United States Patent

[11] **3,568,770**

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[54] **LATCH DEVICE FOR SUPPORTING WELL TOOLS IN A FLOW CONDUCTOR**
21 Claims, 13 Drawing Figs.

[52] **U.S. Cl.** **166/153,** 166/217
[51] **Int. Cl.** **E21b 33/16,** E21b 23/00
[50] **Field of Search** 166/153, 214, 217

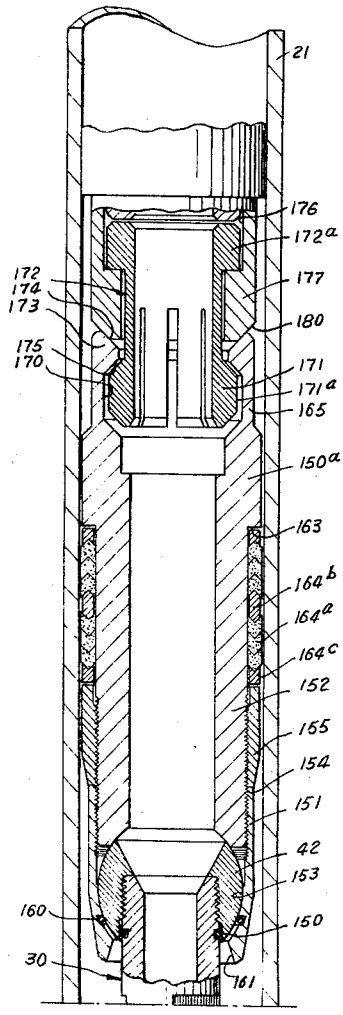
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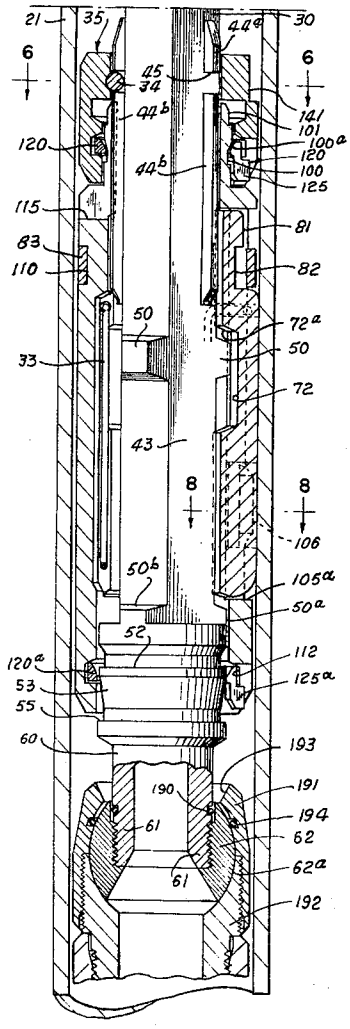
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ABSTRACT: An articulated well tool string comprising a piston power unit, a seal assembly, a safety valve, and a latch for releasably supporting the seal assembly and valve in a flow conductor. The latch includes outwardly biased locking keys supported around a mandrel movable between key-locking and key-releasing positions. During upward movement of the latch in the flow conductor the mandrel shifts upwardly to a key-locking position when the keys expand into a locking recess and engage a downwardly facing shoulder. The train is pumped into and out of the flow conductor by means of the piston which is returned to the surface after installing the latch. The latch and related tools may also be installed by wireline techniques.





