. 6



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IRRADIATION APPARATUS

This invention relates to an irradiation apparatus. More particularly, this invention relates to an irradiation apparatus wherein a load to be irradiated is conveyed on a conveyor assembly.

In order to increase the irradiation efficiency of a system wherein a series of loads are conveyed past or around a radiation source, the individual loads should be as close together as possible, i.e. as a continuous column, when passing the radiation source. Frequently, the conveying means for the loads have been closed chain conveyors which push the individual loads, usually mounted in suspended trolleys, along a plurality of parallel tracks past the radiation source by means of catches. However, these loads cannot readily be transferred from one parallel track to an adjacent track, since the loads, being conveyed close together, cannot easily follow a continuous curve of track unless the distance between them is increased.

Heretofore, devices of this above type have used two different chain conveyor systems. A first chain conveyor system has been a fast-moving system which conveys the load at intervals through a biological shielding whereas the second chain conveyor system has been a slow-moving system disposed within the irradiation chamber proper which carries the loads at shorter intervals along the parallel tracks past the radiation source. Each of these two chain conveyor systems have consisted of straight portions formed by individual closed chains so that transfer of a load within the irradiation chamber from the straight portion of one track to a parallel portion of an adjacent track has been by way of rotary pusher arms. These pusher arms have been used to push the loads on to a short, separate track portion, displaceable at right angles to the straight track portions proper over a kind of bridge, and to also displace this track portion on the bridge from the position in extension of the first straight portion into a position in extension of the adjacent straight track portion. After this displacing operation, the next catch on the second chain conveyor then has entrained the load on the second straight portion, and a second pusher arm returns the short separate track portion into its initial position. However, the transfer device which has used these pusher arms has been complicated, expensive and unreliable, and further has not enabled the loads to be brought close to one another.

Accordingly, it is an object of the invention to convey a series of loads on a chain conveyor substantially in a contiguous manner through an irradiation chamber.

It is another object of the invention to convey a series of loads on a continuous track within an irradiation chamber about a radiation source.

It is another object of the invention to simplify the transfer of a load from one straight track portion to an adjacent straight track portion within an irradiation chamber.

Briefly, the invention provides an irradiation apparatus with a continuous track on which a series of loads are suspended and moved along in a continuous manner by a series of conveyors moving at different speeds about a radiation source within an irradiation chamber. The track includes two pairs of parallel track sections which are disposed on opposite sides of the radiation source and interconnected by loop sections. The parallel track sections allow the loads to be moved about the radiation source for a double dose of radiation.

The conveyor for moving the loads along the track include a fast-moving conveyor which moves the loads along the track at a fast rate of speed while maintaining the loads in a widely spaced relation in supplying the loads to and removing the irradiated loads from the irradiation chamber. In addition, a pair of slow-moving conveyors are provided to move the loads along the parallel track sections about the radiation source at a slow rate of speed while maintaining the load in substantially contiguous relation. Also, a turning conveyor is provided at each loop section between the track sections of each pair of parallel-track sections to move the loads around the loop sections at a fast rate of speed in order to space out the loads and prevent interference between loads during turning through the loop sections. The fast-moving conveyor which supplies and removes the loads also serves to move the loads through the loop connecting the adjacent track sections disposed on opposite sides of the radiation source.

The various conveyors include catches which engage each of the loads to move the loads along the track and which are spaced from one conveyor to the next to move the loads in a continuous manner.

The conveyors are driven from a single drive source outside the radiation chamber and are interconnected by transmissions which serve to reduce or increase the speed ratio between adjacent interconnected conveyors.

In addition, the loads are suspended from the track and mounted in frames which are pivotal with respect to the track. In moving along the track, these frames are locked in position. However, in moving from one parallel track section to the other on opposite sides of the radiation source, the frames are rotated 180° with respect to the track by a parallel motion mechanism. This allows opposite sides of the loads to be exposed to the radiation source in passing by the radiation source on the respective parallel track sections.

These and other objects and advantages of the invention will become more apparent from the following detailed description taken in conjunction with the accompanying drawings in which:

FIG. 1 illustrates a plan view of an irradiation apparatus embodying the invention;

FIG. 2 illustrates a view taken on line II–II of FIGS. 1 and 5;

FIG. 3 illustrates a view taken on line III–III of FIG. 2;

FIG. 4 illustrates a view taken on line IV–IV of FIG. 3 with various parts shown on different scales for clarity;

FIG. 5 illustrates a view taken on line V–V of FIG. 2 of a transmission for moving a load from one track to another; and

FIG. 6 illustrates a view similar to FIG. 5 of a modified transmission according to the invention.

