Corigendum#1 to Expression of Interest (EOI) (PPX-DABG/EOI/21-22/01)

A Corrigendum is issued for the EOI **(PPX-DABG/EOI/21-22/01)**. Assemblies of Loading mechanism and scope of extractors has been added.

The EOI document with assemblies' details, revised scope of extractors as stated above is also attached as Annexure-4.

LIST OF ADDED ASSEMBLIES AND SCOPE OF EXTRACTORS

1. **Loading Mechanism**

   Details of assemblies in Loading Mechanism

   a. Loading Tray Recocking Transmission
   b. Loading Tray Recuperator Device
   c. Loader Drum Transmission and Actuator Cylinder
   d. Transfer Tray Release Assembly

2. **ARM EXTRACTOR**

   a. Extractors Forging (closed die) – Forging shall be either In-House / Outsourced as per BHEL specification. In case of outsourcing, proposed vendor shall be taken up for approval from BHEL.
   b. Machining – In-house facility
   c. Induction / Laser Hardening – Hardening on local area of component as specified in drawing. Hardening shall be either In-house / Outsourced (BHEL approved vendors). Additional vendors proposed shall be taken up for approval from BHEL.
   d. Coating – Shall be In-house / Outsourced (BHEL approved vendors). Additional vendors proposed shall be taken up for approval from BHEL.

Annexure-4

DETAILS OF LOADING MECHANISM ASSEMBLIES

Loading Tray Recocking Transmission

The recocking transmission automatically returns the loading tray in its upper position after each round is fired. For operating, the recocking transmission uses a portion of the gun's recoil energy which is used to:

- rise the loading tray directly by means of the transmission lever system; and
- reload the loading tray recuperator which stores the required energy to lower the loading tray for the next ramming.

The recocking transmission consists of two quite identical mechanisms, located symmetrically at the two sides of the breech ring and connected, by the left side only, to the shaft of the lower pivot levers of the loading tray. The main components of the recocking transmission are the following:

- two articulated linkages, right and left, transmitting the longitudinal motion of the recoiling mass;
- two recocking control cams, right and left, controlling the articulated linkages;
- a crank levers system transforming the longitudinal motion of recoiling mass into angular rotation of the loading tray pivot levers;
- a gun in battery safety device controlling the breechblock closure.

A. Articulated Linkages. The two articulated linkages and connect the recoiling mass to the crank levers recocking the loading tray. The two linkages are identical; each one consists of an elastic attachment (shock absorber) anchored to the recoiling mass, and of two articulated rods. Shock absorber works as shock absorber for the articulated rods during the gun recoil stroke and as an elastic connection that operates the articulated rods during the gun run-out stroke.

The two articulated rods, front, and, rear, are connected together by a fulcrum pin and, at their ends, to the breech ring and to the recocking crank levers. Fulcrum pins of the two articulated rods is provided with a cam shaped protrusion, controlled during the operation of the transmission by recocking control cams and. To the articulated linkages the gun in battery safety device is also connected.

B. Recocking Control Cams. The two recocking control cams and fitted to the cradle sides, one for each articulated transmission, operate on the cam shaped protrusions of articulated rod fulcrum pins so to:

- maintain the articulated rods straight in line during the gun recoil stroke in order to transmit the recoiling movement of the breech ring to the recocking crank levers;

- allow the articulated rod folding at the end of the recoil stroke making the movement of the recocking crank levers independent from the breech ring; thus allowing the releasing and lowering of the loading tray while the gun is running-out, when gun is firing at maximum rate, reducing the loading cycle time.

C. Crank Levers System. Crank levers connect the recocking mechanism to the lower pivot lever shaft of the loading tray and perform the following functions:

- they maintain the loading tray pivot lever locked retaining the loading tray in its upper position until they are released by the releasing transmission; and

- they make the loading tray pivot levers to rotate returning the loading tray in up position and reloading the loading tray recuperator, when actuated by the articulated transmission during the gun recoil.

The crank lever system is built-up of the following parts:

- recocking arm, pivoted idle on crank shaft, which actuates, by means of sliding block, slotted crank splined on shaft of the loading tray lower pivot levers;

- two crank levers, right, and, left, the upper ends of which are connected through the articulated linkages to the breech ring.

Right lever is directly splined on shaft and is returned in its starting position by spring; left crank lever is idle and transmits its movement to shaft through crank splined on the shaft itself. Connection between crank lever and crank is realized by means of a spherical joint to which also crank operating recocking arm is connected;

- crank, pivoted idle on shaft, that operates recocking arm during the gun recoil stroke, through a contact boss; it is in turn actuated by left crank lever through spherical joint.

Movement of the crank levers system is limited and dumped by a series of adjustable limit stops and by a rubber disc type buffer.

D. Loading tray recocking transmission safety device. The loading tray recocking transmission safety device is operated by the right breechblock operating outer crank when the position of the crank corresponds to the breechblock closed. The device ensures that levers are straightened in-line before the gun recoil. Shouldn’t this be verified, fulcrum pin might interfere with cam flange and damage it, or pass over the flange without providing movement to the loading tray during the recoil. It consists of the safety hook lever which controls the two slotted levers trough shaft. When the breechblock is closed the two slotted levers press downward pin which is machined to lever, so as to prevent lever from moving up. Therefore, during recoil, fulcrum pin is assured to move below flange of recocking control cam, thus not permitting levers and to collapse.

E. Operation of the Loading Tray Recocking Transmission. The operation of the loading tray recocking transmission may be synthetized according with the following phases.

- **Loading Tray Up and Hooked.** The loading tray is retained in upper position:

  - recocking arm is retained downward by triggering lever of the releasing transmission and, in turn, retains recocking slotted crank and thus the loading tray in up position;

  - crank lever are against their limit stops;

  - the articulated linkages are extended and stretched by springs of shock absorbers.

- **Loading Tray Releasing.** The releasing transmission has been actuated:
  - triggering lever has cleared recocking arm thus allowing slotted crank to rotate, under the action of the loading tray recuperator, for lowering the loading tray;
  -recocking arm is made rotating clockwise by the action of slotted crank 62 through sliding block;
  -the articulated linkages and crank levers are still stowed.