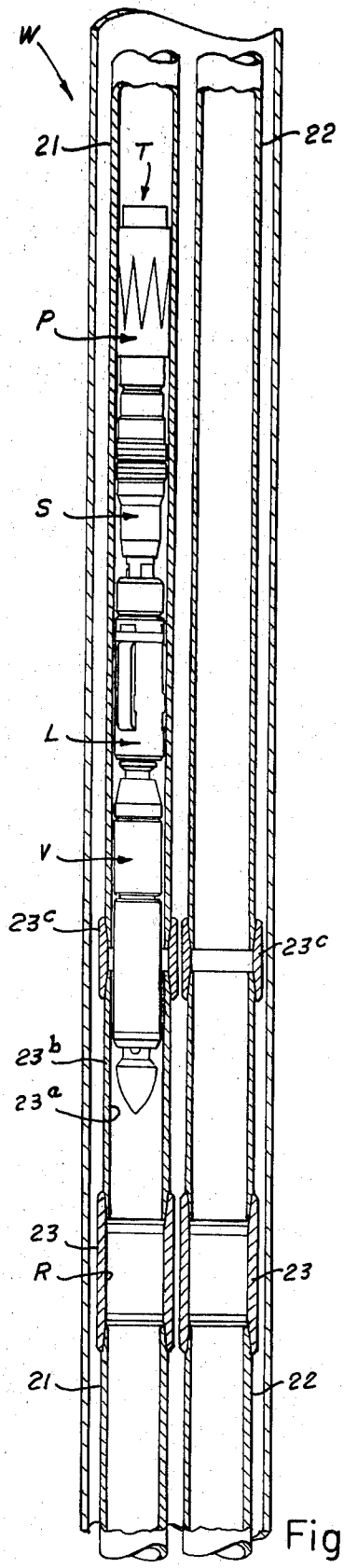


Fig. 1

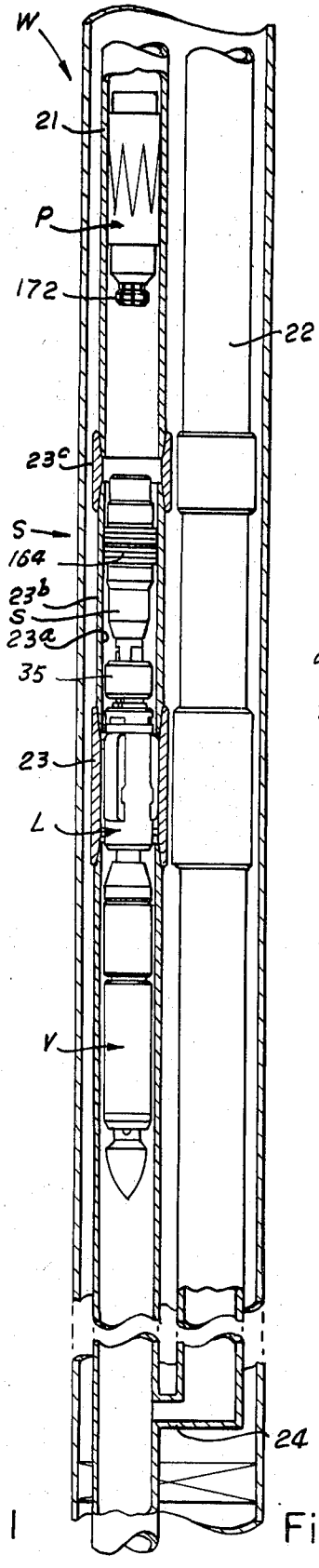


Fig. 2

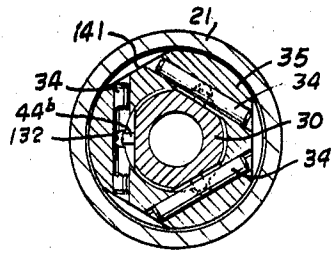


Fig. 6

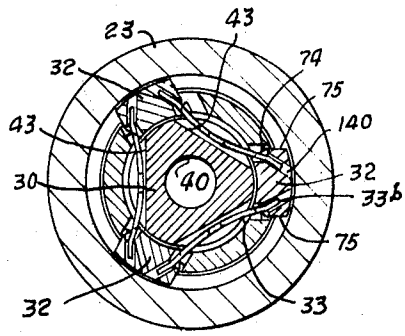


Fig. 7

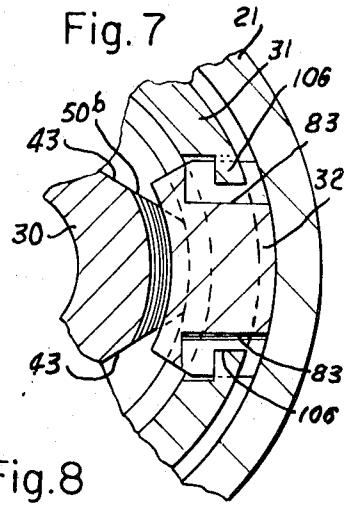


Fig. 8

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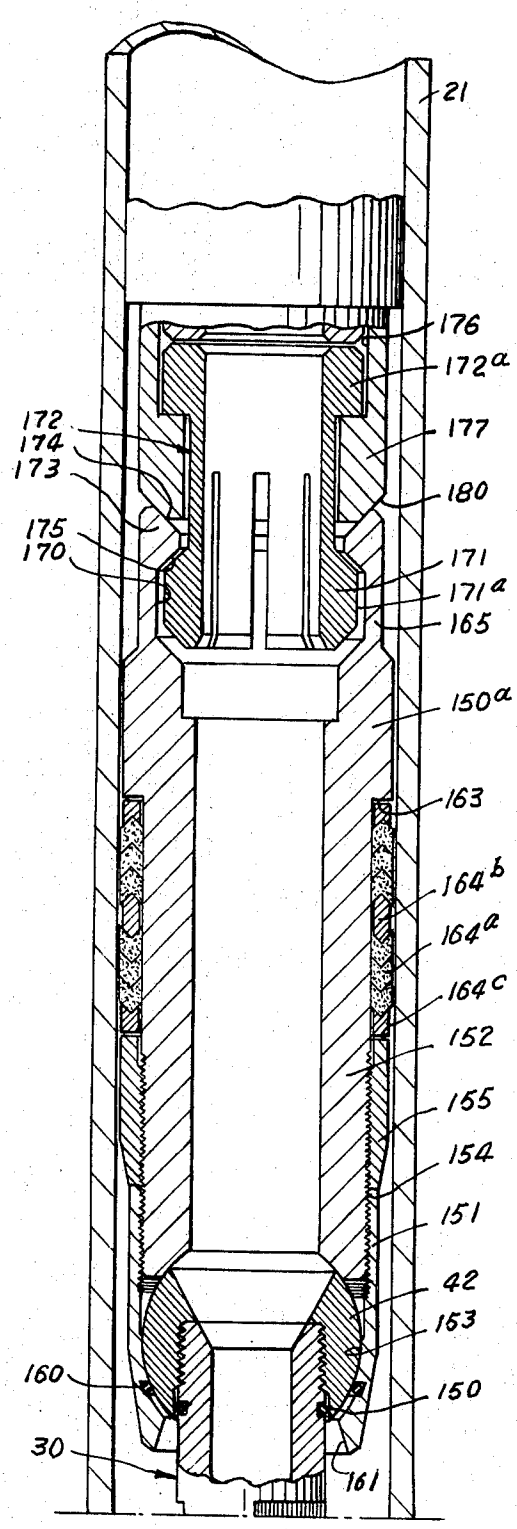


Fig.3A

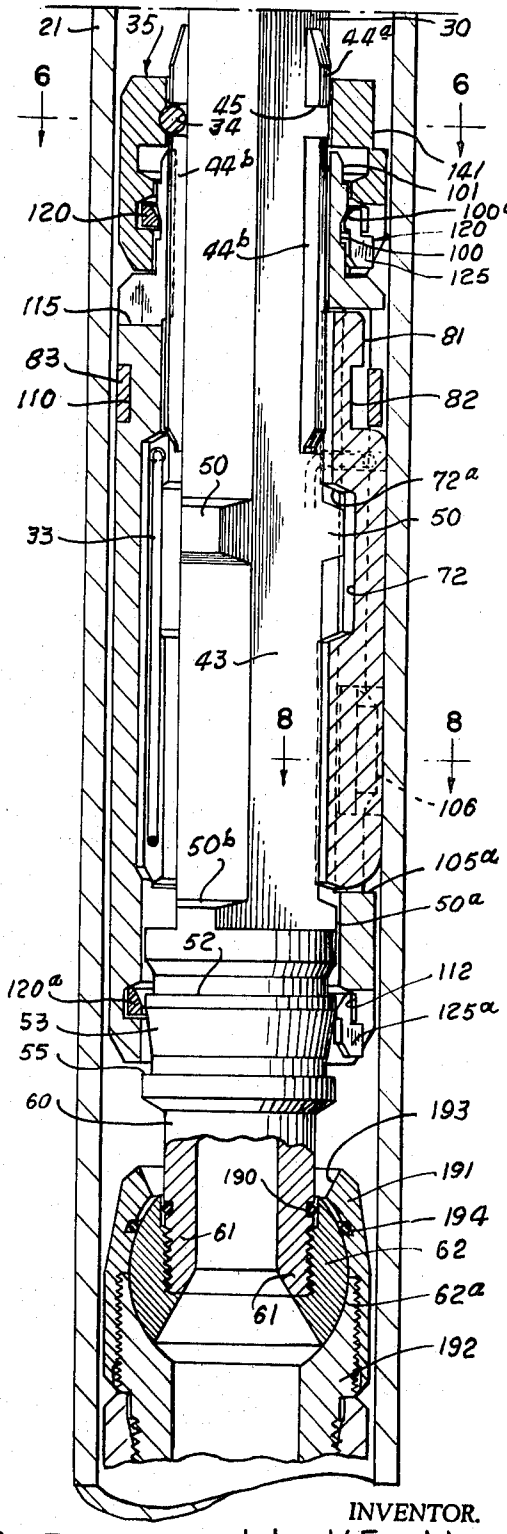


Fig.3B

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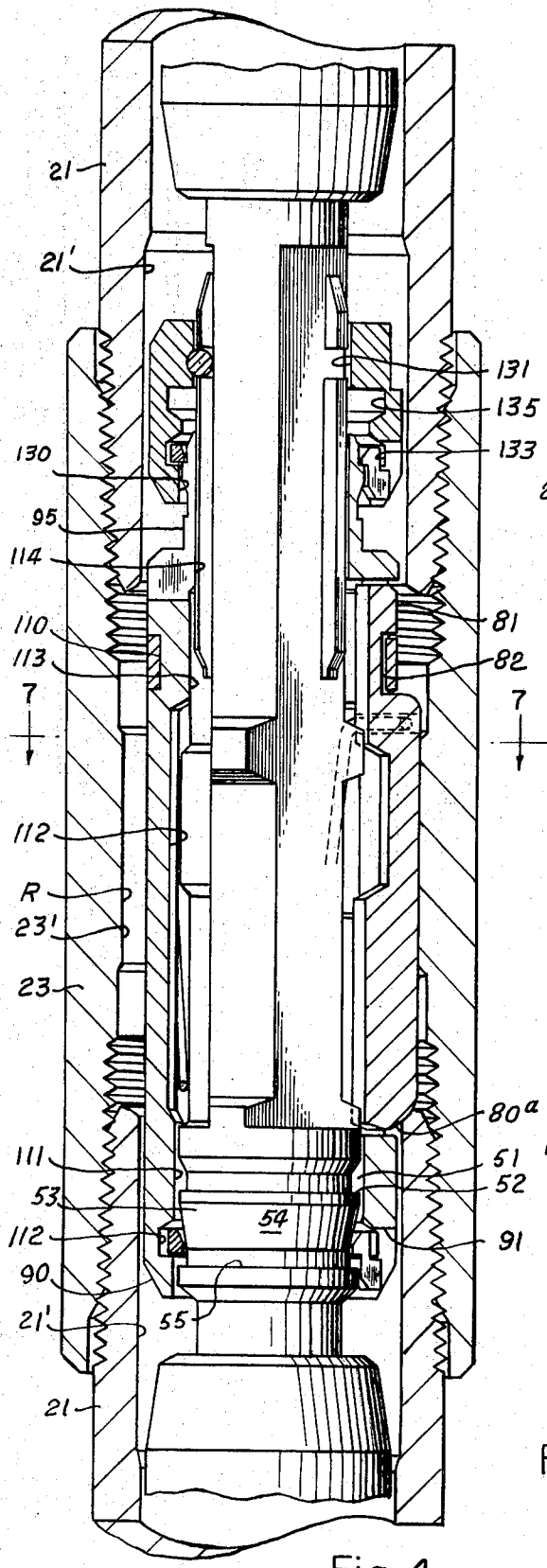


