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(54) IMPROVEMENTS IN OR RELATING TO SOIL CULTIVATING IMPLEMENTS

(71) We, C. VAN DER LELY N.V., of 10, Weverskade, Maasland, The Netherlands, a Dutch Limited Liability Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to soil cultivating implements or machines of the kind which comprise a plurality of soil working members that are arranged in a row so as to be rotatable about corresponding non-horizontal axes, a drive transmission to the soil working members being located wholly or principally above those members. The term "implement(s) or machine(s)" is shortened to "implement(s)" alone for the sake of brevity in the remainder of this specification.

According to the invention, there is provided a soil cultivating implement of the kind set forth, wherein the drive transmission includes at least one non-horizontally disposed spring steel drive shaft, said drive shaft being arranged inside a tube and being rotatably supported at two spaced points by corresponding bearings, and wherein said tube is fastened to a frame portion of the implement which supports said plurality of soil working members thereof.

For a better understanding of the invention, and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:—

Figure 1 is a plan view of a soil cultivating implement in accordance with the invention, in the form of a rotary harrow, connected to the rear of an argicultural tractor,

Figure 2 is a side elevation as seen in the direction indicated by an arrow II in Figure 1,

Figure 3 is a section to an enlarged scale, taken on the line III—III in Figure 1,

Figure 4 is principally a section, to an enlarged scale, taken on the line IV—IV in Figure 1,

Figure 5 is a section, to an enlarged scale, taken on the line V—V in Figure 1,

Figure 6 is a section taken on the line VI—VI in Figure 5,

Figure 7 is a plan view illustrating an alternative soil cultivating implement in accordance with the invention, again in the form of a rotary harrow, connected to the rear of an agricultural tractor.

Figure 8 is a section, to an enlarged scale, taken on the line VIII—VIII in Figure 7,

Figure 9 is a section taken on the line IX—IX in Figure 8,

Figure 10 is a section taken on the line X—X in Figure 8,

Figure 11 is a rear elevation, to the same scale as Figure 8, illustrating an alternative soil working member to that which is shown in Figures 8 to 10 and the way in which it is mounted, and

Figure 12 is a section taken on the line XII—XII in Figure 11.

Referring to Figures 1 to 6 of the accompanying drawings, the rotary harrow that is illustrated therein as an example of a soil cultivating implement in accordance with the invention has a frame which includes a substantially horizontal beam 1 that extends transverse, and usually (as shown) substantially perpendicular, to the intended direction of operative travel of the harrow that is indicated in Figures 1 and 2, and also in Figure 7, of the drawings by an arrow A. The frame beam 1 has a polygonal cross-section which is preferably the square one that is illustrated in the drawings since that formation readily allows one flat external surface of the beam 1 to be horizontally or substantially horizontally disposed. Two beams 2 extend upwardly from the top of the beam 1 in gently convergent relationship at locations which are spaced by equal distances from the mid-point of the beam 1. The upper ends of the two beams 2 are rigidly interconnected by a beam 3 that extends substantially horizontally parallel to the beam 1. Two tie beams 4 diverge downwardly and rearwardly with respect to the direction A (see Figures 1 and 2 of the drawings) from locations that are adjacent to the opposite ends of the beam 3, the rearmost and lowermost ends of the beams 4 being rigidly secured to a frame beam 5 that is of substantially the same length as the frame beam 1 and that extends parallel or substantially parallel thereto at substantially the same horizontal level. The beam 5, like the beam 1, is of hollow formation and polygonal cross-section, the square cross-section that is illustrated in the drawings being preferred. It will be noted that the cross-sectional dimensions of the beam 5 are somewhat smaller than those of the beam 1 and that, when the preferred square cross-section that is illustrated is employed, said beam 5 is so disposed that one diagonal of its cross-section is substantially horizontal whilst the other is substantially vertical. Struts 6 strengthen the connections between the two tie beams 4 and the frame beam 5, said struts 6 being positioned at the relatively facing sides of the two tie beams 4 in the manner that is shown in Figure 1 of the drawings.

Two pairs of lugs 7 project rearwardly from the back of the frame beam 1 at locations which are spaced by equal distances from the mid-point of that beam, said distances being substantially equal to one quarter of the length of the beam 1 and thus being greater than are the distances by which the lower ends of the beams 2 are spaced from said mid-point. Openings in the two lugs 7 of each pair carry corresponding pivot pins 8 in such positions that the two pivot pins 8 are substantially horizontally aligned in a direction that is parallel or substantially parallel to the longitudinal axes of the beams 1, 3 and 5. The leading ends, with respect to the direction A, of corresponding carriers 9 are turnably mounted on the two pivot pins 8 between the two lugs 7 of the respective pairs, each carrier 9 being in the form of a bar or beam of channel-shaped cross-section that is disposed with its web or base lowermost and its limbs projecting substantially vertically upwards therefrom. The rearmost end of each carrier 9, with respect to the direction A, has the substantially vertically disposed limb of a corresponding plate 10 of inverted L-shaped cross-section welded or otherwise rigidly secured to it. The substantially horizontally disposed limb of each plate 10 projects rearwardly with respect to the direction A from the upper edge of the substantially vertical limb concerned and acts as a stop for co-operation with a corresponding stop 11 that is rigidly secured to the frame beam 5 at an appropriate position axially along the length of the latter. The bottom of each stop 11 has a corresponding lug 12 (Figure 3) rigidly secured to it so as to project forwardly therefrom to a location beneath the web or base of the respective channel cross-section carrier 9. Registering holes are formed in each lug 12 and the web or base of the corresponding carrier 9 where those two parts overlap and a bolt 13 is entered upwardly through the registering holes. A helical compression spring 15 is wound around the shank of each bolt 13 so as to bear between the upper surface of the web or base of the corresponding carrier 9 and a stop washer 14 that is mounted on said shank, towards the upper end thereof, in a position which is adjustable axially along the length of the bolt 13 by abutment against two co-operating lock nuts 16 that can be retained in desired axial positions along the length of the shank of the bolt 13 concerned. Clearly, the initial degree of compression of each spring 15 is dependent upon the position along the corresponding bolt shank that is adopted by the respective stop washer 14 after adjustment of the corresponding pair of lock nuts 16.

The bottom of each carrier 9 is releasably connected to a top cover plate 17 of a hollow box-section frame portion 18 that extends substantially horizontally parallel to the frame beam 1, 3 and 5 throughout most of the working width of the harrow. The hollow frame portion 18 has a substantially horizontally disposed bottom and substantially vertically disposed front and rear walls that are connected to the leading and rear edges of said bottom by obliquely inclined portions. The upper edges of the front and rear walls are bent over to form substantially horizontal outwardly directed rims, the top cover plate 17 of the frame portion 18 being releasably secured to said rims by a number of small bolts 19 appropriately positioned ones of which bolts 19 also releasably secure the frame portion 18, including its top cover plate 17, to the two carriers 9. Gasket strips 2 (Figures 4 and 5), are arranged between the rims of the hollow frame portion 18 and the edges of its top cover plate 17 to prevent leakage of lubricant from, and the penetration of dirt into, the interior of the frame portion 18.

The flat substantially horizontally disposed bottom of the hollow frame portion 18 is formed with a row of six circular holes whose centres are spaced apart from one another at regular intervals which preferably, but not essentially, have magnitudes of substantially 50 cms. Six substantially vertical, or at least non-horizontal, shafts 21 are entered upwardly through the six corresponding holes, each shaft 21 being formed, substantially mid-way along its axial length, with an enlarged diameter portion 22. Upper and lower ball bearings 23 surround each shaft 21 immediately above and beneath the corresponding portion 22, the outer races of the two ball bearings 23 of each pair being arranged in corresponding upper and lower bearing housings 27 and 24, respectively. Each lower bearing housing 24 has an upright rim which extends upwardly just into the corresponding circular hole in the bottom of the frame portion 18 and also includes a flange 25 that projects substantially radially outwardly away from said rim in parallel relationship with the bottom of the hollow frame portion 18 and abutting contact with the lower surface thereof. It will, however, be seen from Figures 4 and 5 of the drawings that each flange 25 includes an outer frusto-conical rim 26 that is of upwardly and inwardly tapering configuration, the junction between the upper edge of said rim and the integral outer edge of the planar flange 25, proper, having a diameter whose magnitude is substantially the same as the fore and aft width of the substantially flat bottom of the hollow frame portion 18. Each upper ball bearing 23 is located at substantially the top of the corresponding bearing housing 27, the bottom of that housing 27 being formed with a downwardly projecting cylindrical rim which is a close fit just inside the upright rim of the corresponding lower bearing housing 24. The lower circular edge of said rim of each upper bearing housing 27 abuts againnst the top of the outer race of the corresponding lower ball bearing 23. Each upper bearing housing 27 has a flange 28 close to its lower end, the lower surface of said flange being in contact with the upper surface of a bottom portion of a dished plate 29 that extends inside the hollow frame portion 18 throughout substantially the whole of the transverse length thereof. The lower surface of the bottom portion of the dished plate 29 bears against the upper surface of the bottom of the frame portion 18 and it will be seen from the drawings that substantially vertically disposed bolts 30 are entered through holes in each flange 26, the corresponding flange 28 and the intervening plate 29 and frame portion (18) bottom to fasten those parts securely, but releasably, to one another.

The dished plaate 29 acts to strengthen the frame portion 18 and its bottom portion, which is also flat, is bent over upwardly at locations which register with the front and rear edges of the flat bottom of the immediately underlying frame portion 18 to form obliquely upwardly extending portions that are inclined to the horizontal at a considerably larger angle than are the neighbouring oblique portions of the frame portion 18. The obliquely upwardly extending portions of the dished plate 29 are again bent over, at substantially the same horizontal level as the junctions between the upright front and rear walls of the frame portion 18 and the underlying oblique portions thereof, to form front and rear substantially horizontal portions that are in parallel or substantially parallel relationship with the top cover plate 17 of the frame portion 18. The free extreme leading and rear edges of the dished plate 29 are located very close to, but not actually in contact with, the internal surface of the front and rear walls of the hollow frame portion 18 (see Figure 5). Strengthening ribs 31 that are of substantially right-angled triangular configuration rigidly interconnect the upper surface of the flange 28 of each upper bearing housing 27 and the external surface of the curved wall of the main substantially cylindrical body of that housing 27.