- **Loading Tray Is Down.** After being released the loading tray reaches its down position; the lowering of the loading tray causes the ramming of the round into the barel that, on its turn, releases the extractors and closes the breechblock. The recocking transmission is in the following condition:

  -the articulated linkages are still extended and stretched by springs of shock absorbers

  -the crank levers are in stowed position against their limit stops;

  -recocking arm is vertical and contacts, with its boss, the corresponding boss of idle crank

  -safety hook lever is operated by boss machined on right breechblock operating outer crank which has been rotated by the releasing of the breechblock; it operates downward the slotted lever that, by means the fulcrum pin, maintains levers and straightened in-line.

- **Starting of Gun Recoil -** After fire the gun starts to recoil:

  -the articulated linkages, maintained straight by the combined action of recocking control cam on cam shaped pin and of bearing boss of the breech ring on rear articulated rod, transmit the recoiling movement to the crank levers system;

  -crank levers and start to rotate counterclockwise making crank to drag recocking arm with it;

  -recocking arm, in turn, through its sliding block, makes slotted crank to rotate clockwise, thus rising the loading tray and reloading its recuperator.

- **Gun Recoils 200 mm from Battery.** As the recoiling mass reaches the 200 mm from battery position, the loading tray is completely recocked:

  -crank levers and have reached their rotation stroke end and recocking arm has engaged triggering lever of the releasing transmission;

  -cam shaped pin of front articulated rod is no more controlled by the upper ridge of recocking control cam thus allowing the subsequent folding of the articulated linkage.

- **Gun Recoils from 200 mm to Maximum Recoil (230 mm From Battery** As the 200 mm from battery position has been overcome, the lower ridge of recock-ing control cam forces cam shaped pin upward thus starting the folding of the articulated linkage:

  -cam shaped fulcrum pin, no more retained by the rim of control cam allows the folding of front and rear articulated rods and under the action of cranks and loaded by return spring;

  -cranks and no more connected to the recoiling mass, trip to their stowed position against limit stops and under the action of return spring.

  -recocking arm, and then the loading tray, rests retained by triggering lever of the releasing transmission.

- **Gun Returns to Battery** While gun is returning to battery, the articulated linkages return in the unfolded position passing with cam shaped pin over recocking control cam:

  -crank levers and do not intervene during the gun run-out phase and rest in their stowed position;

  -recocking arm is held blocked by triggering lever 84 until the loading tray releasing transmission is not actuated by a new round loaded onto the loading tray.

Loading Tray Recuperator

The loading tray recuperator provides the energy necessary to the loading tray for lowering, and for ramming the round into barrel. The recuperator is of the hydro-pneumatic type and stores energy during the recoil stroke of the recoiling mass when the loading tray is recocked in its upper position. The recuperator is installed inside the cradle, right hand side, its driving cylinder rod protruding forward, has a rack, machined on it, which meshes with sector gear splined to shaft of loading tray lower levers and. To the same shaft, the recocking slotted crank, connected to the recoiling mass through the recocking transmission, is also splined.

The recuperator consists of a double cylinder in which two pistons slide:

- driving piston; and
- separator piston.

- Driving piston moves sealed inside the upper cylinder and forms a rear chamber whose volume varies according to the position of the loading tray. The chamber contains hydraulic fluid, filled inside through filling valve, and is in communication with fluid chamber of separator piston.
- Separator piston moves sealed inside the lower cylinder and forms two chambers: the rear one containing hydraulic fluid and in communication with the upper cylinder, and the front one containing nitrogen under pressure. Nitrogen is filled inside the rear chamber through filling needle valve arranged in the separator piston rod. The hydraulic fluid level in the recuperator should be checked on indicator 58 when the loading tray is in lower position. The nitrogen pressure in the recuperator should be read on pressure gauge on the cradle.

Operation of Loading Tray Recuperator. Operation of the loading tray recuperator can be synthetized in the following stages:

a. Loading Tray up. When the loading tray is in its upper position, both driving piston and separator piston are completely re-entered inside their cylinders. Front fluid chamber of separator piston has its maximum volume and the nitrogen pressure inside rear chamber has its maximum value.

b. Releasing of Loading Tray. As the loading tray is released, pressure of nitrogen inside rear chamber 68 causes separator piston to move rearward delivering fluid under pressure into the rear chamber of driving piston. The driving piston extends forward making sector gear to rotate thus lowering the loading tray.

c. Loading Tray Down. When the loading tray is in its lower position, both driving piston and separator piston are completely extended. Front fluid chamber of separator piston has its minimum volume and the nitrogen pressure inside rear chamber 68 has its minimum value.

d. Rising of the Loading Tray. Under the action of the recocking transmission, sector gear is rotated causing the rising of the loading tray and the re-entering of driving piston through rack.Fluid contained in the rear chamber of driving piston is forced into rear chamber of separator piston; piston re-enters causing the compression of the nitrogen inside the front chamber, untill the loading tray does not reach its upper stroke end.

Loader Drum Operating Transmission. The loader drum operating transmission makes the drum itself rotate step by step in synchronization with the movement of the rocking arms.

The operating transmission consists of:

- loader drum actuator cylinders;
- the mechanical transmission (pin shifter coupling and bevel gear drive transmission);
- the *"Drum Rotation Completed"* interlock (above the pin shifter coupling,)

Loader Drum Actuator Cylinders. There are two identical cylinders operating the loader drum. They are installed on the cradle, in front of the mechanical linkage connecting them to the loader drum.

The cylinders are of the differential type and operate with an alternating movement: at every stroke of the rocking arms, the rod of one of the two hydrualic cylinders moves outward causing the loader drum to rotate one step (1/6 of a turn).The hydraulic cylinder operating the loader drum transmission receives pressure oil from the clamps actuator cylinder.

The rod of the hydraulic cylinder which is at exhaust is made re-enter the cylinder by the roller on the appendix of the rocking arm which is arriving onto the elevating mass.

Each cylinder consists of a piston sliding into a cylinder body,and of a series of valves to control the oil flow. The piston, inside the cylinder, forms two chambers connected to the union fittings through which the pressure and return oil passes by means of passage. A throttle groove machined into the lower part of the housing in which the piston slides, has the function to buffer the piston when it reaches the two end positions of its stroke.

The valves controlling the oil flows are four; unidirectional flow control valve 61, check valve, check valve and needle throttle valve. Unidirectional flow control valve is of the automatic disc type and reduces the oil flow entering the cylinder ensuring a smoother movement of the loader drum; the valve has no function during the piston rod re-entering phase.