Fig. 4

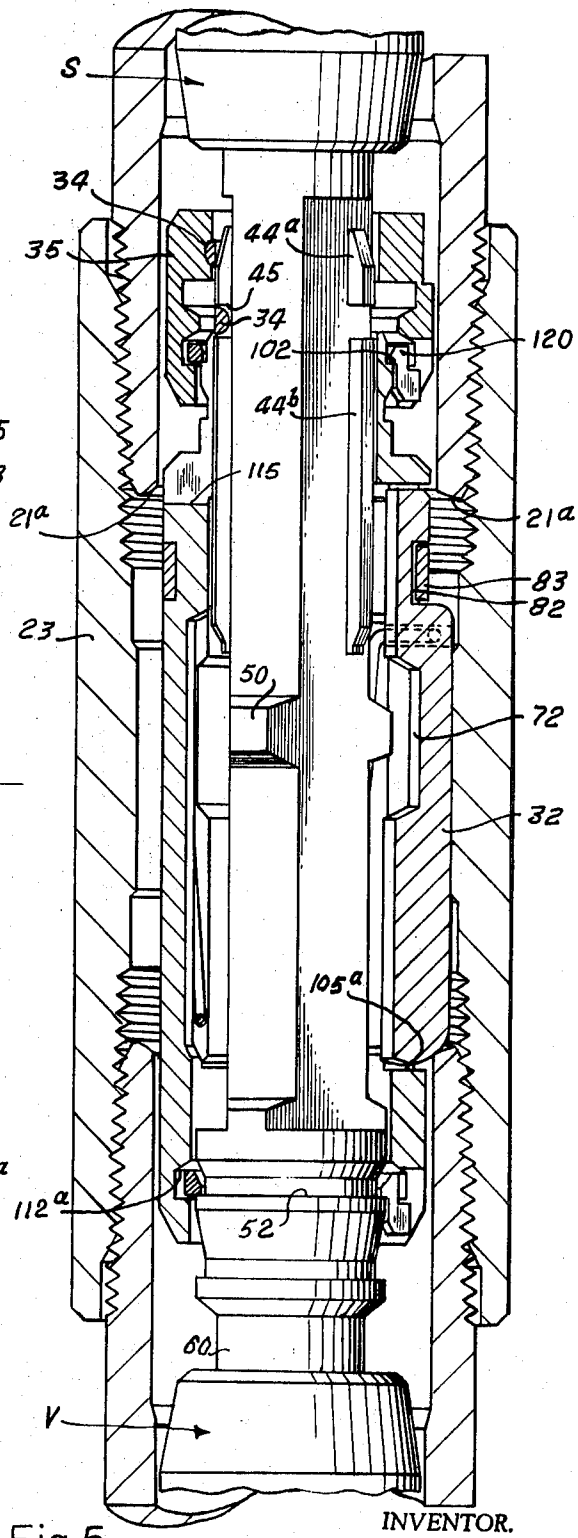


Fig. 5

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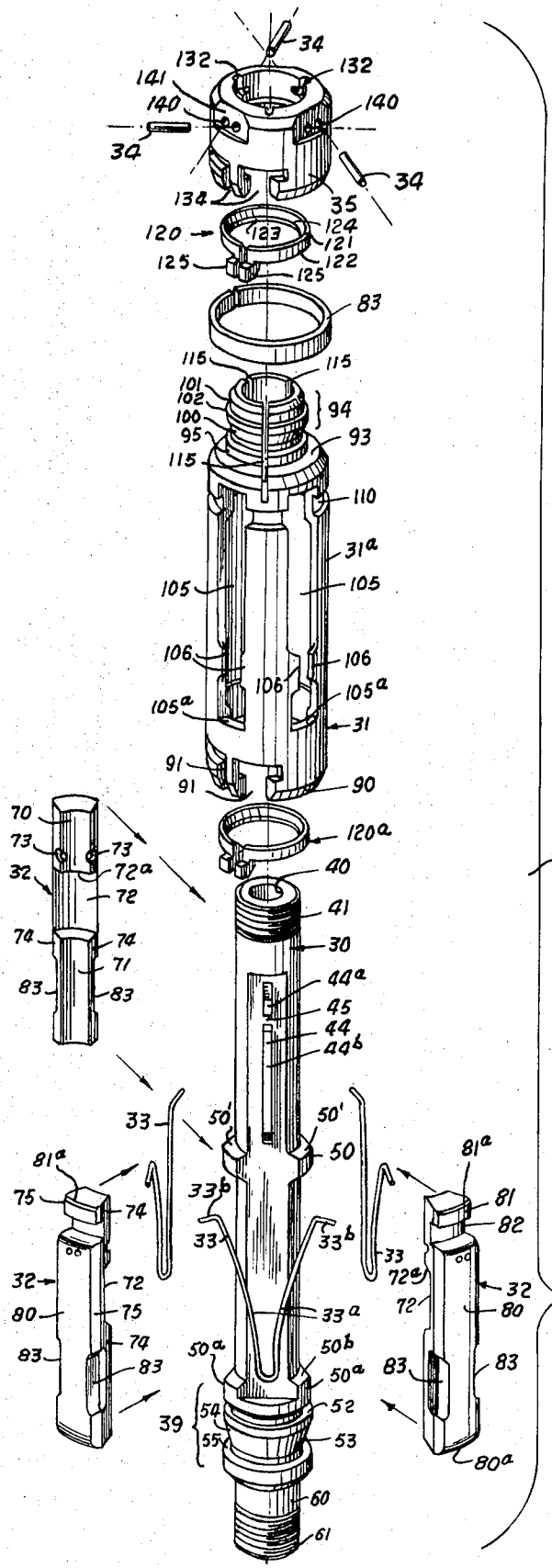


Fig.13

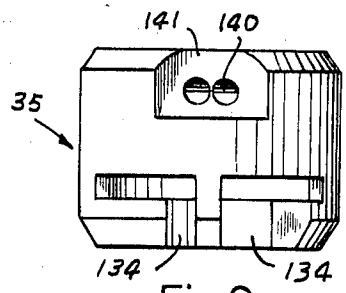


Fig.9

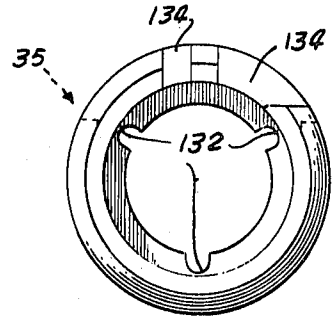


Fig.10

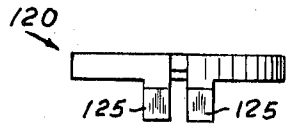


Fig.11

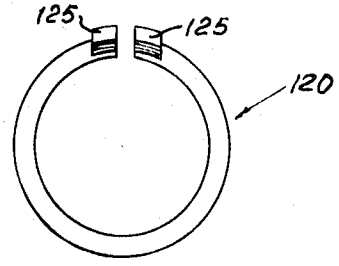


Fig.12

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LATCH DEVICE FOR SUPPORTING WELL TOOLS IN A FLOW CONDUCTOR

This invention relates to well tools and more particularly it relates to a latch which is releasably locked at a recess in a flow conductor for supporting other well tools within the conductor.

It is an especially important object of the invention to provide a new and improved latch which is releasably lockable at a locking recess along a flow conductor by a minimum force and movement in one direction and is releasable by application of a predetermined force in the other direction.

It is another especially important object of the invention to provide a new and improved latch which is remotely lockable in and retrievable from a flow conductor.

It is a further object of the invention to provide a latch of the character described which may be manipulated in a flow conductor by either pump-down techniques or wireline procedures.

It is another object of the invention to provide a latch of the character described which has a minimum number of operating parts.

It is a further object of the invention to provide a latch having locking keys continuously biased outwardly so that they will engage an internal locking recess along the flow conductor contoured to conform to the external shape of the keys so that the latch selectively seeks a locking recess which receives the locking keys on the latch.

It is a further object of the invention to provide a latch of the character described for use in a well flow conductor which is freely movable through the flow conductor in a first direction and which finds and locks at a locking recess in the flow conductor when moved in the opposite direction through the conductor.

It is another object of the invention to provide a latch of the character described which locks upon upward movement into engagement with a downwardly facing shoulder in a flow conductor.

It is a further object of the invention to provide a selective latch which is releasable after locking in place only by severance of shearable means in response to application of a predetermined force on the mandrel of the latch.

It is a further object of the invention to provide a latch which after release from a locked condition in a flow conductor must be removed from the conductor and reset before it is again lockable in the conductor.

It is a further object of the invention to provide a latch which is introduced into a flow conductor and moved along a first direction past the locking recess at which it is to be locked and subsequently returned in the opposite direction to the locking recess for locking.

Still another object of the invention is to provide a latch of the character described which is moved downwardly in a flow conductor below a locking recess and returned upwardly for locking therein and which is removable from the flow conductor only by a downward force for releasing the locking keys of the latch from the locking recess before withdrawing the latch in its released condition upwardly in the flow conductor.

It is a still further object of the invention to provide a latch of the character described which is locked in a flow conductor by movement of the mandrel of the latch from a first running and key release position to a second lock position and is subsequently released by movement of the mandrel from the second locked position back to a third key release and withdrawal position.

It is a further object of the invention to provide a latch of the character described comprising outwardly biased locking keys having inner locking surfaces and a mandrel having key-locking surfaces and longitudinally movable between key-locking and key release positions.

