The present invention relates to material handling machines and more particularly to improvements in back hoe excavators of the hydraulic type.

It is the principal object of the present invention to provide a completely hydraulic back hoe excavator capable of fast, accurate operation and effective use in a large variety of work.

A further object of the present invention is to increase the available digging forces in a back hoe over a wide area of digging depth without increasing the weight of the boom and bucket assembly.

Another object of the present invention is to provide a substantially horizontal path of travel for the bucket to increase the usefulness and efficiency of excavators of this type. A related object is to permit digging excavations with a cab or bucket mounted so that minimum clean-up work is required to form a completed excavation having a flat bottom and vertical walls.

A more detailed object is to provide more nearly uniform velocities of bucket travel at all levels of digging for better control and digging operation.

It is also an object of the present invention to reduce the time required for lifting and unloading the bucket to increase the efficient use of back hoe machines.

Other objects and advantages of the invention will become apparent as the following detailed description proceeds and with reference to the drawings, in which:

FIG. 1 is a side elevation of the machine shown in FIG. 1 on a reduced scale and showing the boom and support assembly in two different positions of operation;

FIG. 4 is a fragmentary perspective of a bucket showing its coupling to the machine; and

FIG. 5 is a schematic diagram of a hydraulic system used in the machine of FIG. 1.

While the invention will be described in connection with a preferred embodiment, it will be understood that it is not intended to limit the invention to that embodiment.

On the contrary, it is the intention to cover all alternatives, modifications, and equivalents as may be included within the spirit and scope of the invention as defined by the appended claims.

With reference to the drawings, FIG. 1 illustrates an earth digging machine 20 of the general type known as a back hoe. The illustrative machine includes a base or main frame 21 mounted on a mobile ground support mechanism, such as a pair of endless tracks 22. The base 21 has a cab 24 for enclosing a source of power (not shown) and suitable controls, and is usually mounted on a turntable or swivel 25 to permit turning the cab 24 in different directions without moving the entire machine.

To perform the digging operation, the machine has an outwardly projecting boom 26 which is pivotally supported at its inner end to the base 21. The outer end of the boom carries a pivotally mounted arm 28 having a dipper or bucket 29 at its lower end. The bucket 29 is of usual form opening in the direction of the machine to permit digging as the bucket 29 moves from the outer reach of the boom 26 and bucket arm 28 toward the machine base 21.

In the embodiment of the invention illustrated in the drawings, the boom 26 is of box construction, formed by a pair of longitudinal side members 30 of more or less elongated triangular shape in side elevation and a top plate 31 joining the side members throughout the central portion of their length. The inner ends of the side members 30 are spread laterally from each other to form legs 34 which provide a broad support for the boom 26. As seen in FIG. 1, the drawings, the inner ends are pivotally supported on a downwardly and rearwardly opening support yoke 32 fixed to the machine base. A long pivot pin 35 which passes through aligned pivot holes in the inner ends of the boom legs is supported at a point near the lower central section of the yoke to allow up and down swing of the boom and at the same time minimize sideways twisting.

The bucket arm 28 is also of box type construction, as seen in FIG. 4, having side plates 36 of triangular shape with a support bracket 38 rigidly fixed to each side plate and projecting inwardly toward the machine. To mount the arm 28 on the outer end of the boom, a horizontal pin 39 extends through aligned pivot holes in the brackets 38 and outer ends of the boom side members. The outer or lower ends of the side plates of the arm 28 have a transverse pivot pin 40 for supporting the bucket 29. For the latter purpose, the bucket 29 has a pair of transversely spaced projections or lugs 41 on its rear wall which have holes for receiving the ends of the bucket support pin 40, thus providing for angular tilt of the bucket relative to the boom arm.

In accordance with the present invention, means are provided in the form of a novel supporting and actuating means for hydraulically moving and controlling the bucket or dipper travel. For this purpose, means in the form of a hydraulic digging ram 42 and a pair of hydraulic hoist rams 44, 44a pivotally mounted on the machine base 21 are operatively connected to the boom and bucket arm.

In the illustrated machine the hydraulic means for applying digging and retracting forces to the dipper arm is in the form of a double acting hydraulic ram 42 and a rigid connecting rod or link 45. To permit the application of an increased digging force, the digging ram 42 is mounted directly to the machine base. Preferably, this mounting comprises the same support yoke 32 which carries the inner end of the boom 26. As shown in FIGS. 1 and 2, the shank of the support yoke 32 extends upwardly and forwardly with respect to the pivotal support 35 for the boom, and is slotted vertically to receive the inner end of the digging ram. A pivotal connection 46 between the shank and the ram is thus provided which is spaced upwardly and outwardly of the boom support pivot 35 and which carries the ram forces directly to the base of the machine.