Referring to FIG. 1, the irradiation apparatus includes a shielding block **1** which contains an irradiation chamber **2**. The irradiation chamber **2** is accessible to the outside of the shielding block **1** through a supply passage **3** and contains a radiation source **4**, for example, a grid of cobalt 60 rods, which are mounted in a conventional manner. A pair of slow moving closed loop chain conveyors **5, 6** are disposed on opposite sides of the radiation source **4** and each has a chain which runs on a track along the path shown by dash lines. In addition, a fast-moving closed loop chain conveyor **7** is disposed within the supply passage **3** and partially outside the shielding block **1** and partially inside the irradiation chamber **2**. The chain conveyor **7** serves to communicate a loading-unloading- and transfer station **8** outside the shielding block **8** to the irradiation chamber **2** through the supply passage **3** and runs at approximately 1 ½times the speed of the slow-moving conveyors **5, 6**. The track of the chain conveyor **7** which is disposed in the path shown by a chain line partially overlaps portions of the tracks of the chain conveyors **5, 6** near the entrance to the irradiation chamber **2**.

A pair of turning conveyors **9, 10** are mounted at the closed end of the irradiation chamber **2** (shown at the left in FIG. **1**) with the tracks of each in partial overlapping disposition with the left-hand ends of the tracks of the respective slow moving conveyors **5, 6**. The chains of these turning conveyors **9, 10** run in the paths shown in chain lines in FIG. **1** at approximately 1 ½times the speed of the chains of the slow moving conveyors **5, 6** and serve to move a load at a fast speed from one parallel track portion to the other of each slow moving conveyor **5, 6**. Also, a loop **11** of the fast-moving conveyor **7** is disposed in overlapping relation with the right-hand ends of the slow-moving conveyors **5, 6** near the entrance of the irradiation chamber in order to permit the chain of the conveyor **7** to move a load at a fast speed from one parallel track portion of one slow-moving conveyor **5** to the adjacent parallel track portion of the other slow-moving conveyor **6**. A parallel motion mechanism **12** is provided adjacent to the loop

11 in order to facilitate a turning of a load 180° relative to the chain of the conveyor 7 within the extent of the loop 11 so as to present an opposite surface of the load to the radiation source 4.

The chain conveyor system is operated by an electric motor 15 by way of a driving wheel 16, both of which are outside the shielding block 1.

In operation, the individual loads are mounted in trolleys 20 which are conveyed by the chain conveyor 7 through the supply passage 3 into the irradiation chamber 2 in the direction indicated by the arrow. At a point 21 the trolleys 20 are taken over by the slow-moving chain conveyor 5, and the individual trolleys 20 close up together while being conveyed along the first straight portion of the conveyor 5. The trolleys 20 are then transferred at a point 22 to the fast-moving turning conveyor 9. On the portion of track covered by the fast moving chain conveyor 9, the distances between the trolleys 20 are sufficiently increased for them to be able to turn tangentially relative to the track curve without colliding with each other. At a point 23 the trolleys 20 are again received by the slow moving chain conveyor 5 and conveyed to a point 24 where the trolleys 20 are taken over by the fast moving chain in the loop 11. In moving through the loop 11 the lower trolley portion which carries the load moves parallel to itself to pass at a point 25 to the other slow moving chain conveyor 6. Thereafter, the trolleys 20 are conveyed to a point 26 and transferred to the chain of the turning conveyor 10 for transfer at a point 27 back to the slow moving conveyor 6 and then at a point 28 to the chain of the supply conveyor 7. Because of the parallel displacement in the loop 11, the loads are irradiated symmetrically relative to a vertical central plane parallel to the direction of movement.

Immediately next to the paths of the chains of conveyors 7, 5, 9, 5, 7, 6, 10, 6 and 7 shown in FIG. 1, at least within the irradiation chamber 2, there is a continuous T-section roller track 32 (FIG. 2) which forms an enveloping track for the paths of the individual chains and carries the individual loads 20 without suddenly changing their direction of movement.

Referring to FIGS. 2 to 4, the T-section roller track 32 is suspended by arms 31 from a T-section frame 30. Each trolley 20 is suspended from the track 32 by means of two rollers 33, 34 which run along the arms or flanges of the T-section track 32. These rollers are mounted on a traveller 36, which ends at the top in a projection 37 and carries a pivot 38 below. A sleeve 39 on the pivot 38 is axially mounted on a ball bearing 40, supported on a shoulder 41 of the pivot 38. Also, a sleeve 42 surrounds and is attached to the sleeve 39 by two screws 43 in order to prevent relative rotation. The sleeve 42 is part of a box 44 with three decks which is used to carry the loads to be irradiated.

The box 44 is made, for example, of sheet metal and has two walls 45, 46, three floors 47, of which only one is shown, a roof 48 and four ribs 49 which connect the roof 48 to the sleeve 42. The floors 47 are reinforced by longitudinal beads 50. The loads of material for irradiation are pushed into the three decks in the box 44 at right angles to the plane of FIG. 2 through the openings between the walls 46, 46.