Additional objects and advantages of the invention will be readily apparent from reading the following description of a device constructed in accordance with the invention and by reference to the accompanying drawings wherein:

FIG. 1 is a schematic longitudinal view partly in section and partly in elevation illustrating a pump-down-type tool train in a flow conductor of a well system and including a latch embodying the invention;

FIG. 2 is a view similar to FIG. 1 showing the seal assembly, latch, and well valve of the tool train locked in the flow conductor in accordance with the invention and the piston power unit released and returning to the surface;

FIGS. 3A and 3B taken together constitute a longitudinal view partly in section and partly in elevation of the seal assembly and latch of the tool train of FIGS. 1 and 2 with the locking keys of the latch expanded against and dragging along the inner wall surface of the flow conductor;

FIG. 3A is a longitudinal fragmentary view in section and elevation showing the lower end portion of the piston power unit, the seal assembly, and the upper end portion of the latch;

FIG. 3B is a fragmentary longitudinal view in section and elevation showing a major portion of the latch and an upper end portion of the well valve supported from the latch;

FIG. 4 is a longitudinal view in section and elevation showing the latch with the locking keys expanded into a locking recess of the flow conductor and the latch mandrel at an upper end key-locking position for holding the locking keys expanded;

FIG. 5 is a longitudinal view in section and elevation showing the mandrel returned to its lower release position to allow the locking keys to move inwardly for releasing the latch from the locking recess;

FIG. 6 is a reduced view in section along the line 6–6 of FIG. 3B;

FIG. 7 is a reduced view in section along the line 7–7 of FIG. 4;

FIG. 8 is an enlarged fragmentary view in section along the line 8–8 of FIG. 3B;

FIG. 9 is a side view in elevation of the shear sleeve of the latch;

FIG. 10 is a bottom view in elevation of the shear sleeve of FIG. 9;

FIG. 11 is a side view in elevation of one of the locking rings of the latch;

FIG. 12 is a bottom view in elevation of the lock ring of FIG. 11; and

FIG. 13 is an exploded view in perspective of the latch showing all of its component parts and their interrelationship with each other.

Referring to the drawings, FIGS. 1 and 2 show different depth segments of a well system W equipped for pump-down servicing techniques in which a pumpable tool train T including a latch L embodying the invention is pumped to a locking recess R within one of the strings of tubing of the well system, locked in the tubing at the recess, and subsequently released and removed from the tubing. FIG. 1 shows the tool train moving downwardly toward its locking depth while FIG. 2 illustrates the latch of the tool train locked in the tubing supporting a safety valve V and a seal assembly S while the piston power unit P is detached and being returned to the surface. In accordance with the invention, the piston unit is pumped back to the tools in the tubing to release the latch and retrieve the entire tool train which is pumped to the surface after coupling with and releasing the latch.

The well system S includes a casing 20 in which a pair of parallel first and second tubing strings 21 and 22 are supported from a wellhead, not shown. The tubing strings 21 and 22 illustrated in FIGS. 1 and 2 include spaced collars 23 and 23*c* connected by a nipple 23*b* having an inner seal surface 23*a*. The collar 23 defines a locking recess R within the collar between the ends of the tubing sections connected into the collar for receiving the locking keys on the latch L so that the latch is locked in the tubing string at the collar as shown in FIG. 2. The enlarged detail of FIGS. 4 and 5 provide a better showing of the structure of the adjacent ends of the tubing sections and the connecting collar 23 defining the locking recess R. Each adjacent end portion of the tubing sections 21 has an enlarged bore portion 21′ which allows the keys on the latch

to begin expanding preliminary to entry into the locking recess R between the ends of the tubing sections. The spacing between the ends of the tubing sections and the diameter of the bore portion 23' of the collar determines the selectivity of the locking recess so that if several such tubing and collar connections are made along a tubing string only that one in which it is desired to lock the latch L has a recess R of sufficient length and internal diameter to accept the locking keys of the latch at their fully expanded positions so that the latch may be locked at such recess.

As shown in FIG. 2, the tubing strings 21 and 22 communicate through a crossover connection 24 between the tubing strings below the recess R to provide input and return flow paths in the well so that the tool train may be pumped into and out of the tubing string 21 as discussed in more detail hereinafter. The surface ends of the tubings 21 and 22 are provided with suitable valves, pumping apparatus, and the like for establishing either of the tubing strings as an input line and the other string as a return line. One or both of the tubing strings at the surface also is equipped with the necessary apparatus, such as a lubricator, for the introduction and withdrawal of the tool train so that it may be pumped into and out of the well through the tubing string. Arrangements for the connection of the input and return lines to the well system W and the inclusion of the lubricator for introduction and retrieval of the tool train in one of the tubing strings are illustrated schematically in U.S. Pat. Nos. 3,419,074 and 3,419,075 both issued Dec. 31, 1968 to Norman F. Brown.

The piston power unit P may comprise any of a number of known types of pumpable seal units which are displaced through a flow conductor by fluid pressure. For example, the piston unit 200 illustrated in FIG. 6 of U.S. Pat. No. 3,419,075 may be utilized with its connector socket 205 slightly modified as represented in FIG. 3A herein to accommodate the collet connector used for coupling the piston unit with the seal assembly S. Similarly, the safety valve V may be a known unit such as the valve 10 described and claimed in U.S. Pat. No. 3,070,119 issued to G. M. Raulins, Dec. 25, 1962.

In accordance with the invention, the latch L includes a longitudinally extending mandrel 30 which is movable within a key cage 31 and a plurality of circumferentially spaced, longitudinally extending, and radially expandable and contractable locking keys 32. The keys are biased outwardly by springs 33 and are locked at their fully expanded positions by the mandrel when it is shifted behind the keys to what shall be defined as its "locking position" which is the upper end position when the tool is oriented as illustrated in the drawings. Once the mandrel is lifted to the upper end position for locking the keys at their fully expanded positions, it is returnable downwardly to release the keys only by shearing the pins 34 which interlock the shear sleeve 35 of the latch with the mandrel.

The mandrel 30 is basically a tubular-shaped structure having a longitudinal bore 40 extending throughout its length to accommodate well production fluids and fluids used for pumping the tool train to and from the desired location in the tubing string. The mandrel is threaded along an upper end portion 41 into a ball joint member 42 used to provide a pivotal coupling between the upper end of the latch and the seal assembly S. Along a major portion of its length the mandrel is provided with longitudinal circumferentially spaced flat surface portions or faces 43. One of the key springs 33 is disposed along the lower portion of each of the faces 43 as best represented in FIG. 13. A longitudinally extending, centrally aligned guide rib 44 provided with a shear pin notch 45 is formed along the upper portion of each face 43 for receiving one of the shear pins 34 to interlock the shear sleeve 35 with the mandrel. The guide vanes each comprise a short upper portion 44*a* and a substantially longer lower portion 44*b* which are spaced to define the shear slot 45. As particularly evident in FIGS. 4 and 5, each of the guide ribs is tapered inwardly along each of its opposite end portions toward the face 43. The mandrel is enlarged along a short central portion located about midway between the ends of the side faces 43 providing three locking bosses 50 circumferentially spaced 120° apart around the mandrel between the faces 43 so that each of the locking bosses lies within one of the locking keys 32 for movement between lock and release positions. The mandrel is also enlarged along a lower portion 39 at the lower ends of the faces 43. The mandrel portion 39 is provided with lower locking surfaces 50*a* and cam shoulders 50*b*, and a first upper locking recess 51 the lower end of which is defined by an abrupt locking shoulder 52. The mandrel portion 39 also has a second lower somewhat longer recess 53 defined by an upwardly extending divergent surface 54 and a lower upwardly facing abrupt shoulder surface 55. The recesses 51 and 53 perform a lock ring receiving function as discussed in detail hereinafter. The mandrel has a lower end portion 60 which is threaded at 61 to form a connection with a ball joint member 62, FIG. 3B, for coupling the latch with the safety valve V.

Each of the key springs 33 is substantially flat when free and relaxed as illustrated in FIG. 13. Each spring is provided with a V-shaped body portion 33*a* and outwardly extending, short, free end portions 33*b* each of which engages an adjacent locking key 32. Each spring is disposed along one of the mandrel faces 43 with spring end portions 33*b* engaging locking keys on opposite sides of the face. Three such springs are used, one being positioned along each mandrel side face between adjacent edges of the locking keys located along opposite sides of the springs so that the cooperative action of the three springs functions to constantly bias the three locking keys radially outwardly.