A lower splined portion of each shaft 21 projects downwardly from beneath the corresponding lower bearing housing 24 and co-operates with the internally splined hub 32 of a carrier or support that is generally indicated by the reference 33, said carrier or support 33 forming a part of a corresponding rotary soil working member that is generally indicated by the reference 34. Each carrier or support 33 is provided with three tines 35 which are spaced apart from one another at regular 120° intervals around the longitudinal axis of the shaft 21 concerned. The upper end of each carrier hub 32 is located inside the bottom of the corresponding lower bearing housing 24 and actually abuts against the lower surface of the inner race of the co-operating lower ball bearing 23. Each such hub 32 is formed with a flange 36 at a level just beneath that of the bottom of the corresponding lower bearing housing 24, the outer edge of the circular flange 36 being integrally connected to the smaller diameter lower edge of a downwardly tapering frusto-conical rim 37. It will be seen from Figure 5 of the drawings that the upper free edge of each rim 37 is located in very closely spaced relationship with the lower edge of the corresponding non-rotary rim 26, said rims co-operating to form protective elements for fastening members, in the form of bolts 45, of the carriers 32 which bolts 45 will be referred to again below.

The lower end of each hub 32 is of upwardly tapering frusto-conical configuration and receives, with some clearance, a matchingly shaped upwardly recessed central portion of a corresponding locking plate 38. The recessed portion of each locking plate 38 accommodates the head of a fastening bolt 38A whose shank is screwed into a matchingly threaded axial bore in the lower splined portion of the corresponding shaft 21, said bore opening at the extreme lower end of that shaft 21. It will be seen from Figure 6 of the drawings that each locking plate 38 is of hexagonal shape having three longer sides of equal length and three shorter sides of equal length that are arranged in alternate relationship around the periphery of the plate. It is preferred, but is not essential, that the length of each longer side should be substantially twice that of each shorter side. Three pairs of inner and outer spring steel strips 39 and 40 are retained between the lower surface of each flange 36 and the upper surface of the corresponding locking plate 38. The two strips 39 and 40 of each pair lie alongside each other and each strip is so disposed that, as seen in cross-section, the longer parallel edges of that section are in parallel or substantially parallel relationship with the longitudinal axis of the corresponding shaft 21. The two strips 39 and 40 of each pair are angularly bent to form brackets, said strips thus having central rectilinear webs or bases 41 and 42, respectively, from the opposite ends of which webs or bases project outwardly divergent rectilinear limbs 43, and rectilinear limbs 44, respectively. The webs or bases 41 and 42 are integrally connected to the limbs 43 and 44 by sharp bends that have angular magnitudes of substantially 150°. It will be seen from Figure 6 of the drawings that the webs or bases 41 and 42, the limbs 43 and 44 and the longer sides of the locking plates 38 are all of substantially the same length.

The pairs of strips 39 and 40 are arranged around each hub 32 in such a way that the webs or bases 41 of the three inner strips 39 bear tangentially against the outer surface of that hub 32 whilst each pair of rectilinear limbs 43 and 44 projects substantially radially outwardly with respect to the longitudinal axis of the corresponding shaft 21 in abutting engagement with a second pair of rectilinear limbs 43 and 44, it being the two inner limbs 43 concerned that actually make surface-to-surface contact with one another. The three groups that each comprise two limbs 43 and two limbs 44 thus project substantially radially with respect to the longitudinal axis of the corresponding shaft 21 at substantially 120° intervals around that axis. One of the aforementioned tines 35 is firmly but releasably mounted at the radially outer end of each of the three limb groups or arms, that has just been described, of each carrier or support 33, the three tines 35 of each rotary soil working member 34 thus also being spaced apart from one another at substantially 120° intervals around the longitudinal axis of the shaft 21 concerned. Each of the carriers or supports 33 is provided with six of the aforementioned bolts 45 and it will be seen from Figure 6 of the drawings that said bolts 45 are positioned at the sharp angular bends between the opposite ends of the webs or bases 42 of the outer strips 40 and the radially inner ends of the corresponding rectilinear limbs 44. Once the bolts 45 are tightened, the spring steel strips 39 and 40 are reliably, but readily releasably, retained in their appointed positions.

The rectilinear limbs 43 of the inner strips 39 are, in fact, a little shorter in length than are the rectilinear limbs 44 of the outer strips 40, the two limbs 44 of each group of four limbs being curved towards one another at their free ends where they project short distances beyond the adjacent free ends of the co-operating limbs 43. Spaces are thus produced which form parts of holders for fastening portions 46 of the tines 35. Each holder also comprises an upper clamping plate 47 and a lower clamping plate 48. Each upper clamping plate 47 has a downwardly directed rim and each lower clamping plate 48 has an upwardly directed rim, said rims embracing the curved outer end regions of the corresponding limbs 44 so as to subtend an angle of not less than substantially 180° at the longitudinal axis of the corresponding tine fastening portion 46. It will be seen from the foot of Figure 6 of the drawings that each pair of clamping plates 47 and 48 actually extends radially inwardly towards the corresponding shaft 21 to a location that is just inwards of the extreme outer free ends of the two limbs 43 of the corresponding limb group. Each upper clamping plate 47 has a substantially central opening that is formed with a downwardly tapering frusto-conical wall which is arranged to co-operate with a matchingly tapered frusto-conical portion of a fastening nut 49 that is mounted on a screwthreaded upper end part of the fastening portion 46 of the corresponding tine 35. The lower clamping plate 48 of each pair of plates 47 and 48 also has a central aperture which is surrounded, through more than 180°, by a downwardly projecting rim 50. The rim 50 is formed with two diametrically opposed notches or grooves 51 each of which receives a corresponding lug or tooth 52 that is formed integrally on the fastening portion 46 of the corresponding tine 35 at a location that is at, or near to, the lowermost end of said portion 46. The aperture in each lower clamping plate 48 has the fastening portion 46 of the corresponding tine 35 entered upwardly through it when the rotary soil working member 34 concerned is assembled and said aperture has an upwardly directed wall that co-operates with a shoulder 53 formed on the corresponding tine 35 near the lowermost end of this fastening portion 46, said wall also embracing lower edge regions of the two outer strips 40 of the corresponding group of four strips 39 and 40 in such a way that the plate 48 cannot turn about the longitudinal axis of the corresponding tine fastening portion 46. Thus, when each fastening nut 49 is tightened, the co-operation between the corresponding lugs or teeth 52 and the notches or grooves 51 in the respective lower clamping plate 48 prevents the tine 35 concerned from turning about the axis of its fastening portion 46 in its holder.

The lower end of the shoulder 53 of each tine 35 makes an integral junction with a soil working portion 54 of that tine. Both the fastening portion 46 and the soil working portion 54 of each tine 35 are straight but said two portions are relatively inclined in such a way that an angle of substantially 8° is enclosed between their longitudinal axes at the integral junction of the two portions. For most harrowing and cultivating purposes, the tines 35 are so disposed in their holders that the soil working portions 54 thereof trail rearwardly from top to bottom with respect to the intended directions of operative rotation of the corresponding soil working members 34. A lower region of the soil working portion 54 of each tine 35, which region comprises a major part of the length of said portion 54, tapers downwardly towards the lowermost free end or tip of the portion 54 and has a substantially rhombic cross-section, the longer diagonal of the substantially rhombic cross-section being in substantially tangential relationship with an inmaginary circle that is centred upon the axis of rotation of the corresponding soil working member 34. The leading and rear corners of the substantially rhombic cross-section region of each tine portion 54 are shaped to form ribs and the four what would otherwise be flat sides of each such region are formed throughout major portions of their widths with grooves that extend lengthwise of said regions of the portions 54 to the lowermost free ends or tips thereof.

Each shaft 21 is formed with splines throughout the length thereof that extends above the corresponding enlarged diameter portion 22 and said splines co-operate with the internally splined hub of a corresponding straight-toothed or spur-toothed pinion 55. The lower end of the hub of each pinion 55 abuts against the top of the inner race of the corresponding upper ball bearing 23, all of the six pinions 55 that are provided in the example which is being described being located wholly inside the hollow frame portion 18 at a level just beneath the top cover plate 17 thereof. Between each neighbouring pairs of shafts 21, two further substantially vertical, or at least non-horizontal, shafts 56 are provided, said shafts 56 being in parallel relationship with the shafts 21 and the longitudinal axes of all of said shafts 21 and 56 being contained in a common vertical or substantially vertical plane that is substantially perpendicular, or at least transverse, to the direction A. The two shafts 56 of each pair are spaced apart from one another by the same distance and each shaft 56 is spaced from the nearest shaft 21 by the same distance, the latter distance being, however, greater than the distance between the two shafts 56 of each pair themselves. Each shaft 56 is rotatably mounted in ball bearings (not visible) that are carried by corresponding bearing housings 56A (Figure 4) that are secured to the frame portion 18. Each shaft 56 has mounted on it, by way of interengaging splines, a corresponding straight-toothed or spur-toothed pinion 57, all of the pinions 57 being of the same effective diameter which is half the effective diameter of each of the larger pinions 55. As can be seen in Figures 1 and 4 of the drawings, the row of single pinions 55 and alternating pairs of pinions 57 is so arranged that the teeth of each pinion in said row are in meshing engagement with those of the immediately neighbouring pinion, or those of both of the two immediately neighbouring pinions, in said row. The arrangement is such that each pinion 55, together with the corresponding shaft 21 and soil working member 34, will revolve, during the use of the rotary harrow, in a direction that is opposite to the direction of rotation of the next pinion 55, shaft 21 and member 34 along said row, these intended directions of operative rotation being indicated by small arrows in Figure 1 of the drawings.