The box 44 is rotatable on the pivot 38, but is normally locked by a lever 51 (FIG. 4) against rotation. The lever 51 has a lug 52 at one end which engages one of two grooves 53 in the pivot 38 to prevent relative rotation of the box 44 and pivot 38. In addition, the lever 51 is mounted on a pin 54 supported on two fins 55 from the sleeve 39 and is biased by a spring 56 into engagement with one of the grooves 53. The base of the vertical arm of the lever 51 is pivotally connected to a push rod 57 which bears on a saddle 58 mounted on the box 44 and ends in two arms 59 with forked ends.

Referring to FIGS. 3 and 4, the parallel-motion mechanism 12 comprises a profiled bar 60 which is pivoted on a fixed base 63 by means of two parallel links 61, 62 and urged by a draw spring 64 into a position which is remote from the base 63 and is determined by a stop 65.

The parallel-motion mechanism 12 operates as follows. When the trolley 20 runs against the bar 60 at the beginning of the loop 11, the forked ends of the arms 59 engage the bar 60, and the weaker spring 56 yields under the lever 51 so that the lug 52 springs out of the groove 53. The box 44 can now rotate freely relative to the pivot 38. The box 44 c orientates itself on account of the wide spacing of the forked ends of the arms 59 on the bar 60, which, as the box 44 continues to move along the loop 11, is pressed on to the base 63 and then released again. As the trolley 20 then runs along the loop 11, the pivot 38 turns through 180° (as viewed by a stationary observer) while the box 44 is displaced parallel to itself. Shortly before the forked ends 59 come away from the bar 60, the lug 52 catches in the other groove 53, so that for subsequent conveying the box 44 is again rigidly connected with the traveller 36.

Referring to FIG. 2, the fast conveyor chain 7 and slow chain 5 run respectively in two guide sections 80, 81 attached to the frame 30. Curved catches 83 are attached to the outer links on the chain 7 at suitable intervals to abut the projections 37 of the trolleys and push the trolleys along the track and the central links of the chain 5 carry straight catches 84 similarly at intervals corresponding to the length of the trolley boxes. The fast chain conveyor 7 drives the slow chain conveyor 5 through a transmission which includes a chain wheel 85 on which the chain 5 is mounted. The chain wheel 85 is connected by screws 86 and an insert 87 to a transmission wheel 88. The chain wheel 85 and transmission wheel 88 are rotatably mounted by a pair of ball bearings 90 on a pin 91 which is welded to a cross member 92 which connects the two sections 30 of the profiled frame. The outer rings of two ball bearings 90 are clamped between a shoulder 89 and the insert 87 and between a shoulder on the wheel 88 and the insert 87.

Similarly, the chain 7 runs over a chain wheel 93 (FIG. 2) connected by an insert 94 to a transmission wheel 95 (FIG. 5) concealed behind the wheel 88. The wheel 95 has a smaller diameter than the wheel 88 and is coupled to the wheel 88 by a chain 96 so that the chain 5 is driven by the chain 7 with a reduction in the ratio of 2:3.

FIG. 5 is a diagrammatic plan of the connection between the fast conveyor chain 7 and the slow conveyor chain 5, the slow chain 5 being indicated by a dash line and the fast by a chain line.

It is noted that with the transition from a fast to a slow chain shown, care should be taken by suitably selecting the transmission, the distances between the catches on the individual chains 5 and 7 and their succession relative to each other, and the distance between the two wheels 85 and 93, so that the projection 37 (FIG. 2) of a trolley 20 is not caught between the catch 84 on the slow chain 5 and the catch 83 on the fast chain 7, i.e. so that the fast chain does not reach the slow chain catch 84 preceding it too early. The transfer of the loads from the other fast chains to the slow chains and vice versa takes place in the same manner and need not be further described.

The apparatus embodying the invention can of course be modified in various ways. For example, referring to FIG. 6, the fulcrum of the chain wheel 85 need not lie beyond that of chain wheel 93 relative to the center of gravity of the chain 5, but can be on the nearer side of the center of gravity so that the chain 5 does not pass round the fulcrum of the wheel 93.

Also, the traveller 36 may be different. For example, the traveller can have only one supporting roller instead of the two shown. To permit turning through very small radii at the ends of the parallel tracks, the track can be prism-shaped and the trolleys can be carried and conveyed in the track on balls, each trolley preferably carrying two balls arranged at a distance from one another and one behind the other. The trolleys are supported on these balls by means of ball cups enclosing a large number of small balls to reduce friction.

The parallel motion, i.e. the pivoting of the box 44 relative to the traveller 36, can also be effected by other means, e.g. by a guide for the box 44 on the track 32 or on auxiliary guide means.