Each of the locking keys 32 is basically a cylindrical segment having upper and lower inner spaced cylindrical surface portions 70 and 71, respectively, formed on a diameter slightly greater than the diameter of the mandrel 30 so that when the keys are fully retracted or compressed inwardly along the cylindrical surface portions of the mandrel between the faces 43 the keys fit snuggly along the mandrel. With the keys retracted the inner surface portion 70 of each key is disposed along the mandrel above the bosses 50 and the lower cylindrical portion 71 of the key lies along the mandrel below the bosses 50. Each key has an inwardly opening inner recess 72 between the inner surface portions 70 and 71 to receive a mandrel locking boss 50 when the key is fully compressed inwardly. Each of the keys has a pair of laterally spaced inwardly opening diverging holes 73 which are somewhat flared at their inward ends opening through the inner face 70 of the key and the adjacent side or edge face of the key as best illustrated by the upper left key in FIG. 13 and in FIG. 7. Also the holes 73 lie in a plane which is perpendicular to the longitudinal axis of the key. The holes 73 are each sized to receive a free end portion 33*b* of the key springs so that the end portions of each spring are received in the holes 73 along the adjacent side faces of the pair of locking keys on opposite sides of the spring. The vertical side edges of the keys are formed by inwardly convergent inner edge portions 74 and outer parallel edge portions 75. The outer cylindrical face 80 of each key extends over the major portion of its length defining a locking portion of the key which is receivable in the recess and drags relatively smoothly along the wall of the tubing string as the latch moves to and from the locking recess. The upper end portion of each key has a surface portion 81 spaced from the outer surface portion 80 defining therebetween an outwardly opening recess 82 adapted to receive a split retainer ring 83 which retains the upper end portions of the keys. The diameter of the surface portion 81 of each key is less than the diameter of the surface portion 80 as best seen in FIGS. 4 and 5. A longitudinal side opening recess 83 is formed along the lower portion of each edge of each key to perform a key retaining function for limiting the outward movement or expansion of the lower end portions each of the keys. The pair of recesses 83 in each key are laterally spaced from each other and longitudinally spaced from the lower end of the key. The upper and lower outer end edges of the key portions defined by the outer surfaces 80 are curved at 80*a* and 81*a* so that when the

keys are free to expand and contract they are readily cammed inwardly at either end by various shoulders and other surfaces encountered when moving the latch into or out of the tubing string.

The key cage **31** is basically a hollow cylindrical member having a downwardly and inwardly beveled lower outer edge surface **90** and a pair of circumferentially spaced, downwardly and outwardly opening inverted L-shaped slots **91** along the lower end portion of the cage. At the upper end of its major uniform diameter body portion **31***a* the key cage has an upwardly and inwardly convergent beveled edge surface **92** which joins an upwardly facing shoulder surface **93** in a plane perpendicular to the longitudinal axis of the key cage. Above the surface **93** the key cage has a reduced end portion **94** which is provided with a cylindrical surface **95**, a lower external annular lock ring recess **100**, and an upper upwardly and outwardly opening lock ring recess **101** above a locking shoulder surface **102** defining the lower end of the upper lock ring recess **101**.

The body portion **31***a* of the key cage **31** is provided with three longitudinal, circumferentially spaced, key slots **105** opening from the inner bore through the wall of the key cage. Each of the slots **105** is shaped to receive one of the locking keys **32** in a sufficiently loose fitting relationship to permit the key to radially expand and contract between the positions represented in FIGS. **3B** and **5**. Each of the key slots **105** is reduced in width along a lower intermediate portion defining a pair of laterally spaced longitudinally aligned retainer flange portions **106** which are received in the recesses **83** of the locking key disposed in the slot to retain the lower end portion of the key in the slot. The outward expansion of the key is limited by the depth of the slots **83** as measured inwardly from the outer face **80** of the key. When the key is moved outwardly, the outward movement of the key is limited by the engagement of the flanges **106** with the bottom surfaces of the key slots **83**. The key cage is provided along its upper portion of the body **31***a* with an external annular recess **110** which intersects the slots **105** and receives the key retainer ring **83** so that the retainer ring is disposed around the key cage within the recess extending through the recesses **82** in each of the keys disposed in the slots **105** to retain the upper end portions of the keys.

The bore of the key cage varies in diameter so that the different diameter portions of the mandrel **30** are receivable in the key cage and permit the mandrel and the key cage to move longitudinally relative to each other. The bore of the key cage includes a lower portion **111** sized to receive the lower enlarged end portion of the mandrel along its locking ring recesses **52** and **53**. This lower end portion of the key cage bore has an internal annular locking ring recess **112** which intersects the lock ring slots **91**. The key cage bore is enlarged above the portion **111** along a central portion **112** to provide space around the mandrel within the cage between the keys to accommodate the key springs **33**. Above the portion **112** the key cage bore has a reduced portion **113** to provide the cage with sufficient wall thickness to accommodate the key retainer ring recess **110**. The key cage bore is still further reduced in diameter along a portion **114** also to provide sufficient wall thickness for structural strength along the lock ring recesses **100** and **101** and to accommodate three slots **115**. The slots **115** are circumferentially spaced 120° apart, extend longitudinally parallel to the longitudinal axis of the key cage, open radially completely through the entire wall thickness of the key cage, open upwardly at the upper end of the key cage, and extend downwardly in the key cage into the body portion **31***a* above the annular recess **110**. The guide ribs **44** on the mandrel are each received in one of the slots **115** along the reduced bore portion **114** of the key cage to prevent the rotation of the mandrel relative to the key cage while providing for free longitudinal movement of the mandrel relative to the cage. The function of the slots does not require that they be cut entirely through the wall of the key cage so long as they are sufficiently deep radially to accommodate the guide ribs. The particular construction shown requires substantially simpler machining procedures than would be necessary to cut the slots within the cage bore only sufficiently deep to accommodate the guide ribs.

Locking functions between the mandrel and the key cage are performed by the upper and lower split locking rings **120** and **120***a*, respectively, which are identical in all respects with the suffix *a* being used to denote the lower ring and its features. The locking ring has a split ring body **121** which has an outer cylindrical surface **122** and inner cylindrical surfaces **123** and a chamfered or tapered inner surface **124**. A downwardly and outwardly extending lug or retainer foot **125** is formed integral with each free end portion of the ring body. The locking rings **120** and **120***a* perform locking functions with respect to the relationship between the mandrel and the key cage and are assembled between such parts as described in further detail below.

The shear sleeve **35** is a tubular or cylindrical member having beveled upper and lower end faces and is provided with a longitudinal bore sized along its lower portion **130** to fit over the upper end portion **94** of the key cage and reduced in diameter along its upper end portion **131** to loosely fit over the cylindrical upper end portion of the mandrel **30**. The portion of the shear sleeve along the bore section **131** is provided internally with three longitudinal grooves **132** spaced 120° apart to receive the guide fins **44** on mandrel so that the mandrel and shear sleeve may move relative to each other when the sheer sleeve is assembled over the mandrel as represented in FIGS. **4** and **5**. The grooves **132** extend only the length of the bore portion **131** as the bore portion **130** of the shear sleeve is sufficiently larger in diameter that it fits over the upper end portion **94** of the key cage exteriorly of the mandrel ribs **44**. The lower bore portion **130** of the shear sleeve is provided with a lower internal annular locking ring recess **133** intersected by a pair of laterally spaced inverted L-shaped downwardly opening slots **134** which receive the tabs **125** on the locking ring **120** when it is disposed within the recess **133** for coacting with the upper end portion of the key cage in manipulating the mandrel for locking and releasing the keys **32**. The bore portion **130** of the shear sleeve also is provided with a second upper internal annular recess **135** for the sheer pin fragments when the latch is released as in FIG. **5**.

Three shear pinholes **140** are provided in the shear sleeve to receive the shear pins **34** for coupling the mandrel and the shear sleeve and holding them together until a force is applied to the mandrel for releasing the latch keys from their expanded locked positions. The shear pinholes all lie in a common plane which is perpendicular to the longitudinal axis of the shear sleeve. Each of the holes extends in such plane perpendicular to a radius line drawn from the longitudinal axis of the shear sleeve to the longitudinal axis of the vertical slot **132** intersected by the shear pinhole so that a shear pin **34** disposed in the hole may pass through the slot **45** of the mandrel guide rib disposed through the shear sleeve slot **132** when the shear pin slot **45** is aligned with the shear pinhole. The opposite ends of the shear pinholes open through flat side faces **141** provided at 120° spacing around the shear sleeve. The near ends of adjacent shear pinholes open through the same sleeve side face **141** as evident in both FIGS. **6** and **13**. Geometrically each of the side faces **141** lies in a plane which is parallel to the longitudinal axis of the shear sleeve and perpendicular to a radius line drawn from the sleeve axis to the vertical centerline of the face **141**. The opening of the shear pinholes at their opposite ends facilitates assembly of the latch and ready insertion of one or more of the shear pins from either end of any one of the shear pinholes for interconnecting the shear sleeve and mandrel.