Control of the bucket arm at all relative positions of the boom 26 and arm 28 by means of the digging ram 42 is accomplished by a change of direction coupling means including the connecting rod 45 and a crosshead arrangement 48. For this purpose the connecting rod 45 is interposed between the outer end of the digging ram 42 and the upper end portion of the bucket arm 28 which is slotted vertically to receive and pivotally engage the end of the rod. The inner end of the rod 45 is pivotally connected to the outer end of the digging ram 42 and is held in a guided linear path of movement by a crosshead 48 and guide means. The guide means comprises two pairs of guide bars or strips 50, 50a fixed to the respective inner sides of the longitudinal boom members 30. As shown in FIG. 1, the guide bars 50, 50a of each pair are spaced
3,094,220

vertically from each other forming parallel guideways extending generally in a radial direction with respect to the pivot support point of the boom. The guideways 50, 50a are of sufficient length to cover the distance of travel of the outer end of the digging ram 42 which in the illustrative machine is from about one-fourth of the length of the boom to slightly over one-half of the boom length. Moving within the guideways are rollers or sliders 51, 51a mounted coaxially with the connecting rod pivotal connection to maintain the latter in the desired path of movement.

By means of the crosshead 48 and guideways 50, 50a, the force and movement of the digging ram 42 is first directed upwardly and then is directed in a downwardly and outwardly direction by the connecting rod 45. By thus changing the direction of the application of digging force, the digging ram 42 is able to control and swing the bucket arm 28 without at any point in the usable range of the machine arriving at a dead center position, and in addition provides a more uniform application of torque to the bucket arm.

The hydraulic hoist means is arranged for novel co-action with the hydraulic digging means to provide not only fast lifting of the dipper to unloading position, but also to maintain a substantially horizontal path of dipper travel over a wide range of elevations and to enable digging and shaping vertical walls or banks. To this end the hoist means includes a hoist crank or arm 52 actuated by a pair of single-acting hydraulic rams 44, 44a and a tension member 54 interconnecting the crank and the bucket arm.

In the machine of the drawings the hoist crank or arm 52 is of inverted L shape having an upright portion formed by spaced apart legs 55, 55a which are pivoted on the machine base 21 for forward and rearward swing and also having a generally horizontal portion 56 extending forwardly toward the boom end of the machine. The pivotal support connection for the hoist arm is preferably positioned above and to the rear of the support for the boom by means of an A frame 28 permitting the outer end of the arm 52 to swing forwardly and downwardly across the front of the machine cab 24 and rearwardly and upwardly to a substantial elevation over the cab.

To provide a lift connection between the hoist arm 52 and the boom and bucket arm assembly, the upper forward projecting portion 56b has a pair of forwardly projecting rigid fingers 59 spaced laterally from each other in general alignment with the respective opposite sides of the bucket arm 28. Joining the inner ends of the fingers 59 is a solid section having a semicircular arcuate edge. To support the cable tension member 54, the facing sides of the fingers 59 are grooved and the arcuate juncture between them has an arcuate tube or hole 60 for receiving the bight of a continuous cable 54 which has its ends connected to opposite sides of the bucket arm 28 below its support point. At the outer ends of the fingers 59 the cable 54 also passes through short tubular pieces 61 fixed to the hoist arm to further hold the cable. In this manner, a self-adjusting or compensating pair of tension lift members are provided to apply lifting and guiding forces to the boom and bucket arm assembly.

The hoist arm 52 is actuated by the laterally spaced single-acting hydraulic rams 44, 44a which have their lower ends pivotally supported on the machine base 21 and their upper ends pivotally connected to the hoist arm 52 at the junction of the upright and horizontal portions 55, 56 of the arm. Preferably, the base supporting pivot is formed by the same pivot pin 35 and supporting plate 32 which hold the inner end of the boom 26. Thus, to lift the boom 26 the hydraulic hoist rams 44, 44a are extended, causing the hoist arm 52 to rock backwardly about its support on the A frame 58. As the hoist arm 52 moves rearwardly, the two lengths of cable 54 pull upwardly on the bucket arm 28 below its pivotal support on the end of the boom 26. As the boom and bucket are raised, the linkage, formed by the digging ram 42 and rod 45, the upper end portion of the bucket arm 28, and the boom 26, tends to swing the bucket arm 28 inwardly toward the machine base. As a result, the machine of the present invention is well adapted to work and shape vertical walls.