It can be seen in Figure 5 of the drawings that the upper end of each shaft 21 is located in very closely spaced relationship beneath the bottom of a corresponding shallow depression that is formed in the top cover plate 17 of the frame portion 18. The upper ends of the hubs of the pinions 55 are similarly spaced from the bottoms of said depressions, the latter thus acting to prevent the pinions 55 from being displaced upwardly along the shafts 21 to any significant extent. However, any pinion 55 can readily be removed from its shaft 21, when required, merely by temporarily taking off the top cover plate 17. One of the centre pair of six shafts 21 has an upward extension though a hole in the top cover plate 17 (see Figure 4) and projects axially into the lower end of a substantially vertical, or at least non-horizontal, tube 58. The lower end of the tube 58 is welded or otherwise rigidly secured in a hole in a plate 59 that is fastened to the top cover plate 17 of the hollow frame portion 18 in flat abutting relationship with that cover plate 17. An obliquely disposed bracing strip 59A has its opposite ends welded to the top of the plate 59 and to one side of the tube 58 and thus considerably strengthens the perpendicular connection between those parts. The upward extension of one of the shafts 21 that can be seen in Figure 4 of the drawings is splined and said splines co-operate with matching splines inside a socket 59B. The upper end of the socket 59B is a force fit on the lower end of a torsionally deformable spring steel shaft 60 whose diameter, in the example that is being described, is substantially 35 mms and whose axial length is substantially 600 mms. An upper end region of the shaft 60 projects axially above the upper end of the surrounding tube 58, said region being provided, again by force fitting, with a surrounding sleeve 61. In fact, the sleeve 61 surrounds the upper region of the shaft 60 between a level that is just beneath the top of the tube 58 and a level that is marginally beneath the extreme upper end of the shaft 60. The sleeve 61 is surrounded, towards its lower end, by the inner races of a pair of closely neighbouring ball bearings 62, the outer races of the same ball bearings 62 being received in a surrounding housing 63. The bottom of the housing 63 abuts against the upper surface of a flange 64 that is welded to the upper end of the tube 58. A lower end region of the sleeve 61 is screw-threaded and receives a nut 65 against the upper surface of which abuts the lower end of the inner race of the lower one of the two ball bearings 62. The outer edge of a circlip 66 is received in a groove in the internal wall of the bearing housing 63 and said circlip 66 lies between the outer races of the two ball bearings 62 in contact with both those outer races. The upper ball bearing 62 projects by a short distance above the top of the bearing housing 63.

The top of the bearing housing 63, and thus part of the upper ball bearing 62, is located just inside an opening in the bottom of a flat casing of a change speed-gear 67. Said casing comprises lower and upper portions 69 and 70 that are of substantially symmetrically identical formation except for the provision, in the lower portion 69, of openings one of which has already been mentioned above. The upper portion 70 is releasably secured to the lower portion 69, at inter-engaging marginal rims of said two portions, by wing nuts 68, a synthetic plastics or other gasket 71 being sealingly sandwiched between the inter-engaging rims when the wing nuts 68 are tightened. Substantially vertically disposed bolts 72 firmly but releasably secure a lower substantially horizontal wall of the lower portion 69 of the change-speed gear 67 to the flange 64 at the upper end of the tube 58, a spacing and screening ring 73 being arranged around the bolts 72 between the periphery of the flange 64 and the underneath surface of said lower wall of the change-speed gear portion 69. There are several of the bolts 72, said bolts being arranged around the external surface of the bearing housing 63 in closely spaced apart relationship with that surface.

The external surface of the sleeve 61 is provided, inside the change-speed gear 67, with axially extending splines and said splines are arranged to co-operate with matching splines in the hub of a straight-toothed or spur-toothed pinion 74. The teeth of the pinion 74 that is located inside the change-speed gear 67 are in driven mesh with those of a second smaller straight-toothed or spur-toothed pinion 75 whose hub co-operates, by way of inter-engaging splines, with a sleeve 76 that tightly surrounds an upper end region of a driving shaft 77 which extends downwardly from the interior of the change-speed gear 67 through an opening in the bottom wall of the lower portion 69 of that gear 67 in parallel relationship with the torsionally deformable spring steel shaft 60. The bottom of the hub of the pinion 75 bears against the top of a spacing ring 78 that surrounds the driving shaft 77, the bottom of the spacing ring 78 abutting, in turn, against the top of the inner race of a ball bearing 79 which race surrounds the lower end of the sleeve 76. The ball bearing 79 is accommodated in a housing 80 that surrounds its outer race, the upper end of the housing 80 fitting in a second aperture in the bottom wall of the lower portion 69 of the change-speed gear 67. The bottom of the bearing housing 80, which has an internal lip for co-operation with the outer race of the ball bearing 79, abuts against the upper surface of a flange 81 that is welded or otherwise rigidly secured to the upper end of a tube 82 that projects downwardly from substantially the level of the bottom of the housing 80 in concentrically surrounding relationship with a major portion of the length of the driving shaft 77. However, the tube 82 has a considerably shorter axial length than does the tube 58, the lower end of the tube 82 being disposed at a level above that of the midpoint of the tube 58. A spacing and screening ring 84 extends between the periphery of the flange 81 and the underneath surface of the bottom of the lower portion 69 of the change-speed gear 67, a number of substantially vertically disposed bolts 83 that are located radially inwardly of the ring 84 being provided to clamp the flange 81 firmly but releasably to the change-speed gear 67. The bolts 83 and spacing ring 84 are arranged in the same general manner relative to the bearing housing 80 as are the previously described bolts 72 and ring 73 relative to the bearing housing 63, the axial length of the parts 80, 83 and 84 being, however, considerably less than the axial length of the parts 63, 72 and 73.

The lower end of the tube 82 is welded or otherwise rigidly secured into a hole in the top of a substantially horibontally disposed support 85. One side of the support 85 is welded or otherwise rigidly secured to the external surface of the tube 58 at a level which is a short distance above that of the mid-point of that tube. The support 85 is thus in parallel or substantially parallel relationship with the plate 59 that lies at some distance beneath it. That side or edge of the support 85 which is remote from the tube 58 is bent over through 90° to form a downwardly extending portion whose lowermost edge is welded or other wise rigidly secured to the upper surface of the plate 59 close to the edge of the latter. The extreme lowermost end of the tube 82 is entered, just beneath the support 85, into a hole in the substantially flat top 87 of a gear box 88. An underlying substantially trough-shaped portion 89 of the gear box 88 is secured to its top 87, and to the overlying support 85, by a number of substantially vertically disposed bolts 86 and it will be seen from Figure 4 of the drawings that the lowermost end of the driving shaft 77 projects downwardly beneath the coresponding end of its surrounding tube 82 into the interior of the gear box 88 where it is splined to carry a bevel pinion 90. The matchingly splined hub of the bevel pinion 90 has an uppermost portion of reduced diameter around which is arranged the inner race of a ball bearing 91. The outer race of the same ball bearing 91 is arranged in a housing 92 that is in the form of a downwardly projecting portion of the top 87 of the gear box 88. A circlip 93 whose inner edge is engaged in a groove that is formed in the driving shaft 77 very close to the lowermost end of that shaft retaining the bevel pinion 90 in its appointed axial position on the splined region of the shaft 77, the teeth of the pinion 90 that are, at any instant, at the rear of the pinion with respect to the direction A (see Figure 2), being in driven mesh with those of a bevel pinion 94 which is of smaller size than the bevel pinion 90. The hub of the bevel pinion 94 is keyed to a rotary input shaft 95 that extends substantially horizontally parallel to the direction A through the gear box 88 to project beyond both the front and rear walls of that gear box. The projecting ends of the shaft 95 are splined and the leading projecting end can be placed in driven connection with the rear power take-off shaft of an agricultural tractor or other operating vehicle through the intermediary of a telescopic transmission shaft 96, which is of a construction that is known *per se*, having universal joints at its opposite ends. The splined rearwardly projecting end of the shaft 95 can be used as a source of rotary power for the moving parts of some other tool, implement or machine that may be disposed behind the rotary harrow with respect to the direction A for use in combination, or conjunction, with that harrow. It will have been noted that the upper portion 70 of the change-speed gear 67 can readily be removed from the lower portion 69 thereof merely by temporarily releasing the wing nuts 68. The two pinions 74 and 75 are of different sizes and thus provide a corresponding transmission ratio between the driving shaft 77 and the torsionally deformable spring steel shaft 60. The two pinions 74 and 75 can be interchanged in position on the sleeves 61 and 76 that correspond to the two shaft 60 and 77 and, moreover, at least one other pair of co-operating pinions that are similar to the pinions 74 and 75, except as regards their sizes, is preferably provided. Thus, the transmission ratio between the shaft 77 and the shaft 60 will depend upon the particular pair of pinions that is chosen for use in the change-speed gear 67 and the particular arrangement thereof that is selected on the splined sleeves 61 and 76. The speed at which the soil working members 34 will revolve can thus be increased, or decreased, as may be desired without having to change the speed of driving rotation that is applied to the forwardly projecting end of the rotary input shaft 95. The speed of rotation that is chosen will usually depend upon the nature and condition of the soil that is to be dealt with and the particular purpose for which that soil is required after treatment.

Two downwardly projecting lugs 97 are provided at the opposite ends of the frame beam 1 and each lug has a corresponding arm 99 pivotally connected to it by a respective pin 98, the two pivot pins 98 being substantially horizontally aligned in a direction that is parallel to the length of the frame beam 1. The arms 99 extend generally rearwardly with respect to the direction A from the corresponding pivot pins 98 and each of them is formed, at some distance in front of the rearmost end thereof, but behind the frame portion 18 with respect to the direction A, with a hole for the reception of a corresponding substantially horizontally disposed bolt 100. Strips 102 project downwardly towards the ground from the opposite ends of the rear frame beam 5 and each strip is formed with a corresponding curved row of holes 101, all of the holes 101 being equidistant from the substantially horizontal axis that is defined by the pivot pins 98. The holes in the arms 99 that have been mentioned above are at the same distance from said axis and the bolts 100 can therefore be entered through the holes in the arms 99 and chosen one of the holes 101 in the corresponding rows by turning the arms 99 upwardly or downwardly, as may be required, about the respective pivot pins 98. Once the bolts 100 are tightened, the arms 99 are retained firmly and reliably in corresponding angular settings about the axis that is defined by the pivot pins 98. A combined supporting member and soil crumbling member of the rotary harrow in the form of a ground roller 103 of open cagelike construction is mounted in a freely rotatable manner between substantially horizontally aligned bearings that are carried at the extreme rearmost ends of the two arms 99, the substantially horizontal axis of rotation of the roller 103 thus being parallel to the frame beams 1, 3 and 5 and substantially perpendicular, or at least transverse, to the direction A. The roller 103 comprises a central axially extending support shaft, that is preferably of tubular construction, to which support shaft a plurality, such as five, of circular support plates 105 are secured at regularly spaced apart intervals along the length of the roller, two of the support plates 105 being located very close to the opposite axial ends of said roller 103. The support plates 105 are substantially vertically disposed in parallel relationship with one another and parallel or substantially parallel relationship with the direction A. Each support plate 105 is formed close to its edge with a plurality, such as eight, of holes that are regularly spaced apart from one another around the longitudinal axis of the roller 103. A corresponding number of elongate elements 104, that are formed from solid rod-shaped or tubular material, are entered lengthwise through the holes in the plates 105 so as to extend helically around the axis of rotation of the roller 103 throughout substantially the whole of the axial length of that roller.