The supply and discharge passages can be separate. However, the combination of the two passages in a single passage has the additional advantages that the apparatus as a whole is more compact and that personnel can reach the irradiation chamber **2** along the passage **3**, so that they can, if necessary, carry out overhauls when the radiation source has been lowered.

Also, the individual loads need not be conveyed in boxes **44** suspended from an overhead track, but could be in similar boxes pushed forwards by the chains on a roller conveyor.

It is further noted that one means for loading and unloading the trolleys **20** and for exchanging the loads in a known manner between the various decks in the box **44** are not described in detail, since they are not the subject of the present invention. These means can, for example, be conventional pushing devices.

The invention thus provides an irradiation apparatus in which the material to be irradiated is carried in individual loads from a conveyor chain at very short distances from one another in at least one horizontal conveying plane on at least two mutually parallel tracks past a radiation source, and a fast-moving closed chain passes the loads to at least one slow-moving closed chain which moves along the parallel tracks.

Advantageously, the drive for the various conveyor chains is effected in such a way that the individual conveyor chains are interconnected by transmissions while the whole system of conveyor chains is operated by a drive outside the biological shielding. This has the advantage that the drive motor is not exposed to radiation and is always accessible in the event of a breakdown.

Also, the individual loads are mounted in frames which are turned through 180° about their vertical axes (relative to the direction of movement) at least once on their way round the radiation source in order to permit uniform irradiation of the loads.

A major advantage of the apparatus embodying the invention is that even when the loads are transferred, the force exerted on them always runs in the direction of movement, so that friction and therefore stressing of the chains and abrasion can be substantially reduced.

I claim:

1. An irradiation apparatus comprising:

an irradiation chamber;

a radiation source mounted within said chamber;

a continuous track for conveying a series of loads to be irradiated thereon, said track having a pair of parallel track sections on each side of said radiation source, and loop sections connecting adjacent track section to each other at the ends thereof;

a fast-moving conveyor for moving the loads at a first speed into said irradiation chamber onto one of said parallel track sections, said fast moving conveyor having a loop portion disposed in parallel relation to said loop section connecting said parallel track sections on opposite sides of said radiation source;

a pair of slow-moving conveyors, each slow-moving conveyor being disposed in parallel relation to a pair of said parallel track sections for moving the loads thereon at a second speed slower than said first speed, each said slow-moving conveyor being in overlapping relation at one end with said fast moving conveyor; and

a turning conveyor positioned in overlapping relation to each of said slow-moving conveyors at the opposite end thereof, each said turning conveyor being in parallel relation to said loop section connecting adjacent track sections of a pair of parallel track sections for moving the loads thereon at a third speed faster than said second speed whereby the loads are continuously moved at a fast speed in widely spaced relation on said fast conveyor onto said parallel track sections, subsequently moved at a slower speed in closely spaced relation on said parallel track sections, and moved at a fast speed on said loop portions in widely spaced relation.

2. An irradiation apparatus as set forth in claim 1 wherein each of said conveyors includes a plurality of spaced catches for engaging successive loads to move the loads along said track.

3. An irradiation apparatus as set forth in claim 1 further comprising a plurality of transmissions, each transmission being positioned between adjacent overlapping conveyors to interconnect said overlapping conveyors.

4. An irradiation apparatus as set forth in claim 3 further comprising a drive means connected to said fast-moving conveyor outside said irradiation chamber for drivng said fast-moving conveyor.

5. An irradiation apparatus as set forth in claim 1 further comprising a parallel motion mechanism positioned adjacent said loop section connecting said parallel track sections on opposite sides of said radiation source, said mechanism projecting into the path of the loads to pivot each load 180° relative to said track on movement of the load past said mechanism.

6. An irradiation apparatus as set forth in claim 5 wherein each load is mounted on a pivotal box frame suspended from said continuous track.

7. In an irradiation apparatus comprising:

an irradiation chamber;

a radiation source mounted within said chamber;

a continuous track for conveying a series of loads to be irradiated thereon, said continuous track having at least two parallel track sections, each said track section being disposed on an opposite side of said radiation source, and a loop section for conveying the loads from one of said parallel track sections to the other parallel track section;

a fast-moving conveyor positioned in parallel with said loop section for moving the loads thereon at a first speed in widely spaced relation;

a slow-moving conveyor positioned in parallel with each said parallel track section for moving the loads thereon at a second speed slower than said first speed and in closely spaced relation, each slow moving conveyor being in overlapping relation with said fast-moving conveyor;

a transmission connecting each slow moving conveyor to said fast-moving conveyor to convey the loads in a continuous manner; and

a parallel motion mechanism positioned adjacent said loop section for pivoting the loads 180° relative to said track.

8. In an irradiation apparatus as set forth in claim 1 wherein each of said conveyors include a plurality of spaced catches projecting into the path of the loads on said respective track sections for abutting the loads to move the loads along said track sections.