For additional control of the dipper or bucket 29, hydraulic tilt means is also provided. In the illustrated machine the tilt means comprises a double acting hydraulic ram 62 positioned along the outer or forward side of the bucket arm 28 and pivoted at its upper end to the arm 28. Movement of the tilt ram is transmitted to the bucket 29 by means of a pair of laterally spaced pivot links 64 connected to the bucket mounting lugs 41 at points spaced from the bucket support pivot 49. Guiding the lower end of the ram and directing its line of action is a pair of parallel cranks 65 which are pivoted at one end on respective sides of the bucket arm 28 and are interconnected at the second end by a cross member 66 to which is fixed the lower end of the tilt ram 62. To the second end of the crank links 65 are also pivotally attached the upper ends of the bucket links 64 such that movement of the tilt ram 62 causes the link links 65 about their support pivots for moving the bucket links 64 in unison to swing the bucket 29 about its supporting pivot connection.

For actuating the hydraulic rams, a series type hydraulic system is provided in the exemplary machine of the drawings. With reference to FIG. 5 of the drawings, the system includes a pump 70 which supplies fluid under pressure to a series of three valves, 71, 72, 73, one for each of the hydraulic ram means. As shown in the drawings, the valves are three position valves, each being illustrated in its neutral position in which the pressure fluid flows through the first directing ports to the boom, to the bucket tilt valve 72, through the hoisting ram valve 73, and back to a reservoir or sump 75. In the neutral position of the valves, each of the rams is isolated, that is, blocked from the fluid supply and from the supply returns.

In more detail, the digging ram valve 71 is provided with five ports or fluid connections. Fluid is supplied to the valve through either of two conduits 76, 77, one of which is open for straight through flow of fluid and the second of which has a one-way valve 79 for supplying fluid to the digging ram cylinder 42. The oneway valve 79 prevents suction of back sumps of fluid from reaching the supply conduits. Such surges of back pressure are dumped to the reservoir 75 by means of a separate return line 80 joined through a group of one-way valves 81 and a pressure relief valve 82. Pressure fluid is delivered to opposite sides of the double acting digging ram cylinder 42' by a pair of conduits 84, 85 from the ram valve 71. When the left hand portion of the digging ram valve 71 is moved to active position, the straight through supply conduit 76 is blocked and fluid is directed from the second supply conduit 77 to the left hand or digging end of the ram cylinder 42'. The conduit 64 leading to the right hand or retracting end of the cylinder is at the same time connected through the control valve 71 to the fluid delivery conduit 87 leading to the control valve 72 for the tilt ram cylinder 62. When the digging ram valve 71 is moved to the left, the supply connection and exhaust connection are reversed with fluid being supplied to the right hand end of the cylinder 42' to retract the bucket, and with the left hand end of the cylinder exhausting fluid through the valve 71 to the tilt ram valve 72.

To prevent the bucket from uncontrolled swinging in the digging direction due, for example, to its own weight, a counterbalance valve 86 is provided which permits the exhaust of fluid from the right hand end of the digging cylinder 42' unless positive pressure is applied to the left hand end or digging end of the cylinder. As shown
in the drawings, the counterbalance valve 88 is interposed in the conduit line 84 between the digging control valve 71 and the right hand end of the digging cylinder 42 with a control or pilot conduit 89 between the counterbalance valve 88 and the supply conduit 85 for the left end or digging end of the cylinder. In order to admit pressure fluid to the retracting, that is, right hand, end of the digging cylinder 42 under pressure in the digging end of the cylinder, the counterbalance valve 88 is by-passed by a suitable one-way valve 90.

The valving for the bucket tilt ram cylinder 62 is identical with that of the digging ram cylinder 42 and need not be described in detail. Suffice it to say that the tilt ram cylinder 62 has a supply conduit 91, a control valve 92, and a control valve to its left end from applying fluid to tilt the bucket, that is, to swing the bucket toward the machine base, and a second conduit 92 to supply fluid to the right hand end of the cylinder to dump the bucket 29, that is, to swing it upwardly away from the machine.

Moving the control valve 72 to the right connects the pressure fluid to the left end of the cylinder, and moving it to the left supplies fluid to the right or dump end of the cylinder. The tilt ram cylinder 62 also has a counterbalance valve 93 with a one-way valve by-pass 94 which in this case prevents lifting the boom 26 by the controlled rearward movement of the bucket 29 when digging.

The hoist rams cylinders 44, 44a, being single acting, have but a single supply line 96 from the control valve 73. When the hoist control valve 73 is moved to the left, pressure fluid is supplied to the hoist cylinders through a one-way valve supply conduit 97, and when moved to the right, the cylinders 44, 44a are connected to the sump 75 to exhaust fluid. It should be noted that in the lowering or exhaust position of the hoist valve 73, the straight through supply conduit 98 is opened to the sump. With the digging and tilt valves 71, 72, the straight through conduit 98 is opened only in the neutral position. When either of the latter valves 71, 72 is moved to actuate their respective rams, the succeeding valves in the series receive only the exhaust from the respective ram cylinders.