Each arm 99 carries a corresponding protective member in the form of a shield 106 that extends throughout very nearly the whole of the length of the arm 99 concerned and that is afforded by a substantially vertically disposed plate that is in parallel or substantial parallel relationship with the direction A. Each shield 106 has a straight substantially horizontally disposed lower or bottom edge which is preferably in the form of a rim (not visible) that is arranged to slide forwardly over the ground surface, usually with some penetration into that surface, in the direction A. The leading end of the straight lower edge or rim joins the lower end of an upwardly and forwardly curved edge whose convex side faces forwardly with respect to the direction A. The rear end of each lower edge or rim, however, makes an angular junction with an upwardly and rearwardly directed straight edge which terminates alongside the bottom of the corresponding arm 99. It is readily apparent from Figure 2 of the drawings that the vertical extent of each shield 106 is greater towards the front thereof, with respect to the direction A, than it is towards the rear thereof.

Pairs of lugs 107 project downwardly from the lower surface of the frame beam 1 at positions which substantially register with the lower ends of the two beams 2 that converge upwardly away from the top of the beam 1. Substantially horizontally aligned pivot pins 108 releasably interconnect the two lugs 107 of each pair and are arranged to have the free ends of the lower lifting links of a three-point lifting device or hitch at the rear of an agricultural tractor or other operating vehicle connected to them in the generally known manner which is shown diagrammatically in Figures 1 and 2 of the drawings. It is noted that the axis which is defined by the pivot pins 108 is coincident, or substantially coincident, with the axis that is defined by the pivot pins 98. Two lugs 109 project upwardly from the top of the frame beam 3 at a location midway along the transverse length of the latter and are arranged to have the rear end of the upper lifting link of a three-point lifting device or hitch pivotally coupled to them by a releasable substantially horizontally disposed pivot pin 110 by which they are interconnected.

In the use of the rotary harrow which has been described, the lugs 107 and 109 and the pivot pins 108 and 110 are employed in connecting the frame to the three-point lifting device or hitch of an agricultural tractor or other operating vehicle and the known telescopic transmission shaft 96 that has universal joints at its opposite ends is used to place the rear power take-off shaft of the same tractor or other vehicle in driving connection with the forwardly projecting end of the rotary input shaft 95. The speed at which the soil working members 34 will revolve in response to a substantially constant applied driving speed of rotation is adjusted, if required, before work commences by appropriately positioning the pinions 74 and 75, or an alternative pair of pinions of different sizes, in the change-speed gear 67. The maximum depth to which the tines 35 of the soil working members 34 can penetrate into the ground is adjusted, if required, by turning the arms 99 upwardly or downwardly about the pivot pins 98, employing the bolts 100 to maintain the chosen setting. This adjustment determines the level of the axis of rotation of the roller 103 relative to that of the frame portion 18 which frame portion, of course, supports the rotary soil working members 34. As the harrow moves operatively in the direction A over land that is to be cultivated, the soil working members 34 are driven in the directions that are indicated by the arrows in Figure 1 of the drawings through the drive transmission that is contained in the hollow frame portion 18, the change-speed gear 67 and the gear box 88, it being particularly noted that the drive between the change-speed gear 67 and the parts that are contained within the hollow frame portion 18 comprises substantially only the torsionally deformable spring steel shaft 60. The effective working diameter of each member 34 is a little greater than is the spacing between the longitudinal axes of immediately neighbouring shafts 21 so that, durng operation, the neighbouring contra-rotating members 34 work individual strips of land that overlap one another to form, in effect, a single broad strip of worked soil. The rotary harrow that has been described is particularly suitable for use in cultivating land which contains an above average quantity of stones and, possibly, other hard objects. If such a stone or other hard object should become momentarily jammed between any of the rapidly moving tines 35, the spring steel strips 39 and 40 of the corresponding carriers or supports 33 can deflect resiliently thus allowing the tines 35 concerned to yield resiliently through short distances in directions that are substantially tangential to imaginary circles that are centred upon the axes of rotation of the corresponding shafts 21. Any momentarily jammed stone will therefore almost always be released without causing any significant damage. Another precaution against damage to the soil working members 34 and the transmission parts within the hollow frame portion 18 resides in the inclusion in the drive transmission of the torsionally deformable spring steel shaft 60. Finally, it is noted that the whole frame portion 18, together with the soil working members 34, the change-speed gear 67 and the gear box 88 can tilt upwardly relative to the frame beams 1, 3 and 5 about the axis that is defined by the substantially horizontally aligned pivot pins 8 against the action of the compression springs 15 which tend normally to maintain the frame portion 18 in the illustrated position in which the rear ends of the webs or bases of the two carriers 9 bear downwardly against the upper surfaces of the two lugs 12. This provision for upward deflectability of the frame portion 18 and the parts which it carries is particularly advantageous in the event of the tines 35 of one or more of the members 34 coming into contact with rocks or other obstacles that are quite deeply buried in the soil that is to be cultivated. The single substantially horizontal axis that is defined by the pivot pins 8 is, it will be noted from Figures 1 and 2 of the drawings, in advance of both the frame portion 18 and the soil working members 34 with respect to the direction A. The vertically or substantially vertically disposed plates that afford the shields 106 which are connected to the two arms 99 co-operate with the tines 35 of the two soil working members 34 that are located at the opposite ends of the row of those soil working members and ensure that the soil at the margins of the broad strip of ground that is worked by the harrow is efficiently crumbled to substantially the same extent as is soil which lies closer to the centre of that strip. When the arms 99 are displaced upwardly or downwardly to change the maximum working depth of the tines 35 of the soil working members 34, the two shields 106 are moved upwardly or downwardly with said arms 99 and thus automatically match the newly established maximum working depth of the tines 35. The rotary harrow which has been described is constructed and arranged to provide a particularly effective protection against bending or breakage of the tines 35, damage to the fastening portions 46 of those tines and the holders in which they are releasably secured, and overloading of the parts of the drive transmission which rotate the soil working members 34 when the harrow is in use. The provision of these protective measures is particularly important when the rotary harrow is to be used in the cultivation of soil which contains a larger than usual proportion of stones.

Figures 7 to 10 of the drawings illustrate a further soil cultivating implement in accordance with the invention, in the form of a rotary harrow, and it is particularly noted that many of the parts of the harrow of Figures 7 to 10 of the drawings are similar, or identical, to parts that have already been described above in connection with the embodiment of Figures 1 to 6 of the drawings. Accordingly, such parts are indicated in Figures 7 to 10 by the same references as are used in Figures 1 to 6 and will not be described in detail again. The rotary harrow of Figures 7 to 10 of the drawings comprises six rotary soil working members 111 and, as will become apparent below, the drive transmission to those members 111 is different in several respects to the transmission that has already been described above. Each rotary soil working member 111 is driven through the intermediary of a corresponding torsionally deformable spring steel shaft 112, there being six of the members 111 in the example that is being described so that there are thus six of the shafts 112. The upper end of the six shafts 112 are contained inside a hollow box-section frame portion 113 that is very similar to the previously described frame portion 18, said frame portion 113 being closed from above by a top cover plate 113A. The shafts 112 are of greater length than the shafts 21 of the first embodiment, it being preferred that each shaft 112 should have a length of substantially 30 millimetres. Part of the length of each shaft 112 extends coaxially through a surrounding tube 114 that projects upwardly through a corresponding hole in the flat bottom of the frame portion 113 for a short distance into the interior of that frame portion. A flange 115 is welded or otherwise rigidly secured to each tube 114 towards the upper end thereof and said flange 115, which is in perpendicular relationship with the longitudinal axis of the tube 114, is releasably secured by bolts 116 to the lower surface of the flat bottom of the hollow frame portion 113. The connection between each tube 114 and the corresponding flange 115 is strengthened by the provision of three obliquely disposed struts 117 whose opposite ends are welded, or otherwise rigidly secured, to the outer curved surface of the tube 114 and the lower surface of its flange 115. The struts 117 are, of course, angularly spaced apart from one another around the longitudinal axis of each tube 114. Each torsionally deformable spring steel shaft 112 extends upwardly into the interior of the hollow frame portion 113 to a level that is well above that of the upper end of the corresponding tube 114, the upwardly projecting portion of each shaft 112 being surrounded by a corresponding sleeve 118 that is a very tight force fit on the shaft. Each sleeve 118 is surrounded, towards its lower end, by the inner race of a corresponding ball bearing 119, the lower end of said inner race abutting against the upper surface of a small shoulder or flange of the sleeve 118. The outer race of each ball bearing 119 is supported from beneath by the upper end of a corresponding ring 120 which ring surrounds the upper end of the corresponding tube 114 that is located inside the hollow frame portion 113. Each ball bearing 119 and the corresponding tube 120 are located inside a corresponding bearing housing 121, said housing 121 having a flange 122 at its lower end and said flange being releasably secured to the bottom of the frame portion 113 and to the flange 115 of the corresponding tube 114 by the previously mentioned bolts 116.

A dished plate 123 extends throughout substantially the whole of the transverse length of the hollow frame portion 113 and has a flat bottom whose lower surface bears against the upper surface of the flat bottom of the frame portion 113 itself. Said bottom of the dished plate 123 is sandwiched by the bolts 116 between the flanges 122 of the bearing housings 121 and the upper surface of the bottom of the frame portion 113. The bottom of the dished plate 123 is, of course, formed with holes which register with the holes in the frame portion 113 that receive the upper ends of the tubes 114 and it will be seen from Figure 8 of the drawings that, just in front of, and behind, with respect to the direction A, the leading and rear extremities of the housing flanges 122, said plate 123 is bent over to form obliquely upwardly divergent front and rear edge portions. As in the case of the previously described dished plate 29, the dished plate 123 serves to increase the rigidity of the laterally elongate hollow frame portion 113. The upper end of each sleeve 118 is externally splined and co-operates with matching internal splines in the hub of one of the aforementioned straight-toothed or spur-toothed pinions 55, the lower end of said hub bearing downwardly against the upper end of the inner race of the corresponding ball bearing 119. As can be seen in outline in Figure 7 of the drawings, there are again six of the pinions 55 arranged in a row with each pair of neighbouring pinions 55 in the row spaced apart from one another by two of the previously described pinions 57. The pinions 55 are prevented from becoming axially displaced upwardly along the splines of the corresponding sleeves 118 by circlips 124 whose inner edges are engaged in grooves formed in the splined portions of the sleeves 118 very close to the uppermost ends of those sleeves.