FIG. **3B** shows the assembled relationship of the various parts of the latch at the time the latch is run into a tubing string in a tool train as represented in FIG. **1**. The locking keys **32** are each positioned in one of the key cage slots **105** with the edge recesses **83** of each key aligned with the key retainer flanges **106** along the vertical side edges of the slots **105** so

that the flanges **106** are received within the key recesses **83** to hold the keys in the slots and limit their radial expansion. The split ring **83** is placed around the key cage within the external annular recess **110** so that the portion of the ring intersecting each slot **105** is received within the outwardly opening recess **82** of the key in the slot for retaining and limiting the radial expansion of the upper end portion of the locking key. The key springs **33** are installed within the key cage for constantly biasing the key to their fully expanded position. One spring is inserted within the cage along the inner face of the cylindrical portion of the cage between each pair of adjacent key-receiving slots **105**. The opposite free end portions **33***b* of the key springs are inserted into the adjacent holes **73** of the keys on opposite sides of each spring so that each spring biases the keys on either side of it apart and outwardly relative to the key cage. The three springs cooperate to bias the three keys outwardly. FIG. **7** shows the upper end view of the springs when their ends are inserted into the spring holes **73** of the adjacent locking keys. In assembling the spring between each pair of keys the legs **33***a* of the springs are compressed together relative to the normal relaxed position of the spring legs, as shown in FIG. **13**, so that the springs when connected between the keys tend to spread apart resulting in a biasing force forcing the keys outwardly.

Preliminary to insertion of the mandrel into the cage, the lower split locking ring **120***a* is placed in the lower internal annular recess **112** of the key cage with its foot members **125***a* extending in spaced relation into the downwardly opening cage slots **91**. The mandrel is inserted upwardly into the key cage within the keys and springs with the guide ribs **44** on the mandrel being aligned with and inserted through the guide slots **115** of the cage so that the mandrel is aligned within the cage with the lower portion of each of the mandrel side faces **43** disposed within one of the key springs **33** so that the spring lies substantially flat along the mandrel face below the mandrel bosses **50** between adjacent keys as partially shown in FIGS. **3B** and **5**. As the mandrel is introduced into the cage, the locking ring is spread sufficiently for the bosses **50** to readily pass through the ring and to allow the mandrel to move upwardly into the cage until the locking ring is below the flange surface **52** on the mandrel. The slots **91** of the key cage permit the insertion of a tool to spread the ends of the locking ring sufficiently to clear the bosses **50** on the mandrel and the other flange surfaces along the mandrel which the ring must pass to reach its initial operating position below the shoulder surface **52**.

After assembly of the locking keys, springs, cage and mandrel as described above, the shear sleeve **35** is assembled on the upper end of the key cage in the relationship shown in FIG. **3B**. Initially the upper locking ring **120** is inserted into the internal recess **133** of the shear sleeve with the foot members **125** of the ring disposed in the spaced slots **134** opening into the recess **133**. The shear sleeve with the locking ring installed is then placed over the upper end of the mandrel with the slots **132** of the shear sleeve aligned with the guide ribs **44** on the mandrel. The shear sleeve is lowered on the mandrel and over the upper end of the upper end portion of the key cage with the locking ring **120** spread by an appropriate tool within the shear sleeve to clear the uppermost external annular shoulder surface **120** on the upper end portion of the key cage so that the shear sleeve and locking ring are lowered to the position shown in FIG. **3B** at which the lower end face of the locking sleeve substantially engages the shoulder surface **93** on the key cage. The coaction between the guide ribs **44** and the recesses **132** of the shear sleeve holds the shear sleeve against rotation on the key cage and mandrel. Longitudinally the shear sleeve is positioned to align the shear pinholes **140** of the sleeve with the slots **45** in the guide ribs of the mandrel. One or more shear pins **34** are then inserted into the holes **140** of the shear sleeve through the guide rib slots **45** so that the shear sleeve is secured against longitudinal movement on the mandrel by the shear pins. The number of shear pins employed is dependent upon the strength of the material of which the pins are made, the diameter of the pins, and the force level desired for releasing the latch from its locked position in the tubing.

With the various parts of the latch assembled in the relationship shown in FIG. **3B** for running the tool train into the tubing string, the locking bosses **50** on the mandrel are aligned within the internal recesses **72** of the locking keys **32**. Also, at this position of the mandrel the lower cam and locking surfaces **50***a* and **50***b* on the mandrel are below the lower ends of the keys. Thus, the keys are free to be fully compressed inwardly for moving the latch along the tubing string to the locking recess R. The lower locking ring **120***a* is disposed within the key cage recess **112** below the locking shoulder surface **52** on the mandrel. The upper locking ring **120** is disposed within the shear sleeve recess **133** and the lower external annular recess **100** on the upper end portion of the key cage below the locking shoulder **102**. The shear sleeve and its upper locking ring **120** are locked against longitudinal movement on the mandrel by the shear pins. Until the latch is inserted into the tubing string at the surface and if its locking keys **32** are not held compressed by a suitable binding or strap, not shown, the keys will be biased fully outwardly and the movement of the key cage with the keys downwardly on the mandrel is opposed only by the locking ring **120**. The beveled internal annular face **124** of the locking ring engages the downwardly and inwardly tapered surface **100***a* on the cage along its recess **100** opposing the movement of the cage and keys relative to the shear sleeve and locking ring to the extent that the ring is inherently sprung inwardly. If the cage and keys are accidentally forced downwardly on the mandrel moving the cage shoulder **102** below the locking ring **133** and locking the keys outwardly, a suitable tool is inserted into the slots **134** of the shear sleeve to expand the locking ring allowing the cage and key to be moved upwardly releasing the keys for inward movement. Of course, once the latch is inserted into a tubing string having a diameter sufficiently small to preclude the full expansion of the locking keys with the keys being held inwardly as shown in FIG. **3B**, the cage and locking keys are prevented from moving downwardly on the mandrel or the mandrel upwardly in the cage by the engagement of the bosses **50** with the upper end surfaces **72***a* defining the upper ends of the recesses **72** in the keys and by engagement of the mandrel shoulder faces **50***b* with the lower ends of the keys. The cage and keys cannot move upwardly on the mandrel as the shoulder **93** on the cage is engageable with the lower end face of the shear sleeve.

After assembly of the latch L, the latch is connected in the tool train T for pumping into the well. The upper threaded end portion **41** of the latch mandrel is threaded into the ball joint member **42** of the seal assembly S. A seal ring **150** is disposed in an external annular recess around the upper threaded end portion of the mandrel within the ball joint **42** to seal against leakage between the mandrel and the ball joint. The ball joint **42** is confined within the seal assembly cap **151** against the lower end of the seal assembly mandrel **152**. The cap has an internal annular spherical surface **153** which is engaged by the external spherical surface on the ball joint **42**. The cap is threaded on the external threaded end portion **154** of the mandrel **152** against a packing retainer nut **155** threaded on the mandrel above the cap. A ring seal **160** is disposed in an internal annular recess of the cap **151** to seal within the cap around the ball joint. The lower end of the cap **151** is flared at **161** providing an opening into the cap sufficiently larger than the mandrel **30** immediately below the ball joint to permit sufficient pivotal movement between the packing assembly and the latch mandrel for transversing curved portions of the tubing string through which the tool train is pumped in servicing a well.

The mandrel **152** is enlarged along a portion **150***a* providing a downwardly facing annular shoulder **163** against which a packing assembly **164** is held by the upper end face of the retainer ring **155**. The packing assembly is conventional in form including V-shaped packing rings **164***a* and male and female support rings **164***b* and **164***c*, respectively.

The upper end portion 165 of the packing assembly mandrel 152 is provided with an internal annular locking recess 170 opening upwardly to receive radially expandable and contractable collet fingers 171 of a collet 172 supported from the piston unit P. The collet pivotally and releasably couples the power piston with the packing assembly. The upper end of the locking recess 170 is defined by an internal annular flange 173 having an upper, downwardly and inwardly tapered surface 174 and a lower downwardly and outwardly tapered surface 175 permitting ready insertion and withdrawal of the collet fingers. The strength of the collet fingers and thus their resistance to compression determines the force necessary to withdraw the collet from the locking recess 170 disengaging the piston from the seal assembly mandrel and to reinsert the collet fingers into the locking recess. The lower end face 180 of the piston body substantially conforms to the surface configuration of the upper end surface 174 of the seal assembly mandrel and the collet fits sufficiently loosely in the locking recess to permit enough flexing between the piston and seal assembly for traversing the curved portions of the tubing string of a well.

The collet 172 has a ring portion 172 confined within a recess 176 in the lower end portion of the power piston. The other features of the power piston which are not shown are illustrated and described in the earlier noted reference patents.