Check valve is of the automatic disc type with loading spring and allows oil flow only when pressure oil reaches the cylinder. During the rod re-entering phase the check valve closes preventing oil flow through the inlet duct. Ball check valve, inside the piston, is of the automatic ball type with loading spring and allows oil flow through the inner duct of the piston only at the end of the rod re-entering stroke in order to decrease the braking action on the rising rocking arm. Throttle valve is of the needle type and controls the oil flow through passage allowing the adjustment of the braking action at the end of the rod extraction stroke. The actuator cylinder operates in two different ways, when under pressure or when at exhaust.

Operation of the Cylinder Under Pressure. Pressure oil reaches passage *e* (left cylinder) or *f* (right cylinder), passes through flow control valve 61 and opens check valve thus filling the front chamber of the cylinder and, at the same time, also filling the rear chamber flowing through passage and throttle groove; thus an equalized pressure is established between the two chambers. However, the piston side facing the front chamber being larger, oil exerts a greater thrust on this side with respect to the other side. Piston is then forced to move in the direction of the rear chamber thus causing the rod which actuates the loader drum transmission to move outwards.

While the piston is moving, the oil from the rear chamber (reducing in volume) passes into the front one through groove. Nearing the end of the piston stroke, throttle groove continuously decreases in section. The oil is therefore compelled to pass from the rear to the front chamber through passage and through needle throttle valve which, considerably reducing the aperture of the oil passage, buffers, up to stopping it completely, the movement of the piston rod. Needle valve, which can be adjusted, allows to regulate the progressive braking action during the setting up of the loading system.

Operation of the Cylinder at Exhaust. When the roller on the appendix of rocking arm arriving onto the elevating mass, causes the rod, and therefore the piston, to move inward, the oil contained in the front chamber is forced to:

- pass into the rear chamber through throttle groove and needle throttle valve;
- reach passage *e* (or *f*) through oil passage in the cylinder body (check valve is kept closed by its spring and by the pressure of the oil at exhaust, thus preventing the direct flow in the inlet passage from the front chamber).

When piston nears the end of its stroke, the oil pressure opens ball check valve inside the piston and the oil at exhaust flows only through the oil passage inside the piston to the inlet *e* (or *f*) and the rear chamber and no more through groove.Therefore, the displacement speed of the piston is gradually reduced and, as a consequence, the movement of the rocking arm which is reaching the upper end of its stroke, is also cushioned.

Mechanical Driving Transmission. The mechanical driving transmission is operated by the loader drum actuator cylinders and transforms the alternating movement of the two actuator cylinders in a unidirectional step-by-step rotational motion which is transmitted to the loader drum. The transmission consists of two shifter levers which are alternatively coupled to a pin shifter coupling whose movement is transmitted through a hollow shaft and a bevel gear pair to the loader drum.

The two shifter levers are linked to the piston rods of the two actuator cylinders of the loader drum, and are located on hollow shaft on which they swivel idle and are axially locked.

Each of the two shifter levers is provided with a pin, facing pin shifter coupling; the latter, moving alternatively from right to left and from left to right, operates so that at every step, in succession, one of its holes is entered by pin of right shifter lever causing it to be coupled to one or the other of the two shifter levers of the piston rods of the actuator cylinders Pin shifter coupling is also located on hollow shaft and is connected with key to moving shaft inside hollow shaft; moving shaft and then pin shifter coupling, is moved longitudinally by rocker lever of the clamps actuator cylinder.

Hollow shaft brings bevel gear which meshes with driven bevel gear 89 whose shaft is coupled by a universal joint to connecting shaft. The connecting shaft transmits the movement of the mechanical driving transmission to the actual loader drum to which it is coupled by articulated joint. Universal joint and articulated joint compensate the misalignment between the loader drum and the output shaft of the mechanical driving transmission.

Operation of Mechanical Driving Transmission. The presetting of the coupling of the pin shifter coupling to the shift lever linked to the rod of the loader drum actuator cylinder under pressure is simultaneous to the opening of the nose and bottom clamps of the rocking arm in the upper position, because both the clamp control linkage and the rocker lever which operate the mechanical transmission driving the loader drum, are coupled to the rod of the clamps actuator.Rotation of the mechanical transmission driving the loading drum is operated only after the coupling presetting has taken place: in fact, the clamps actuator cylinder delivers pressure oil to the actuator cylinder of the loader drum only when its spool is at the end of its stroke.

After the clamps actuator cylinder has preset the hydraulic connection, the actuator cylinders of the loading drum are as follows:

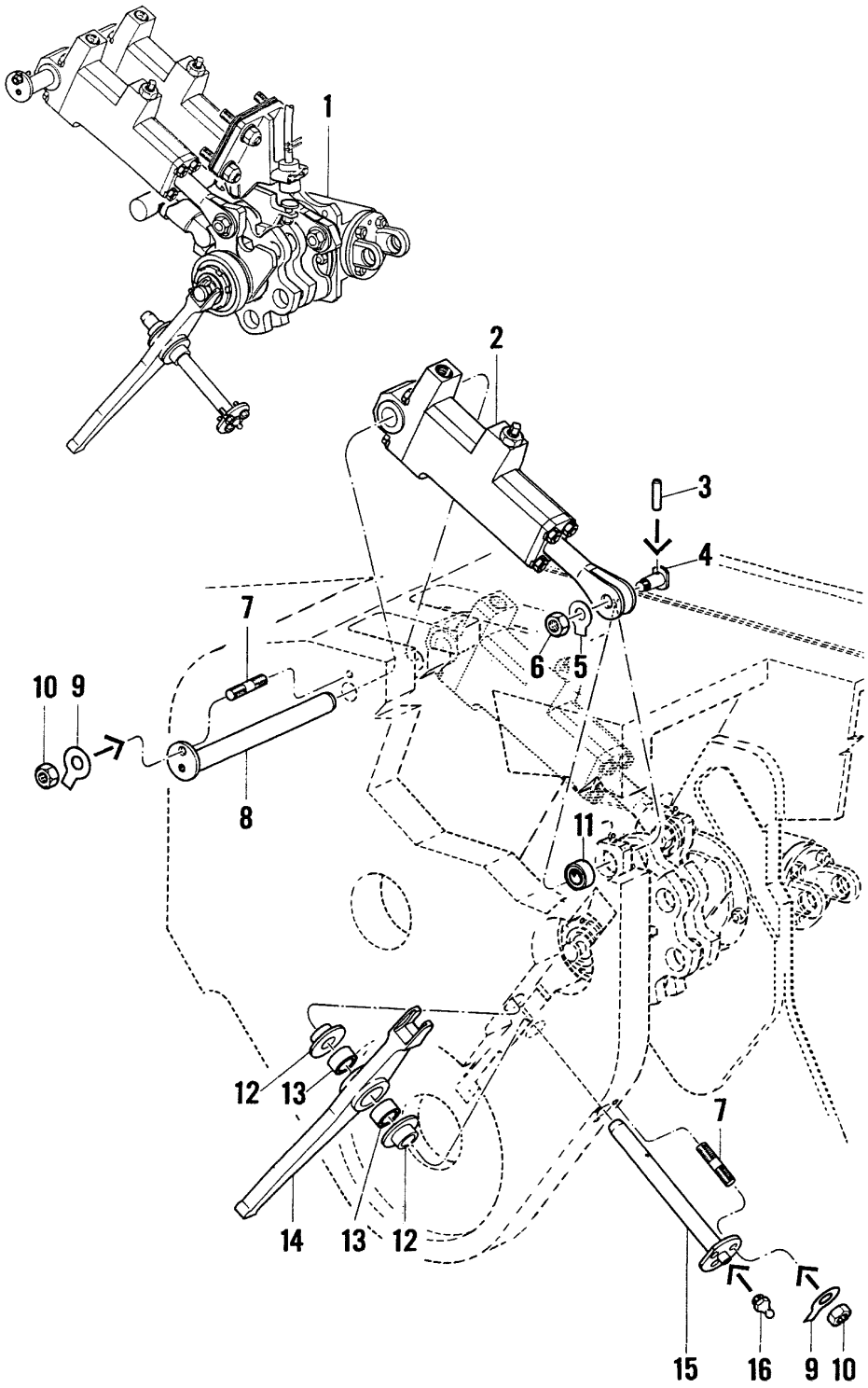
- under pressure, the one the rod of which is linked to the shifter coupled to the pin shifter coupling;
- at the exhaust, the one the rod of which is linked to the shifter lever disconnected from the pin shifter coupling.

The rod of the hydraulic cylinder under pressure, being forced outward, makes its shifter lever swivel. On swiveling the shifter lever exerts its action on pin shifter coupling which was connected to the shifter lever of the cylinder operated by moving shaft that has been shifted by rocker lever.

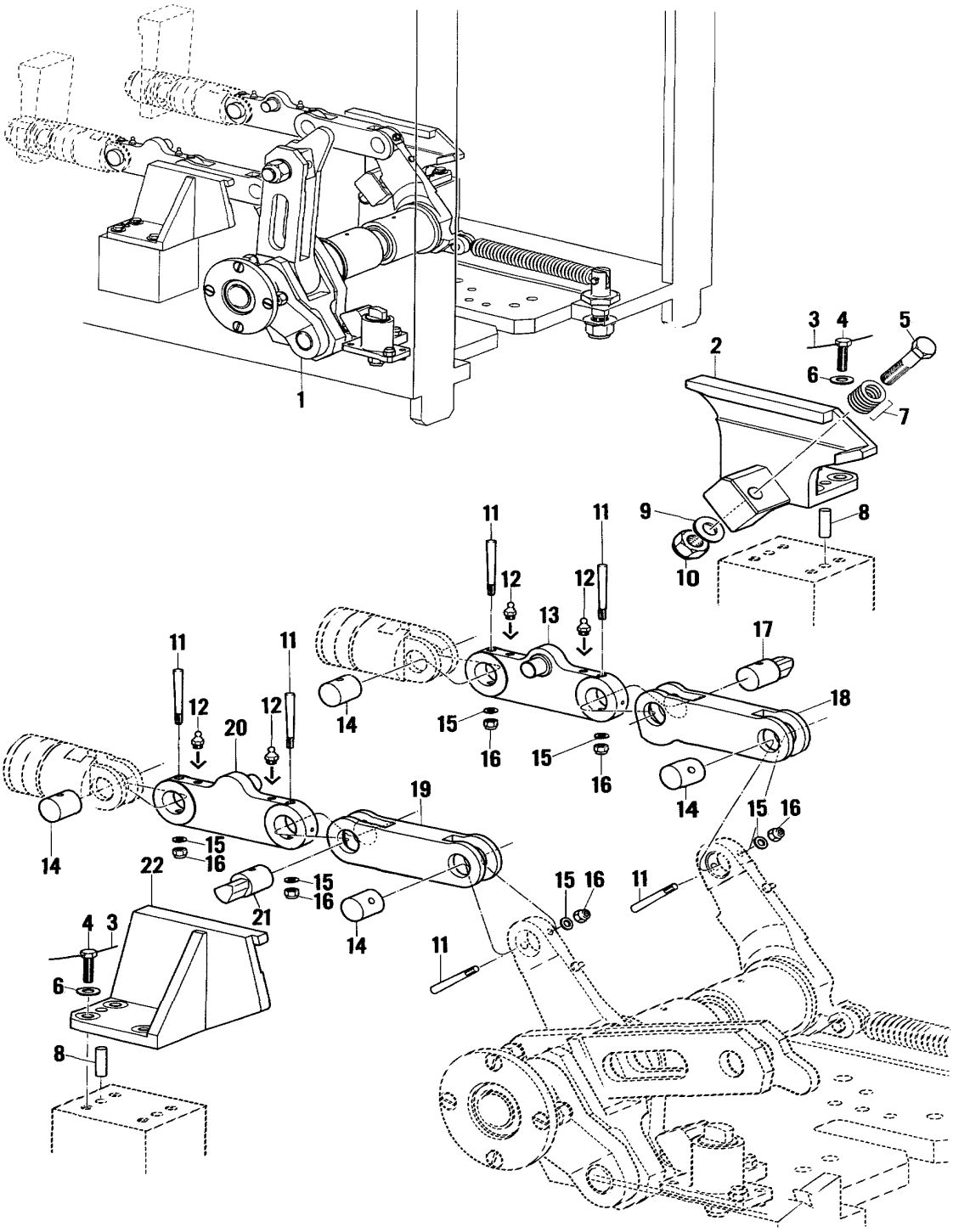
The pin shifter coupling, in its turn, causes hollow shaft to rotate thus making the loader drum rotate through the action of the bevel gear pair. When the piston rod of the actuator cylinder under pressure reaches the end of its stroke, the shifter lever of the same rod, by means of its appendix, strikes against stop (born by shaft fixed to the cradle) which operates as a stroke limiter. The piston rod of the actuator cylinder at exhaust is made re-entered by the rising rocking arm.