The torsionally deformable spring steel shafts 112 project downwardly from beneath the lower ends of the correspondng surrounding tubes 114, said projecting lower ends being surrounded by corresponding sleeves 125 which sleeves are a very tight force fit upon their shafts 112. A shouldered upper end region of each sleeve 125 is surrounded by the inner race of a corresponding ball bearing 126, the outer race thereof being accommodated in a bearing housing 127 which has a rim that is clamped to an overlying flange 129 by a series af substantially vertically disposed bolts 128. Each flange 129 is welded or otherwise rigidly secured to the external curved surface of the corresponding tube 114 at substantially the lowermost end of that tube. The bolts 128 also releasably secure corresponding rings 130 to the bearing housings 127 in surrounding relationship with those bearing housings. Each ring 130 has an outer upwardly tapering frusto-conical rim 131. Each sleeve 125 is provided, beneath the shouldered portion thereof that co-operates with the corresponding ball bearing 126, with external splines that extend downwardly to its lowermost end, said splines co-operating with the internally splined hub 132 of a carrier or support 133 of the rotary soil working member 111 concerned. Each hub 132 is firmly but releasably maintained in its appointed axial position on the corresponding splined sleeve 125 by a bolt 135 and co-operating washer 134, the screw-threaded shank of the bolt 135 being entered into a matchingly threaded axial bore of the respective shaft 112 and said washer 134 and the head of the bolt 135 being located inside a recess at the bottom of their co-operating hub 132. The upper end of each carrier hub 132 is of reduced external diameter and extends into the mouth of the corresponding bearing housing 127 with which it co-operates by way of a diagrammatically illustrated lubricant seal. Said upper end actually abuts against the lower surface of the inner race of the corresponding ball bearing 126. Each carrier hub 132 is formed, just beneath the mouth of the corresponding bearing housing 127, with a radially extending flange 136 whose outer edge integrally includes a downwardly tapering frusto-conical rim 137 whose free upper edge is in very closely spaced apart relationship with the free lower edge of the non-rotary rim 131 of the corresponding ring 130. The co-operating rims 131 and 137 thus afford protective elements for parts which include the ball bearings 126 at the lower ends of the corresponding tubes 114.

Each carrier or support 133 includes three supporting brackets 138 that are spaced apart from one another around the axis of the corresponding shaft 112 by angles of 120°. Each bracket 138 projects outwardly and upwardly at an angle of substantially 45° to the longitudinal axis of the corresponding shaft 112 from substantially the lower end of the hub 132 concerned so that, as seen in side elevation (Figure 8), each carrier or support 133 is principally of downwardly tapering configuration. Each supporting bracket 138 comprises an obliquely disposed supporting surface that is located between two shallow limbs 139, said limbs 139 being contained in corresponding substantially parallel, and substantially vertically disposed planes that are spaced apart from one another. The supporting surface of each bracket 138 has the fastening portions of corresponding upper and lower strip-shaped spring steel tines 141 and 142 clamped to it, in overlapping relationship, by a bolt 140 in such a way that said fastening portions are prevented from turning about the axis of that bolt 140 by the limbs 139 of the bracket 138 concerned. As can be seen at the right-hand side of Figure 8 of the drawings and in Figure 10 thereof, it is the fastening portion of each upper spring steel tine 141 that actually abuts against the supporting surface of the corresponding bracket 138 whilst the fastening portion of the associated lower tine 142 abuts against the outwardly and downwardly facing surface of the fastening portion of the companion tine 141. Each upper spring steel tine 141 has a soil working portion that is substantially coplanar with the fastening portion of the same tine, said soil working portion being bent over through substantially 45° at its upper end to form an upper end portion that is in parallel or substantially parallel relationship with the longitudinal axis of the corresponding shaft 112. The upper end portion has a length which is substantially one-quarter of the length of the obliquely disposed remainder of the same soil working portion. Each upper end portion is shaped to form an inverted substantially V-shaped point or tip at its uppermost extremity. Each lower spring steel tine 142 has a soil working portion which initially, for a very short distance, extends in downwardly and radially inwardly inclined coplanar relationship with the respective fastening portion. However, said soil working portion is then curved downwardly and outwardly in a substantially uniform manner to terminate in a substantially radially outwardly directed end portion which is in perpendicular or substantially perpendicular relationship with the axis of rotation of the shaft 112 to which the member concerned is releasably secured. It can be seen in Figure 10 of the drawings that said end portion of each lower spring steel tine 142 is brought to a substantially V-shaped point or tip at its free extremity. The spring steel strips from which the tines 141 and 142 are made are of substantially oblong cross-section throughout their lengths.

One of the centre pair of shafts 112 of the row of six such shafts has an upward extension through the top cover plate 113A of the hollow frame portion 113 into a gear box 143 that is releasably mounted on top of said plate 113A by some of the bolts 19. A bevel pinion (not visible) that is carried by the upward extension of the shaft 112 that has just been mentioned places that shaft in driven connection, by way of a further bevel pinion (not visible) with a shaft (also not visible) that extends substantially horizontally parallel to the direction A inside the gear box 143. The rearmost end of the last mentioned shaft and a rear end portion of a parallel rotary input shaft 145 project through the back of the gear box 143 into a change-speed gear 144 that is secured to the rear of the gear box 143 with respect to the direction A. Although differently disposed, the change-speed gear 144 has the same function as the previously described change-speed gear 67 in the first embodiment and is thus employed to change the transmission ratio between the input shaft 145 and all of the shafts 112 so that the rotary soil working members 111 can be driven at different speeds without having to change the speed at which the shaft 145 itself is driven from the power take-off shaft of the agricultural tractor or other operating vehicle by way of the known telescopic transmission shaft 96 that has universal joints at its opposite ends. It can be seen in Figure 7 of the drawings that, in fact, the rotary input shaft 145 also projects through a rear cover of the change-speed gear 144 where it is splined or otherwise keyed to enable it to be used, when required, for the same purpose as the rear end of the input shaft 95 that has already been described with reference to the first embodiment.

In use of the rotary harrow that has been described with reference to Figures 7 to 10 of the drawings, its soil working members 111 are driven from the power take-off shaft of an agricultural tractor or other operating vehicle in the directions that are indicated by small arrows in Figure 7 of the drawings, each member 11 thus revolving in the opposite direction to its neighbour in the row of six such members or to the direction of rotation of both its neighbours in that row. The torsional deformability of the six shafts 112 by which the six members 111 are individually driven provides a degree of resilient yieldability in the transmission of rotation to each member 111 which is sufficient to allow stones and other hard objects that may become momentarily jammed between two or more of the tines 141 and 142 to be released without causing a breakage or any significant damage. The tines 141 and 142 are, in any case, themselves made from spring steel strips of oblong cross-section and their soil working portions are therefore yieldable in directions which are substantially perpendicular to the broader surfaces of said strips. This resilient yieldability of the tines 141 and 142 provides further insurance against breakage or significant damage in the event of momentary jamming of a stone or other hard object. The provision of the torsionally deformable shafts 112 in the drive to the members 111 and the furnishing of those members with spring steel tines 141 and 142 has a favourable effect upon the soil crumbling action of the soil working members 111, particularly when the rotary harrow is dealing with wet and/or heavy soil. When the harrow is in operation, the lower ball bearings 126 for the shafts 112 will almost always be disposed beneath ground level but contamination of the bearings 126 is very greatly minimised, if not entirely prevented, by the protective screening effect of the co-operating non-rotary rims 131 and rotary rims 137. An upper top soil layer is cultivated by the soil working portions of the upper spring steel tines 141 whereas a lower top soil layer and/or a layer of subsoil is cultivated by the soil working portions of the tines 142. It will be noted from Figures 8 and 9 of the drawings that the working diameter of the upper tines 141 of each member 111 is the same, or substantially the same, as the working diameter of the lower tines 142 of the same member since the tips at the free ends of the lower tines 142 of each member 111 are substantially in register with the tips of the upper ends of the corresponding upper tines 141 in directions that are parallel to the axes of rotation of the shafts 112.

The obliquely outwardly and upwardly inclined regions of the soil working portions of the upper tines 141 tend to push any stones and the like which they encounter in the top soil downwardly to a lower level so that they will not be left in the seed bed or the like which the harrow is preparing, thus avoiding inhibition of seed germination by such stones or other hard objects. Although not illustrated in Figures 7 to 10 of the drawings, it is noted that the two upper and lower tines 141 and 142 of each pair could, if prepared, be formed integrally from a single length of spring steel strip instead of being formed as separate entities. Each torsionally deformable spring steel shaft 112 is rotatably supported by the corresponding bearings 119 and 126 at two locations which are spaced apart from one another by a considerable distance along the length of the shaft. This arrangement enables the sometimes quite heavy displacement-resisting forces that are exerted upon the members 111 during the operation of the harrow to be absorbed satisfactorily without any likelihood of rapid failure or a fast rate of wear. In this embodiment, the lower ball bearings 126 are located substantially centrally of the corresponding soil working members 111. It is noted that each tube 114 projects downwardly from beneath the bottom of the hollow frame portion 113 by a distance which is substantially equal to the vertical height of that frame portion 113 itself.