The lower end of the latch L is pivotally secured to the safety valve V as shown in FIG. 3B by the ball joint 62 which is threaded on the lower end portion 61 of the latch mandrel. A seal ring 190 is disposed in an external annular recess around the latch mandrel above its threaded lower end portion and seals around the mandrel within the ball joint. The ball joint 62 is held by a cap 191 against the upper end of the mandrel 192 of the safety valve V. The cap and mandrel are provided with internal spherical surfaces engageable with the external spherical surface 62*a* of the ball joint to provide a pivotal connection between the safety valve and the lower end of the latch mandrel. The upper end of the cap 191 has a downwardly and inwardly tapered surface 193 which is sufficiently larger in diameter than the latch mandrel to allow pivotal movement of the latch mandrel relative to the safety valve as the tool train traverses curved portions of the tubing string. A seal ring 194 is disposed within the cap around the ball joint to seal between the cap and the joint. As previously stated, the safety valve V is constructed and functions in accordance with the reference patent showing and describing it.

The installation of the latch L with the seal assembly S and the safety valve V involves known pump-down procedures. The tool train T comprising the power piston, the seal assembly, the latch, and the safety valve is inserted into a lubricator, not shown, located at the surface and communicating with the tubing string 21. The valve V is introduced first with the locking keys 32 of the latch L being held inwardly and the latch cage and keys at upper key release positions as represented in FIG. 3B so that the keys are fully compressed inwardly as the latch is inserted into the tubing string. Fluid pressure is applied in the tubing string behind the tool train to develop a pressure differential across the power piston P for displacing the tool train along the tubing string. The fluid in the tubing string ahead of the tool train moves downwardly in the string, across through the connection 24 into the tubing string 22 below the tool train, and returns to the surface through the tubing string 22 so that a complete closed fluid circuit is provided in the well for moving the tool train to the desired depth in the well. As the tool train moves downwardly in the tubing string, the locking keys of the latch drag along the inner wall of the tubing string as represented in FIGS. 1 and 3B since the keys are held out by the force of the springs 33. The beveled end outer edge surfaces of the keys allow them to pass irregularities along the tubing wall and at joints with the keys flexing radially as they move along such irregularities. The seal 164 on the seal assembly S is sufficiently smaller in diameter than the tubing string internal diameter that it easily slides along the tubing surface without dragging.

The tool train is pumped downwardly in the tubing string 21 until it passes through and is below the locking recess R at which it is desired that the latch L be locked. When the latch reaches the collar 23 defining the recess R, the latch keys expand into the recess but are immediately cammed back inwardly out of the recess allowing the tool train to proceed below the recess since the latch keys are held out only by the force of the springs and cannot be locked outwardly by application of the downward force to the latch mandrel. The approximate depth of the tool train in the tubing string is determined by standard considerations involved in pump-down techniques. For example, the physical dimensions of the well system providing a measure of its volume, particularly that of the tubing string 21, together with a measure of the amount of fluid pumped into the string behind the tool train permits a ready determination of the depth of the tool train at any given time. If the expansion of the locking keys into the recess R during the downward movement of the tool train holds the latch and tool train with sufficient force to provide a noticeable change in pressure in the fluid above the tool train, this change may be detected at the surface indicating arrival of the latch at the recess. However, it is problematical that this method of determining when the tool train is at the proper depth is sufficiently reliable, and therefore, the preferred technique is to pump the train to a depth which clearly is below the locking recess measuring its progress by input fluid volume.

After it is determined that the tool train is at or below the recess R, the fluid flow direction in the well system is reversed with fluid being introduced at the surface into the tubing string 22 and returned to the surface through the tubing string 21. A pressure differential is again applied across the power piston P with the higher pressure being applied below the piston so that the tool train is lifted toward the recess R in the tubing string 21. As the tool train is reversed toward the recess R, the drag of the locking keys 32 along the tubing string wall biases the keys and the key cage downwardly relative to the mandrel and shear sleeve until the upper cam surfaces 50' on the mandrel bosses 50 engage the internal key surfaces 72*a* defining the upper end of the key recess 72 and the mandrel cam surfaces 50*b* engage lower end surfaces of the keys. When the keys move into the recess R, the biasing force of the springs and the camming force from the mandrel expand the keys into the recess allowing the mandrel to move upwardly relative to the keys and key cage to the key-locking position illustrated in FIG. 4. If the tool train moves slowly upwardly into the end of the recess, the locking action of the mandrel may occur before the keys are lifted to the upper end of the recess and engagement with the recess shoulder 21*a*. The piston lifts the latch until the upper end edges of the key surface portions 80 engage the shoulder 21*a* limiting further upward movement of the latch. At this latter position the lower locking ring 120*a* wedges between the mandrel shoulder surface 55 and the lower end of the cage holding the mandrel against further upward movement. The piston is then further lifted to disengage it from the rest of the tool train as discussed hereinafter. If the tool train moves into the locking recess fairly rapidly, the upper end edges of the locking surfaces of the keys may engage the recess shoulder 21*a* while the mandrel cam surfaces are still below and engaged with the key surfaces 72*a* and the lower ends of the keys. The outward-camming action of the mandrel and the biasing forces of the springs overcomes the inward-camming action of the shoulder 21*a* against the keys to fully expand the keys to their locking positions. It will be obvious that the camming surfaces on the mandrel and the keys, both internal and external, and the recess shoulder 21*a* must all be so shaped and at such angles that when the keys arrive at the recess-locking shoulder while the mandrel is fully engaged along its camming surfaces with the keys, the resultant forces on the keys must effect their full expansion to allow the mandrel to move to the locked position. Obviously, too shallow an angle on the shoulder 21*a* might cam the keys back inwardly to preclude proper locking or might possibly wedge the keys

against the mandrel if the latch is moved slowly into the recess so that it would be difficult to release. The relationship of the key cam surfaces and shoulder 21*a* also must be such that when the mandrel is returned to the key release position the cooperative action of the shoulder 21*a* and the key cam surfaces at the upper end of their surfaces 80 will cam the keys back inwardly to release the latch from its locked relationship. The locking shoulder surface and the key and mandrel cam surface angles and shapes are readily determinable by design considerations which will vary depending upon the strength of the key springs, the pulling forces applied to the mandrel, and related factors.

With the keys held against upward movement at the recess R, the key cage also is held stationery due to the disposition of the keys in the slots 105. The lower end faces 105*a* of the slots 105 engage the lower end faces 80*a* of the keys holding the key cage against upward movement so long as the keys cannot move upwardly. The upward force applied by the piston P through the seal assembly to the upper end of the latch mandrel 30 lifted the mandrel and the shear sleeve 35 due to the connection of the shear pins between the mandrel and the shear sleeve. The mandrel is raised within the keys and key cage, and the shear sleeve is telescoped upwardly on the upper end of the upper end portion of the key cage raising the upper locking ring 120 along the upper end portion 94 of the key cage. The mandrel is moved to the position illustrated in FIG. 4 at which the lower face of the locking ring 120 engages the shoulder 102 on the upper end portion of the key cage locking the shear sleeve and mandrel against downward movement relative to the key cage and keys. So long as the locking ring 120 engages the shoulder 102 on the key cage the shear sleeve and mandrel cannot move downwardly within the key cage and keys.

During the upward movement of the mandrel and shear sleeve lifting the locking ring 120, the upwardly and outwardly tapered surface 100*a* along the recess 100 cams the locking ring outwardly spreading it apart so that it passes upwardly along the key cage upper end portion until it is above the shoulder 102 where it snaps inwardly to lock the mandrel and shear sleeve. The raising of the mandrel within the key cage and keys positions an upper portion of the mandrel locking bosses 50 above the recesses 72 of the keys behind the upper inner faces 70 of the keys to lock the upper portions of the keys outwardly so that they cannot be cammed or compressed radially inwardly. Similarly, the lower key-locking surfaces 50*a* on the mandrel aligned with the lower end portions of the faces 43 are lifted behind the lower end portions of the inner surfaces 71 of the keys to lock the lower ends of the keys outwardly so that they cannot be compressed radially inwardly. Any force tending to further lift the mandrel causes the lower locking ring 120*a* to engage the shoulder surface 55 along the lower end portion of the latch mandrel thereby holding the latch mandrel against upward movement relative to the keys and key cage. Thus the upper locking ring 120 and the lower locking ring 120*a* hold the locking mandrel and shear sleeve against upward and downward movement to the extend necessary for the release of the latch while permitting a small amount of movement or shifting of the mandrel, such as about one-eighth to one-fourth of an inch. In this locked relationship at the recess R the latch L resists any upward force which does not exceed the structural strength of the latch parts and any downward force which is not sufficient to shear the pins 34.