In order to synchronize the movement of the rocking arm to that of the loader drum, the shifter levers linked to the piston rods of the loader drum hydraulic cylinders are shaped so that they may couple to the roller on the appendix of the rocking arms. For a part of its movement, the descending rocking arm is in this way mechanically bound up with the mechanical transmission driving the loader drum. Once a certain angle has been overcome (when the rod of the actuator cylinder is completely out) the roller on the appendix of the rocking arm runs tangentially to the shifter lever and the rocking arm movement becomes independent from that of the loader drum. The mechanical coupling of the shifter levers (which are connected to the piston rods of the actuator cylinders of the loader drum) to the rollers of the appendices on the rocking arms, ensures that the rocking arms and the loader drum move synchronized.

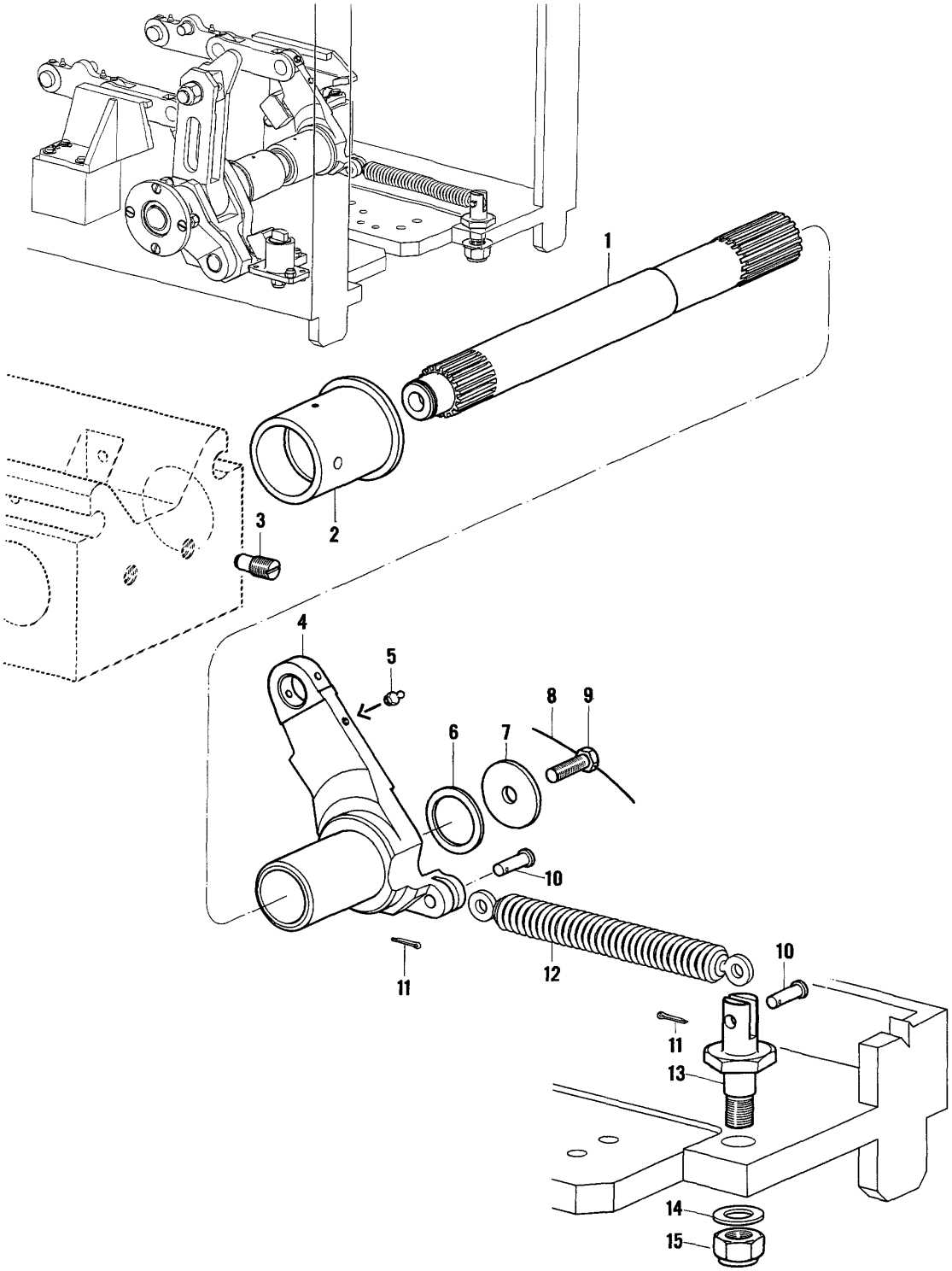
The shifter lever linked to the piston rod of the hydraulic cylinder, which has been disconnected from the pin shifter coupling by the action of the clamps actuator cylinder, has its own cylinder at exhaust. The ascending rocking arm, by coupling the roller on its own appendix to the shifter lever, causes it to rotate backward, thus forcing the piston rod to re-enter the cylinder. The cylinder, which is provided with an oil flow limiting valve, brakes in this way the arrival of the rocking arm for the last section of its ascending stroke.