Figures 11 and 12 of the drawings illustrate an alternative form of soil working member to that of the embodiment of Figures 7 to 10 of the drawings and, also, a modified form of drive transmission thereto. In the embodiment of Figures 11 and 12 of the drawings, the tubes 114 are replaced by tubes 146 that are of shorter axial length, the upper end of each tube 146 substantially coinciding in position with the margins of the corresponding hole in the flat bottom of the hollow frame portion 113. Each tube 146 is provided with a flange 147 at its extreme upper end and said flanges 147 are firmly but releasably secured to the flat bottom of the hollow frame portion 113 by substantially vertically disposed bolts 148. Three obliquely disposed strip-shaped strengthening struts 149 have their opposite ends welded or otherwise rigidly secured to the lower surface of each flange 147 and to the outer curved surface of the corresponding tube 146, said struts 149 being, of course, angularly spaced apart from one another around the longitudinal axis of the tube 146 concerned. A torsionally deformable spring steel shaft 150 extends coaxially through each tube 146 to project both upwardly and downwardly beyond the opposite ends of that tube. Each shaft 150 has a corresponding rotary soil working member 151 mounted at the lower end thereof that projects from beneath the bottom of the tube 146 concerned. The upper end of each spring steel shaft 150 is located inside the hollow frame portion 113 and has a corresponding sleeve 152 arranged as a very tight force fit therearound. Each sleeve 152 is externally splined and said splines co-operate with internal splines in an upper end region of a surrounding, and axially longer, sleeve 153. It can be seen in Figure 12 of the drawings that each sleeve 153 surrounds substantially the whole of the length of that part of the corresponding shaft 150 that is located inside the hollow frame portion 113. The exterior of a lower end region of each sleeve 153 is surrounded by the inner race of a corresponding ball bearing 154, a second ball bearing 156 also surrounding the exterior of each sleeve 153 at a higher horizontal level inside the hollow frame portion 113. The outer races of the two ball bearings 154 and 156 of each pair are surrounded by a corresponding substantially cylindrical bearing housing 157, said outer races being positively spaced apart from one another inside that housing 157 by a ring 155 that is interposed between them in coaxially surrounding relationship with the sleeve 153 and shaft 150 concerned. Each housing is formed, close to its lowermost end, with a substantially radially extending flange 158 and it will be seen from Figure 12 of the drawings that the flange 158 is releasably clamped to the bottom of the hollow frame portion 113, with the corresponding tube flange 147, by the aforementioned bolts 148. As in the preceding embodiment, a dished plate 159 that extends throughout substantially the whole of the transverse length of the hollow frame portion 113 is provided inside that frame portion to increase the rigidity of, and thus strengthen, the frame portion. The plate 159 has a flat bottom which is formed with holes to register with those through which the shafts 150 are entered and said bottom of the plate is also clamped to the bottom of the frame portion 113 itself by the bolts 148 that correspond to each tube flange 147 and bearing flange 158. The dished plate 159 is bent over obliquely upwards at locations that are just beyond the leading and rear, with respect to the direction A, extremities of the bearing flanges 158, the bent-over portions diverging upwardly inside the hollow frame portion 113 to a level which is just beneath that of the lower edges of the substantially vertically disposed parts of the front and rear walls of said portion 113. The plate 159 is again bent over at this level to form substantially horizontally disposed front and rear edge regions. Said edge regions are in parallel or substantially parallel relationship with the flat bottom of the hollow frame portion 113.

The upper end of each outer sleeve 153 is formed with external splines as well as with the internal splines that co-operate with those of the corresponding internal sleeve 152. The external splines co-operate with the internally splined hub of a corresponding one of the previously described straight-toothed or spur-toothed pinions 55. The lower end of the hub of each pinion 55 bears against the inner race of the corresponding upper ball bearing 156 whereas the upper end of said hub abuts against the lower surface of a corresponding circlip 160 whose inner edge is engaged in a groove that is formed in the respective outer sleeve 153 close to the uppermost end of that sleeve. It will be apparent from a comparison of Figures 11 and 12 of the drawings with Figures 7 to 10 thereof that the same tines 141 and 142 are used in the embodiment of Figures 11 and 12, their method of mounting by way of the supporting brackets 138 and bolts 140 also being the same as that which has already been described above.

Each soil working member 151 of the embodiment of Figures 11 and 12 of the drawings comprises a carrier or support 162 having a central substantially cylindrical hub 161. Each carrier hub 161 coaxially surrounds a corresponding sleeve 164 which sleeve is a relatively rotatable fit around a lower end region, but not the extreme lower end, of the respective shaft 150. The inner races of upper and lower axially spaced apart ball bearings 163 surround the external surface of each sleeve 164, the inner race of the upper ball bearing 163 concerned abutting, at its upper end, against a shoulder of said sleeve 164. The inner race of the lower of each pair of ball bearing 163 abuts, at its bottom, against the upper surface of a circlip 165 whose inner edge is engaged in a groove in the sleeve 164 concerned at a location very close to the lowermost end of that sleeve. Inner and outer spacing rings 167 and 168 coaxially surround each sleeve 164 between the two ball bearings 163 of the corresponding pair, the inner ring 167 being disposed between the inner races of the two ball bearings 163 whilst the outer ring 168 is disposed between the outer races of the same ball bearings. The outer race of the upper ball bearing 163 of each pair abuts, at its upper end, against the lower surface of a circlip 166 whose outer edge is engaged in a groove formed in the internal surface of the corresponding hub 161 very close to the open upper end of that hub. The shouldered portion at the upper end of each sleeve 164 integrally includes a radially extending flange 169 which flange is provided with an upwardly tapering frusto-conical rim 170 whose upper edge makes an integral junction with the truly radially extending portion of the flange 169 at a location that is radially just beyond the outer surface of the underlying cylindrical hub 161. The upper surface of each flange 169 is welded or otherwise rigidly secured to the lower end of the corresponding tube 146. The outer surface of each substantially cylindrical hub 161 is provided with a radially extending flange 172 at a level just above one that is midway between the upper and lower ends of the hub 161. It will be noted from Figure 12 of the drawings that each flange 172 is, in fact, interrupted where it registers with each of the three supporting brackets 138 of the rotary soil working member 151 concerned. Each flange 172 is integrally formed at its outer edge with a downwardly tapering frusto-conical rim 171 and it will be seen from Figure 12 of the drawings that the upper free edge of each rotary rim 171 very closely surrounds, with a minimum of clearance, the lower free edge of the corresponding non-rotary rim 170. It will also be noted from that Figure of the drawings that the upper edges of the three supporting brackets 138 co-operate in the same way with the rim 170 in the three regions where the flange 172 and its rim 171 are interrupted. The non-rotary rims 170 and rotary rims 171 co-operate to form protective elements for the pairs of lower ball bearings 163 which they surround. Each hub 161 has an inwardly projecting flange at its lower end and said flange co-operate with a centrally apertured cap or plug 173 that closes the otherwise open lower end of the hub 161 concerned when it is in its operative position. The central aperture in each cap or plug 173 is axially keyed to an extreme lower end region of the corresponding shaft 150 and said cap or plug 173 is releasably maintained in its appointed position by a series of bolts 174 whose shanks co-operate with threaded bores in the inwardly directed flange at the lower end of the associated rotary hub 161.

A rotary harrow that is similar to the harrow of Figures 7 to 10 of the drawings, except that it is provided with the rotary soil working members 151 of Figures 11 and 12 of the drawings, operates in the same way as the harrow of Figures 7 to 10 in most respects. Once again, each member 151 is driven by its own individual torsionally deformable spring steel shaft 150 so that the resiliency in the drive to the members 151, combined with the resiliency of their upper and lower spring steel tines 141 and 142, enables any momentarily jammed stones to be released before any significant damage can occur. Once again, as in the cases of the preceding embodiments, the whole frame portion 113 can tilt upwardly about the axis defined by the substantially horizontally aligned stub shafts 8 against the adjustable restoring action of the helical compression springs 15. This facility is of importance in protecting the soil working members 151 against damage or breakage if, for example, a deeply buried rock or the like should be met with. In the embodiment of Figures 11 and 12 of the drawings, the torsionally deformable shafts 150 are individually releasable from their operating positions, with the corresponding internal sleeves 152, merely by removing the top cover plate 113A and releasing the bolts 174 that maintain to co-operating cap or plug 173 in its effective position. The external splines on the upper internal sleeve 152 concerned will then co-operate slidably with the internal splines of the associated external sleeve 153 so that the shaft 150 under consideration can readily be withdrawn upwardly, replacement being effected in the reverse manner. The caps or plugs 173 drivingly interconnect the shafts 150 and the hub 161 by being provided in their central apertures with the aforementioned keys (see Figure 12) that engage in short axially extending grooves in the extreme lower end portions of the shafts 150. It is noted that, in addition to strengthening the frame portions 18 and 113, the dished plates 29, 123 and 159 act to tend to prevent pieces of any of the pinions 55 and 157 that may become broken or damaged from moving about inside the frame portions and damaging or breaking other pinions by becoming caught between the teeth thereof. This protective effect of the plates 29, 123 and 159 may, if desired, be further enhanced by magnetising them.

At least one of the soil cultivating implements (rotary harrows) that have been described also forms the subject of each of our co-pending Patent Applications Nos. 49232/77 (Serial No. 1589897), 49239/77 (Serial No. 1589898) and 7943710 (Serial No. 1589900) to which reference is directed.

WHAT WE CLAIM IS:—

1. A soil cultivating implement of the kind set forth, wherein the drive transmission includes at least one non-horizontally disposed spring steel drive shaft, said drive shaft being arranged inside a tube and being rotatably supported at two spaced points by corresponding bearings, and wherein said tube is fastened to a frame portion of the implement which supports said plurality of soil working members thereof.

2. An implement as claimed in claim 1, wherein said spring steel drive shaft is a common drive shaft for all of the rotary soil working members and occupies an operative position in the transmission which is between a change-speed gear thereof and a

plurality of transmission shafts to the individual soil working members.

3. An implement as claimed in claim 2, wherein the common drive shaft is drivingly connected to a transmission shaft that is individual to one of the soil working members and is in substantially axial alignment with that transmission shaft.

4. An implement as claimed in claim 2 or in claim 3, wherein the drive transmission comprises a driving shaft that is in substantially parallel relationship with the common spring steel drive shaft, the two shafts being drivingly interconnected by said change-speed gear and said driving shaft being arranged to be indirectly driven from the power take-off shaft of a tractor or other operating vehicle of the implement when the latter is in use.

5. An implement as claimed in claim 1, wherein a plurality of spring steel drive shafts are provided, each such shaft taking the form of a transmission shaft to an individual one of the soil working members.

6. An implement as claimed in claim 5, wherein each spring steel transmission shaft is constructed and arranged so as to be independently releasable from, and replaceable in, the remainder of the drive transmission.

7. An implement as claimed in claim 2, 3 or 4, wherein the common spring steel drive shaft is surrounded by a single tube and said change-speed gear is mounted at the upper end of that tube, the change-speed gear having a casing or housing which comprises two substantially identical portions that are connected to one another in a readily releasable manner.