Turning now to the operation of the machine, reference is made to FIG. 1 of the drawings, showing the bucket 29 resting on the ground close to the machine base 21. In order to extend the bucket 29 to commence digging, the operator moves the hoist valve 73 to the right, causing the hoist rams 44, 44a to extend and swing the hoist arm 32 to the rear which lifts the boom 26 and bucket arm assembly about the boom support pivot 35. At the same time the operator may move the digging valve 71 to the left to retract the bucket, that is, to swing it outwardly. Because of the hoist cable connection 54 to the bucket arm 28 below its support pivot 39, outward swing of the arm 28 assists the hoist rams 44, 44a by adding to the speed of upward movement of the boom 26.

Once the boom 26 has been lifted sufficiently to allow the bucket 29 to clear the ground and swing outwardly, the boom may be lowered by shifting the hoist valve 73 to the left until the bucket reaches the proper level for digging. The tilt valve 72 then moved either right or left to swing the dipper to the proper digging angle with respect to the ground, and the digging valve 71 is moved to the right to cause the digging ram 42 to extend which in turn pushes on the upper end of the bucket arm 28 to force the bucket 29 downwardly toward the machine base and into the ground.

The hoist cable 54 coacting with the linkage formed by the boom 26, the digging cylinder 42, and the portion of the bucket arm 28 between the cable connection and the digging cylinder connection causes the dipper to move in a substantially horizontal path for a wide range of digging and lifting movement. This is accomplished by reason of the linkage causing the boom 26 to swing downwardly as the bucket arms swings inwardly and upwardly about its pivotal support on the outer end of the boom. At the end of the digging movement the bucket is raised by applying hydraulic fluid to the hoist rams 44, 44a, and at the same time, if desired, retracting the digging ram 42. The bucket is tilted forwardly during the lifting to prevent the material from falling out before the unloading position is reached. The latter position is illustrated by solid outline in FIG. 3 in which the hoist rams 44, 44a are fully extended and the digging ram 42 is fully retracted.

The dashed outline of FIG. 3 shows the bucket in an excavation ready to clean up or level the bottom. In this position the hoist rams 44, 44a and the digging ram 42 are retracted. Digging would be accomplished by positioning the bucket end to downwardly and upwardly about its pivotal support on the outer end of the boom. At the end of the digging movement the bucket is raised by applying hydraulic fluid to the hoist rams 44, 44a, and the digging ram 42 is fully retracted. The bucket is tilted forwardly during the lifting to prevent the material from falling out before the unloading position is reached. The latter position is illustrated by solid outline in FIG. 3 in which the hoist rams 44, 44a are fully extended and the digging ram 42 is fully retracted.

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We claim:

1. A back hoe attachment for use with a base machine comprising, in combination, a base adapted to be pivotally supported at its inner end on said base for up and down swinging movement, a bucket arm pivotally supported in the intermediate its ends on the outer end portion of said boom for swinging upwardly and downwardly about its pivotal support and arm support pivots, means for hoisting and positioning said boom and arm including an upwardly extending hydraulic hoist ram pivotally mounted on said base, a pivotally mounted hoist frame extending upwardly above said base and engaged by said hoist arm for forward and backward swinging and a tension member interconnecting said upper end of said frame and a point on said arm intermediate said arm support pivot and said bucket, and means for varying the angle of said bucket with respect to said arm.

2. A back hoe comprising, in combination, a base machine, a boom of generally triangular outline pivotally supported at its inner corner on said base for up and down swinging movement, a bucket arm pivotally supported intermediate its ends for inward and outward swinging movement on the outer corner of said boom, the third corner of said boom being on the upper side of the boom, an inwardly facing bucket pivot located the lower end of said bucket arm, means for actuating said bucket arm including a hydraulic digging ram pivotally supported at its inner end on said base at a point above and outwardly of the boom support connection, a rigid link pivotally connected to the outer end of said ram and to the upper end portion of said bucket arm, respectively, and a linear guideway formed by upper and lower guide bars on said boom extending along the upper inwardly facing side of said boom in a direction generally radial with respect to said boom pivotal support for guiding the pivot connection between said ram and said link and the line of centers of said boom and bucket arm supports, means for lifting and positioning said boom and bucket arm including an upwardly extending hydraulic hoist ram mounted on said base, a pivotally mounted hoist frame arranged for forward and backward swing upon actuation of said hoist ram and said link in the line of centers of said boom and bucket arm supports, and said bucket arm at a point intermediate said arm support pivot and said bucket for lifting said bucket upon actuation of said hoist ram and for guiding said
bucket in a substantially level digging path upon action of said digging ram.

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