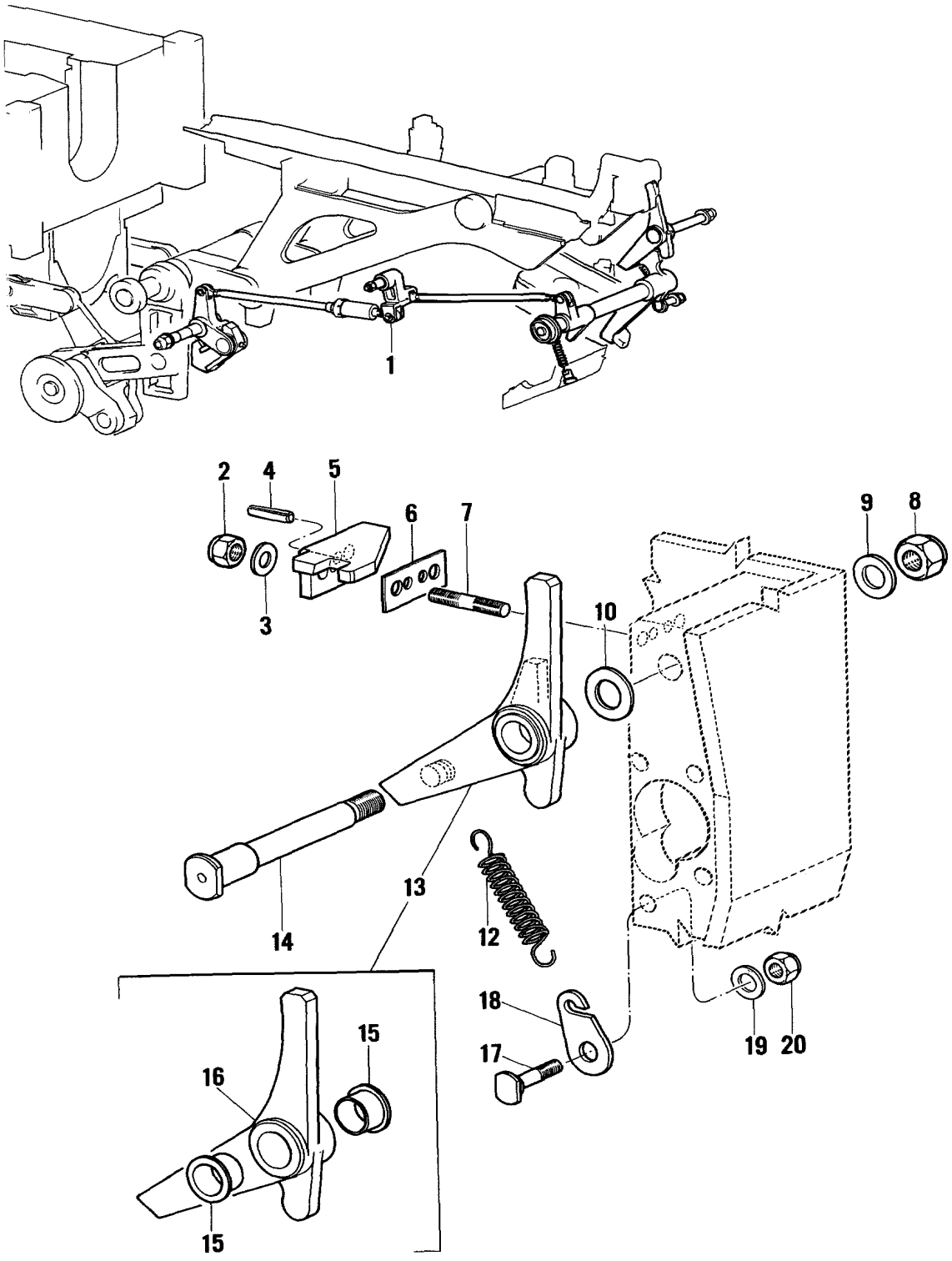
Loader Drum Transmission and Actuator Cylinder