8. An implement as claimed in claim 5 or 6, wherein the individual transmission shafts to each of a plurality of the soil working member are arranged inside corresponding tubes, and wherein said tubes are fastened to the bottom of the frame portion of the implement which supports said plurality of soil working members.

9. An implement as claimed in claim 8, wherein each individual transmission shaft is rotatably supported inside said frame portion and close to the lower end of the respective tube by corresponding ones of said bearings, one end of each such shaft being mounted in a readily releasable manner, and wherein each rotary soil working member has a carrier or support which comprises a hub that is arranged rotatably with respect to the corresponding tube, the corresponding individual transmission shaft being releasably connected to that hub.

10. An implement as claimed in claim 8 or 9, wherein the lower bearing of each individual transmission shaft is protected by elements in the form of a non-rotary rim of a corresponding bearing housing and a co-operating rotary rim of the carrier or support of the soil working member concerned, the fastening of said carrier or support to the respective transmission shaft being located inside the area that is protected by said co-operating elements.

11. An implement as claimed in claim 10, wherein each non-rotary bearing housing rim is downwardly and outwardly inclined and each co-operating rotary rim is upwardly and outwardly inclined.

12. An implement as claimed in any preceding claim, wherein each soil working member has at least one tine that is fastened to a carrier or support or to said carrier or support of that member, the carrier or support being secured in position near a lower one of said bearings of an individual transmission shaft or said individual transmission shaft to the soil working member concerned.

13. An implement as claimed in claim 12, wherein the carrier or support of each soil working member is of substantially downwardly tapering configuration and comprises a supporting surface or surfaces for the corresponding tine or tines, the or each supporting surface being inclined obliquely downwardly towards the axis of rotation of the soil working member concerned, and wherein the or each supporting surface has limbs at its opposite edges which limbs are contained in corresponding planes that are parallel or substantially parallel to the axes of rotation of the corresponding soil working members.

14. An implement as claimed in claim 12 or 13 wherein each soil working member has at least one upwardly directed soil working tine portion and at least one downwardly directed soil working tine portion, both of said portions being inclined obliquely outwardly away from the axis of rotation of the corresponding soil working member.

15. An implement as claimed in claim 14, wherein the upwardly and downwardly directed soil working tine potrions are provided in at least one pair and are at least partly in register with one another in a direction that is parallel to the axis of rotation of the corresponding soil working member, and wherein each upwardly directed soil working tine portion is initially of rectilinear configuration but terminates in an upper end portion that is parallel or substantially parallel to the axis of rotation of the corresponding soil working member, said end portion being shaped to provide a point or tip.

16. An implement as claimed in claim 14 or 15, wherein each downwardly directed soil working tine portion is in substantially horizontally perpendicular relationship with the axis of rotation of the corresponding soil working member throughout a major portion of its length.

17. An implement as claimed in any preceding claim, wherein the frame portion of the implement that supports the plurality of rotary soil working members is hollow and extends substantially horizontally perpendicular, or at least transverse, to the intended direction of operative travel of the implement, said hollow frame portion accommodating the drive transmission to the soil working members and being provided at its bottom with a shaped strengthening plate.

18. An implement as claimed in claim 17, wherein the shaped strengthening plate comprises a portion which is in parallel and abutting relationship with the bottom of the hollow frame portion.

19. An implement as claimed in claim 18, wherein the shaped strengthening plate is secured in its appointed position with respect to the hollow frame portion by the same bolts or other fastenings that releasably secure bearing housings or said bearing housings for transmission shafts to the individual soil working members in their appointed positions.

20. An implement as claimed in any one of claims 17 to 19, wherein the strengthening plate is dish-shaped as seen in cross-section and comprises upwardly divergent regions which are at the front and rear of the bottom thereof with respect to the intended direction of operative travel of the implement.

21. An implement as claimed in any preceding claim, wherein the frame portion and the rotary soil working members which it supports are upwardly and downwardly pivotable, in common, about a single axis relative to a frame of the implement that is constructed and arranged for connection to a tractor or other operating vehicle.

22. A soil cultivating implement of the kind set forth, substantially as hereinbefore described with reference to Figures 1 to 6 of the accompanying drawings, or with reference to Figures 7 to 10 of the accompanyin drawings, or with reference to Figures 7 to 10 of those drawings as modified by Figures 11 and 12 thereof.

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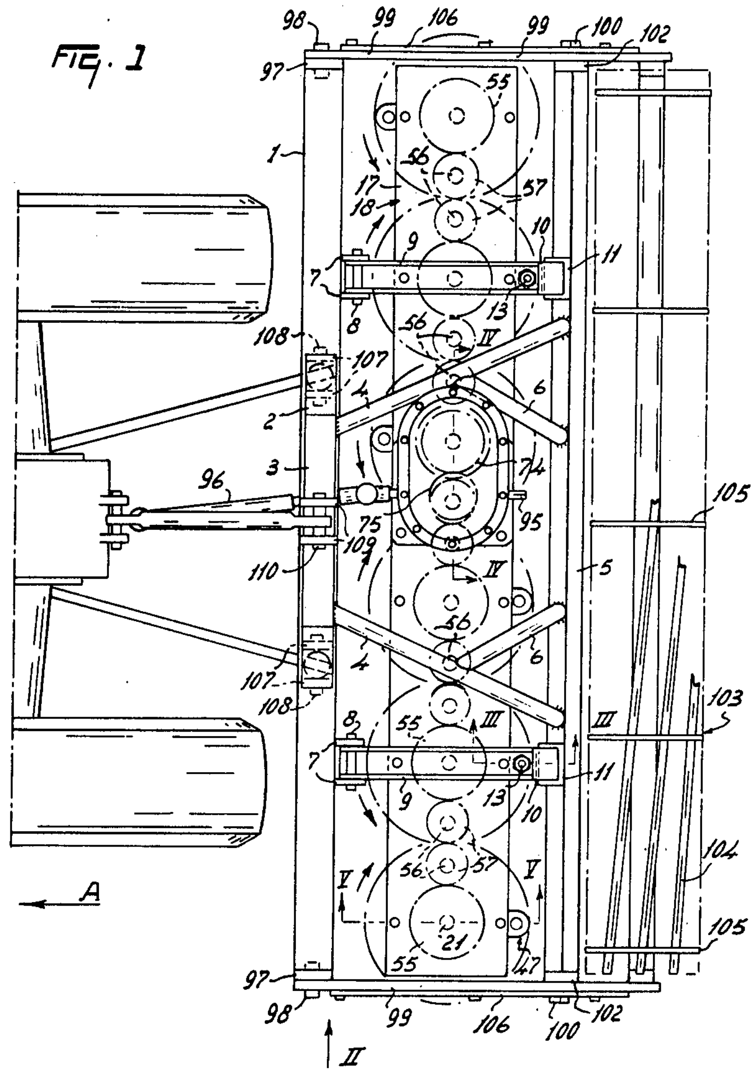
FIG. 1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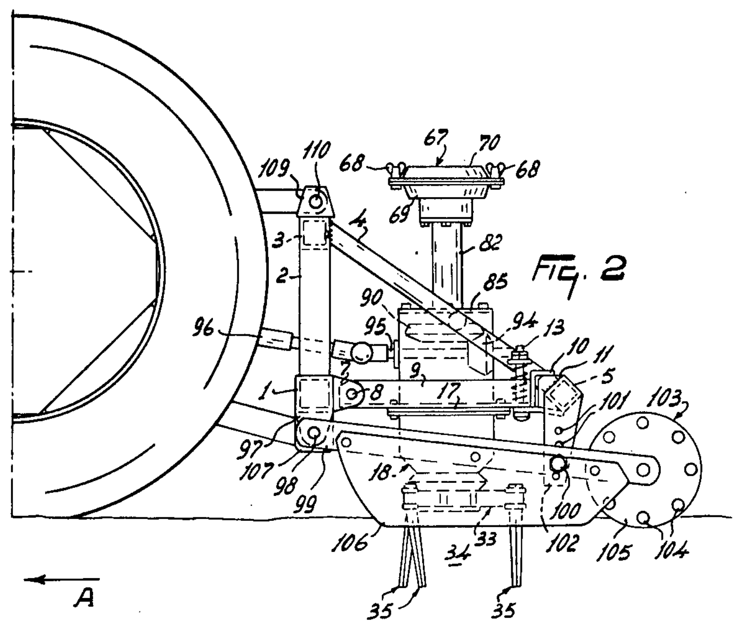
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FIG. 2

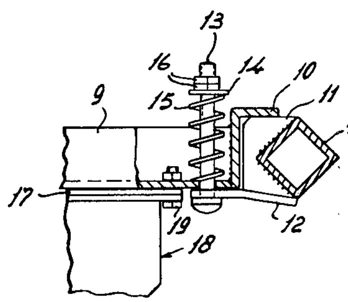
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FIG. 3