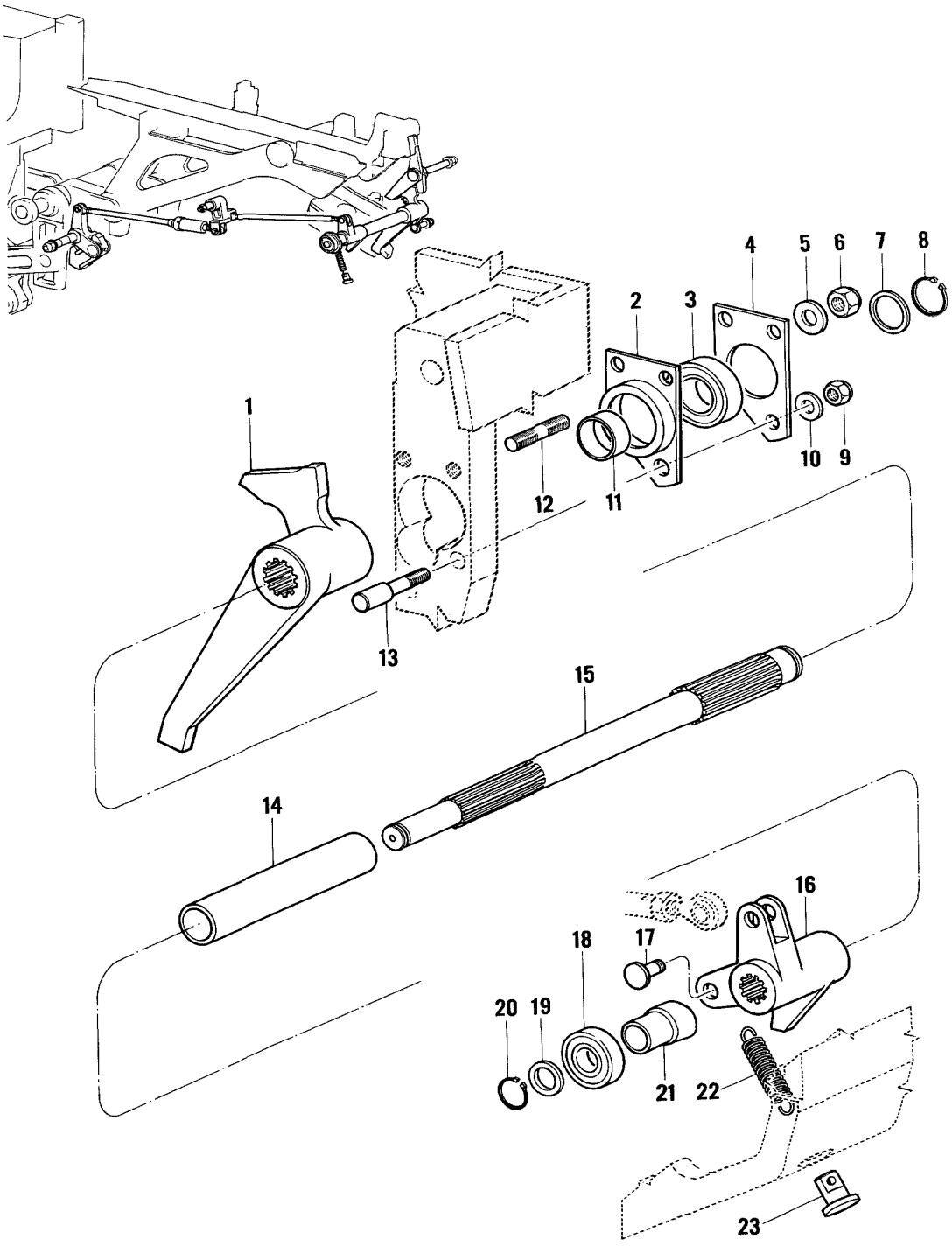
Loading Tray Recocking Transmission



Loading Tray Recocking Transmission



Loading Tray Releasing Transmission



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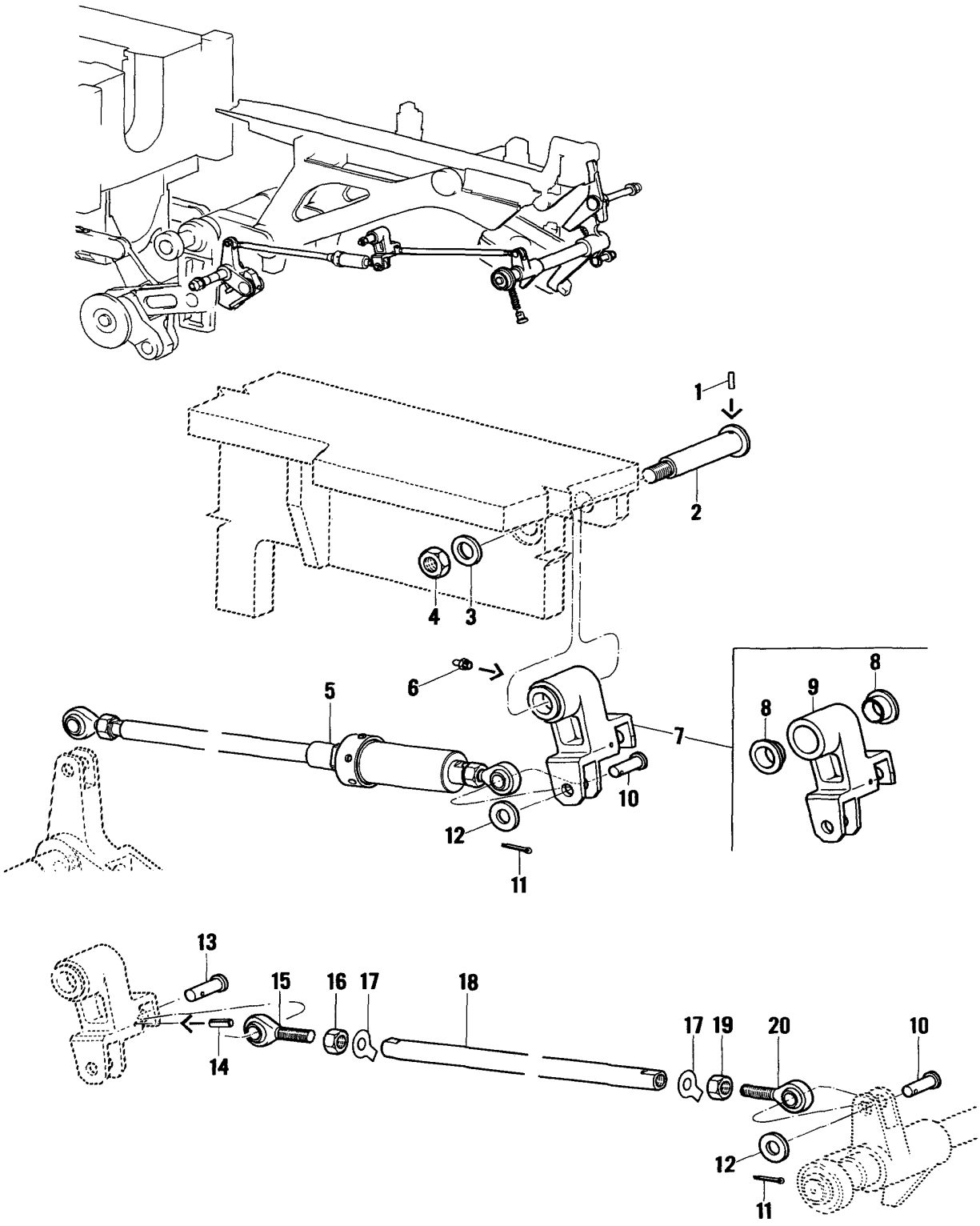

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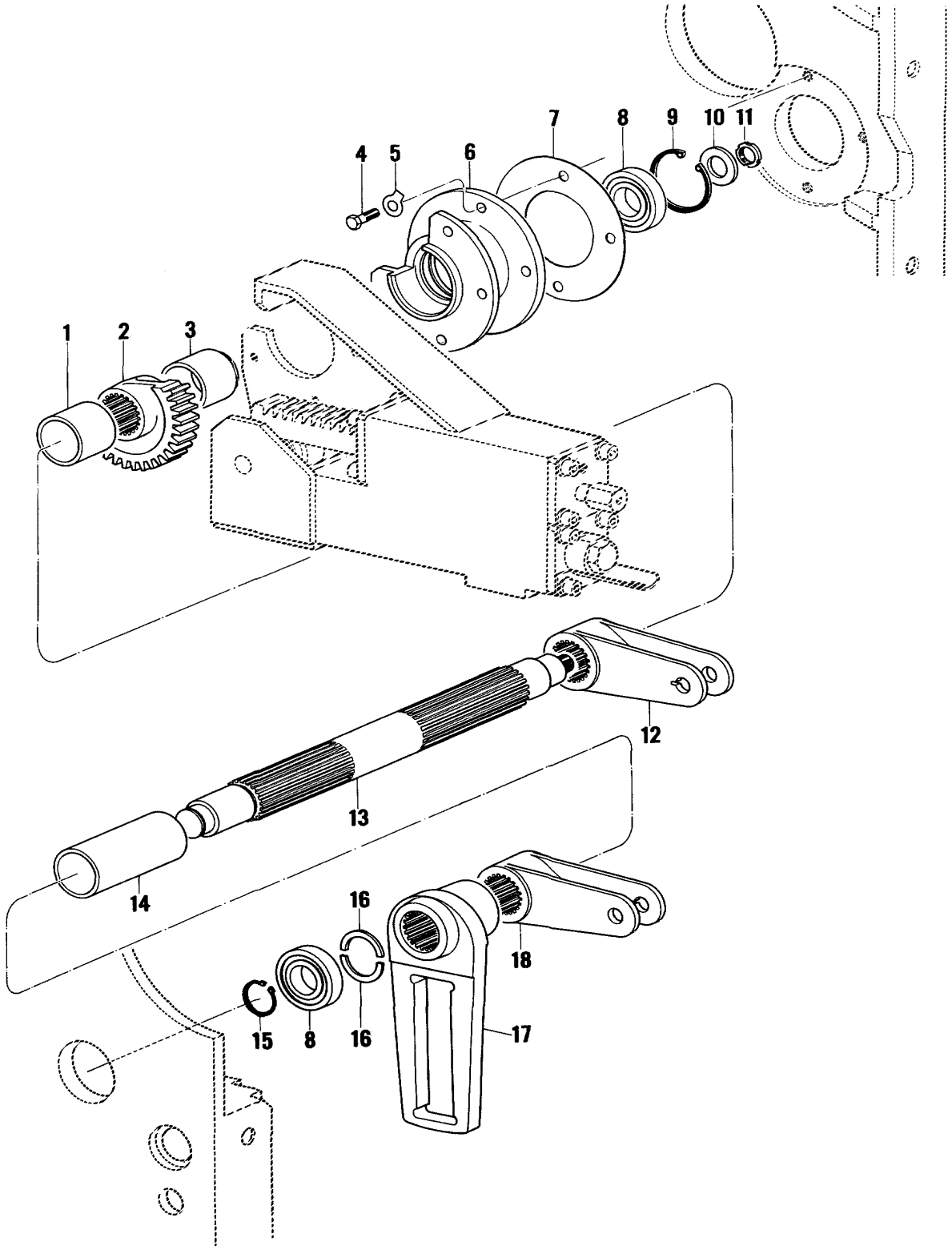
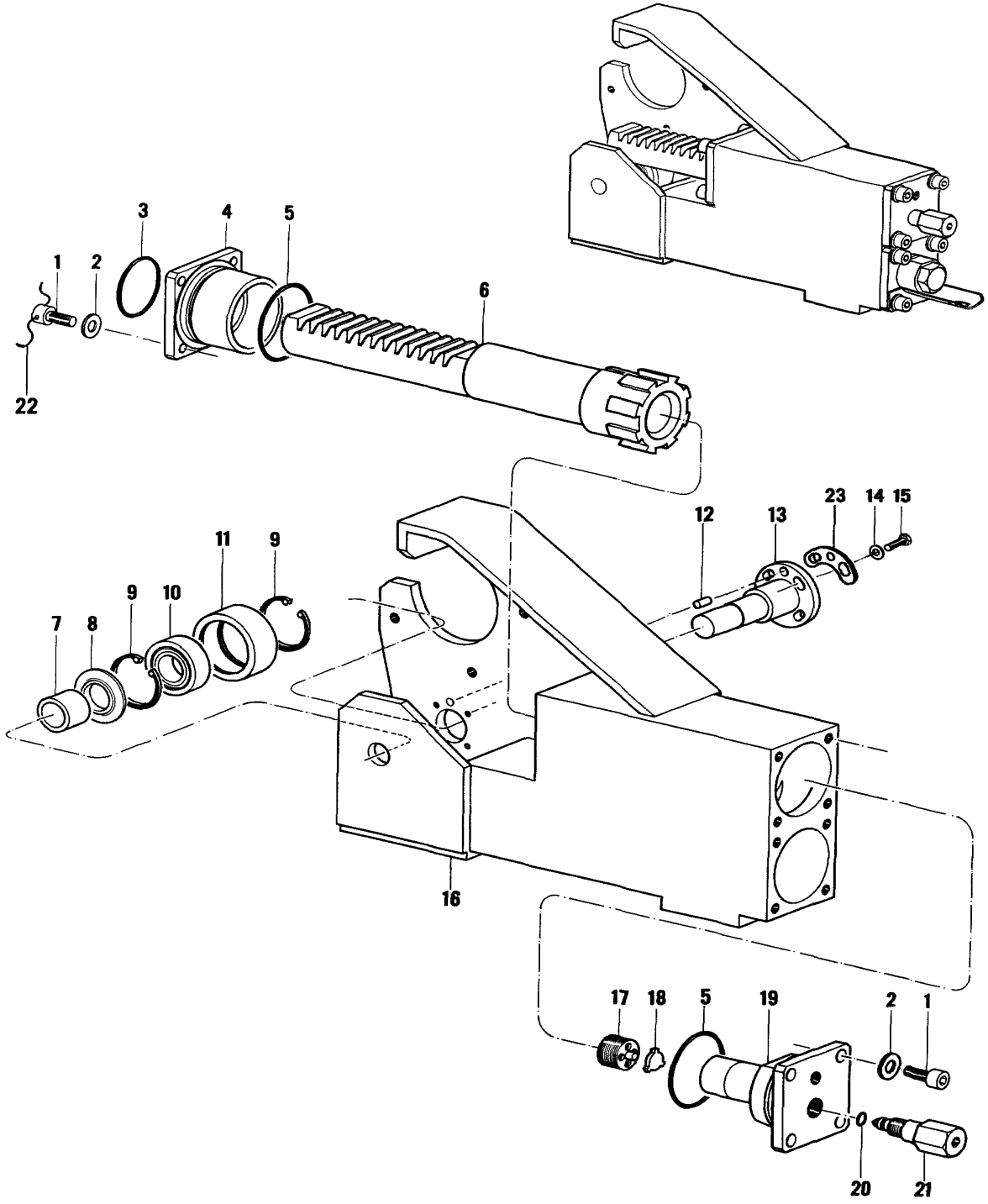


Loading Tray Recuperator



Loading Tray Recuperator

Close die forging components

Extractors. The extractors remove the spent case from the cartridge chamber and lock the breechblock in its open position until the next round is fully seated.

The spent cartridge case is extracted when the breechblock reaches the end of its opening stroke.