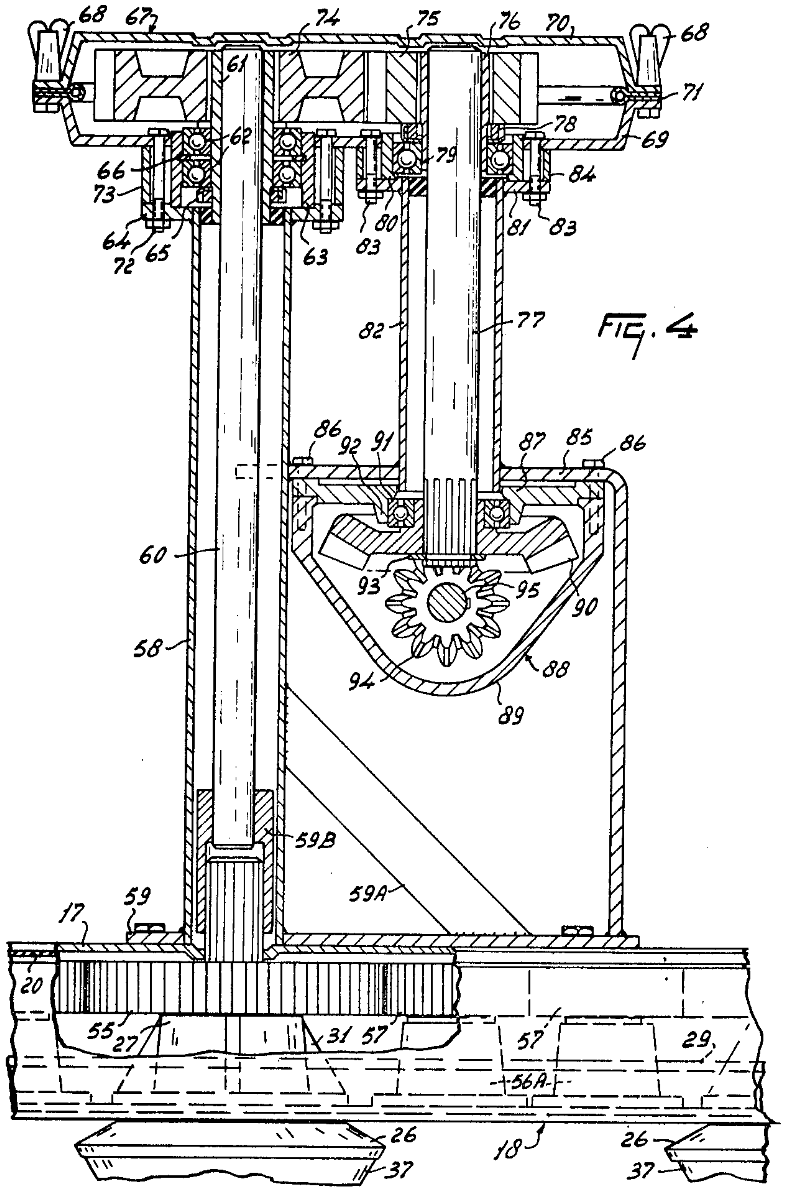
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FIG. 4

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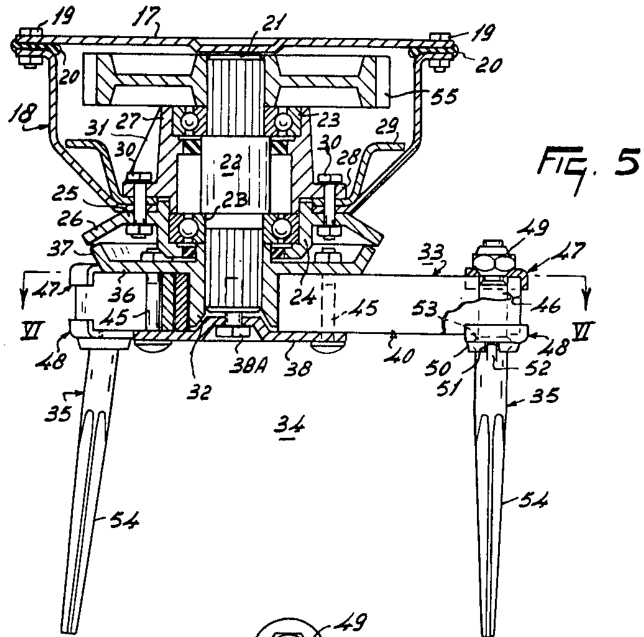
Sheet 4



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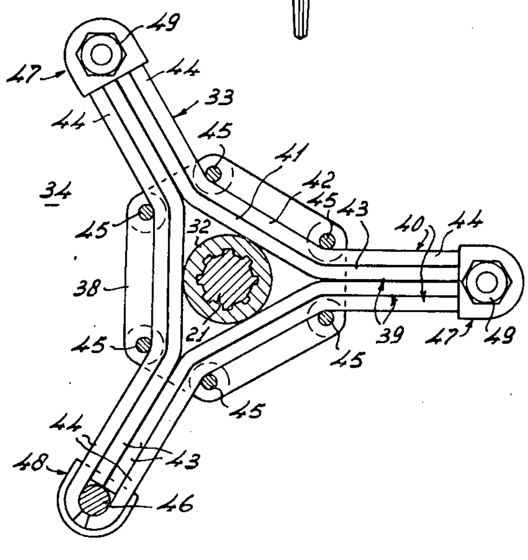
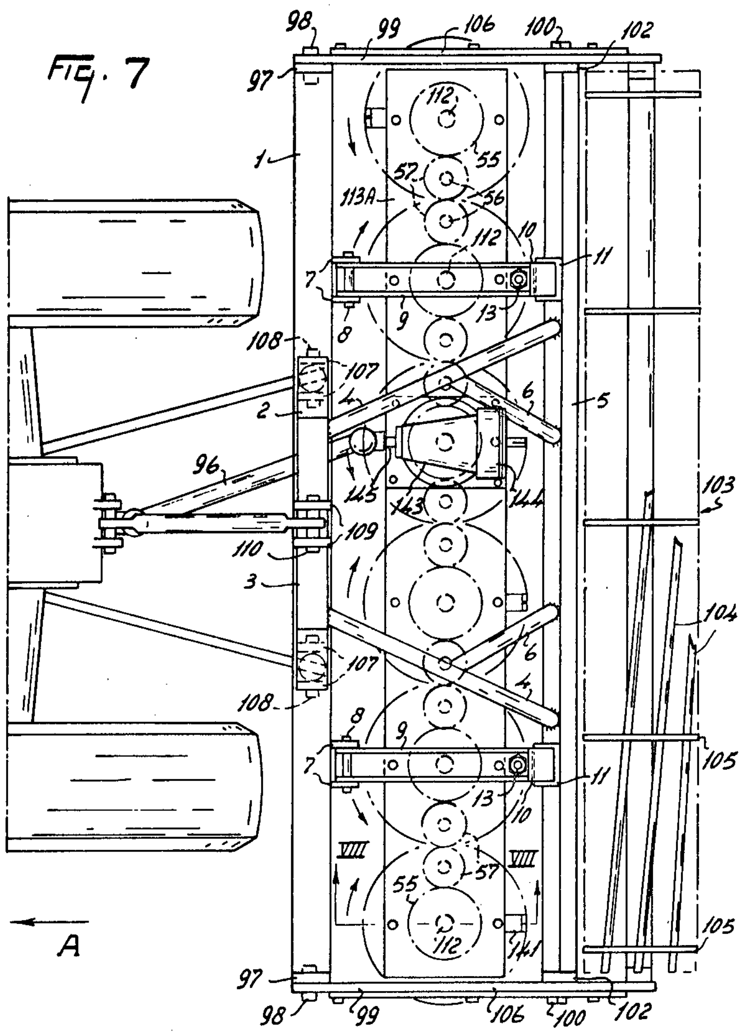


FIG. 6

FIG. 7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Sheet 6

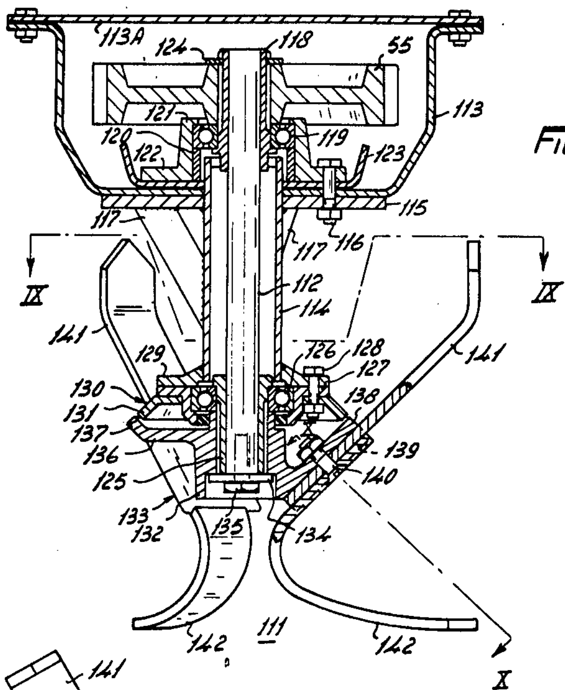


FIG. 8

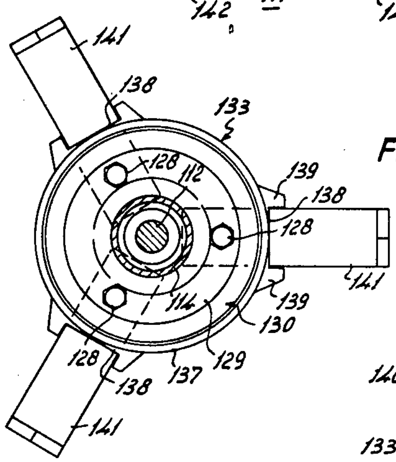


FIG. 9

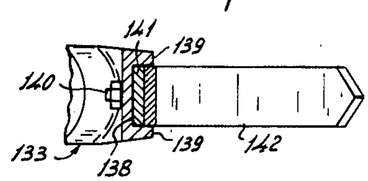
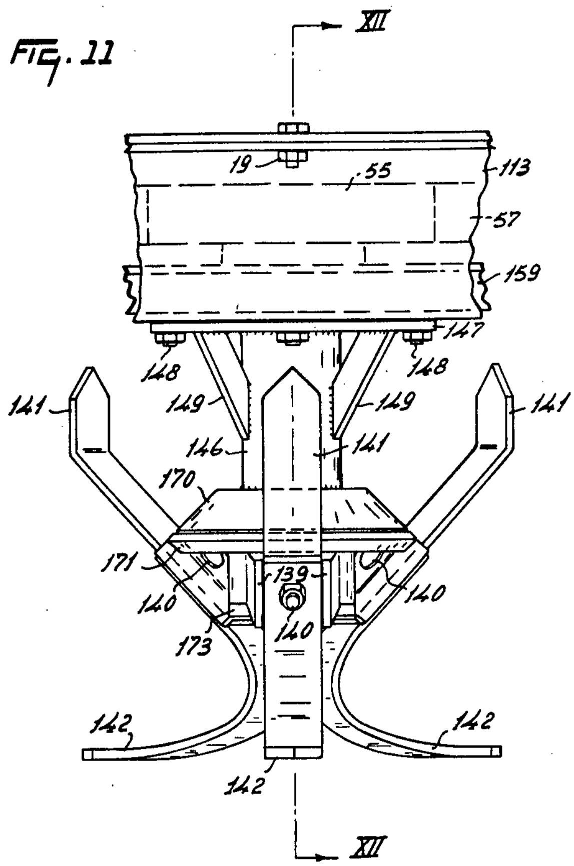


FIG. 10

FIG. 11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Sheet 8

FIG. 12