After the latch mandrel has been shifted to its upper locked position as described above, further upward fluid pressure against the power piston lifts the piston and its collet 172 relative to the seal assembly S camming the collet fingers inwardly releasing them from the locking recess 170 at the upper end of the seal assembly mandrel so that the collet head bosses 171*a* are withdrawn from the locking recess releasing the piston from the remainder of the tool train as represented schematically in FIG. 2. The piston is then pumped back to the surface and removed from the well system through a lubricator, not shown, connected with the tubing string 21. In reversing the fluid flow for pumping the piston back to the surface, fluid flow conditions must be avoided which might result in closing the safety valve V which would interrupt the reverse flow pattern and stop the return of the piston to the surface.

With the piston removed from the system the latch L remains locked at the recess R supporting the safety valve V and the seal assembly S with the seal 164 on the seal assembly engaging the internal seal surface 23*a* in the nipple 23*b* connected between the lower coupling 23 and the upper coupling 23*c* in the tubing string 21. The seal assembly prevents flow of fluids upwardly around the tool string thereby forcing them to pass through the safety valve. The functioning of the safety valve so long as it is latched in the position shown is conventional in nature and comprises no part of the present invention.

When removal of the interconnected latch, seal assembly, and safety valve, from the tubing string is desired, the power piston is again introduced into the tubing string 21 at the surface and pumped downwardly in the tubing string until its collet 172 is reengaged with the upper end of the seal assembly. As the piston is pumped against the upper end of the seal assembly, the collet finger heads 171 engage the upper end surface 174 of the seal assembly mandrel camming the fingers inwardly until they are sufficiently compressed for the piston to fully introduce them into the locking recess to the position in which they are shown in FIG. 3A. The arrival of the piston at and its coupling with the upper end of the seal assembly is readily detectable at the surface by a substantial abrupt increase in the pressure of the fluid being pumped into the well system for displacing the piston downwardly. When it is so determined the piston has arrived and is coupled with the locked components of the tool train, the fluid pressure is further increased to a predetermined level calculated to apply a downward force to the upper end of the latch mandrel 30 sufficient to shear the pins 34 to release the mandrel for downward movement relative to the shear sleeve, key cage, and locking keys. When the downward force is sufficient on the mandrel, the upper sections 44*a* of the three guide ribs on the mandrel sever portions of each of the shear pins releasing the mandrel to move downwardly. The mandrel is then forced downwardly in the locking surfaces along the bosses 50 and the lower locking surfaces 50*a* downwardly below the upper and lower internal surface portions 70 and 71 of the locking keys, respectively, so that the keys are released for inward movement around the mandrel out of the recess R. The shear sleeve and upper locking ring 120 remain at the position shown in FIG. 4 on the upper end portion of the key cage while the mandrel moves downwardly through the shear sleeve and key cage. When the mandrel shoulder surface 52 along its lower end portion passes below the lower locking ring 120*a*, the locking ring contracts inwardly into the mandrel recess 51 as shown in FIG. 5 for holding the mandrel against upward movement so that it may not return to its upper key-locking position. Any upward force on the mandrel then tends to wedge the locking ring against the cage along the shoulder surface 112*a* defining the upper end of the locking ring recess 112 to prevent upward movement of the mandrel relative to the cage. The force applied to move the mandrel downwardly and shear the pins 34 for releasing the locking keys will generally drive the entire tool train downwardly when the keys are released and are cammed inwardly by the action of their lower end faces against the upper end surface of the tubing section connected into the lower end of coupling 23 so that the latch releases allowing the tool train to move below the recess R. The sudden downward release of the tool train will effect a pressure reduction which is transmitted to the surface to indicate that the latch is released and the tool train may be returned to the surface. The direction of fluid flow in the well system is again reversed with fluid being pumped into the tubing string 22 and returned in the tubing string 21 above the tool train for pumping the tool train back to the surface. Since the latch mandrel is locked at its lower key release position, the keys are free to expand and contract being biased out-

wardly by the force of the key springs so that the keys drag along the inner wall surfaces of the tubing string couplings and related surfaces as the tool train returns to the surface in the tubing string.

When the tool train has been returned into the lubricator at the surface, it is removed from the well system. The latch L may be reset for reuse for supporting another safety valve or any other suitable well tool in the tubing string, as previously, described. The latch is reset by initial disassembly to the extend necessary to remove the fragments of the shear pins 34 and replace them with new pins to return the parts of latch to the relationship shown in FIG. 3B. The latch need not necessarily be completely disassembled when resetting for rerunning, though an examination and cleaning of its various parts may be desired in view of its exposure to various fluids during functioning at its locked position in the tubing string. Should complete disassembly of the latch not be desired, it may be reset for running by manipulating the lower locking ring 120*a* to expand the ring and release the mandrel for upward movement and realigning the slots in the mandrel guide ribs with the holes 140 in the shear sleeve so that the shear pin fragments may be punched out. More than likely, however, it will be necessary to remove the shear sleeve upwardly sufficiently to retrieve the small shear pin fragments cut by the mandrel guide ribs which generally will fall from the slots into the recesses within the shear sleeve and should be removed before resetting and relocking the mandrel and shear sleeve with new pins.

Only a single locking recess R has been illustrated in the tubing strings in the well system represented in FIGS. 1 and 2. As previously suggested, it will be understood that a number of such locking recesses may be provided in a well system with each of the recesses being of different length and perhaps depth to provide each with a different recess contour which is matched with the contour of the locking keys on a latch L so that the latch is lockable at only a selected one of the recesses provided along the tubing string. With such an arrangement the locking keys are receivable at their fully expanded positions in only a single locking recess so that the latch will select or seek the proper recess at which its keys expand and are locked at their expanded positions.

The running, setting, and removing of the latch L has been described in terms of its being handled by pump-down techniques. It is to be understood, however, that the use of the latch is not confined to only this particular form of installation and removal. For example, conventional wireline procedures and apparatus may be applied to the handling of the latch. A suitable wireline running tool connected in a string of wireline tools provided with a collet adapted to be received in the locking recess 170 at the upper end of the seal assembly S may be used to support and run the seal assembly, latch, and safety valve or any other well tool supported from the latch. When using such apparatus and procedures the tool string is lowered, as already described, below the locking recess R in the tubing string and raised back to the recess for release and locking, following the steps described in connection with the pump-down procedures. Similarly, the latch may be removed by introducing a wireline tool string equipped with a collet to reengage the locking recess of the seal assembly and jar the tool string downwardly sufficiently to sever the shear pins connecting the shear sleeve and mandrel of the latch for releasing the locking keys of the latch.

Other forms of well tools other than safety valves are supportable from the latch though it will be recognized that where installation and removal of the latch by pump-down procedures is desired, the well tool supported from the latch must permit circulation of the well fluids in the well system. Where wireline installation and removal is to be carried out, it will be recognized that the circulation capability is not required as wireline apparatus involves insertion and removal of tool strings supported from a flexible line extending in the tubing string from the surface and manipulated from the surface and by special handling tools included in the tool string and actuated by application of forces through the wireline from the surface.

If the well tool supported from the latch L does not necessarily require a seal assembly, such as the assembly S, above the latch, the seal assembly may be dispensed with by providing the upper end of the latch mandrel with means for coupling the collet 172 of the power piston with the latch. Such coupling means may comprise a substantially shorter mandrel such as the mandrel 152 provided with a locking recess 170 for receiving the power piston collet. Alternatively, the upper end portion of the latch mandrel may be enlarged and provided with a locking recess, such as locking recess 170, to permit direct coupling of the piston collet with the latch without the intervening seal assembly.

The latch L may be used in multiples coupled in a tool train for running and setting a plurality of the latches in a tubing string having spaced recesses R along its length. In such an arrangement the several latches in the tool train along with the well tools coupled thereto are interconnected in end-to-end array to form an articulated train such as the train T shown in FIG. 1 with the locking keys on each latch being adapted to fit only a selected one of the recesses R in the tubing string. The lowermost latch in the train is sized to engage the lowermost locking recess in the tubing string with each next upper latch being adapted to fit the next recess up the tubing string so that the latches are run to the bottom and progressively released as the tool train is returned back toward the surface in a manner similar to that illustrated and described in U.S. Pat. No. 3,419,074, supra. Such an arrangement must have collets designed so that the lowermost latch is first released and set with each next latch up the tool train being sequentially set as the train is returned toward the surface. Releasing the latches in such order will, of course, require substantial differences in the actuating forces for the several collets to avoid accidental parting of the tool train units at the wrong place during the setting of the latches.

It will now be seen that a new and improved tool has been described and illustrated for releasably supporting a well tool in a tubing string at a desired location. It will be recognized that the tool is adapted to be handled either by pump-down techniques or wireline procedures.

It will be further seen that a new and improved latch has been described and illustrated for locking and supporting well tools at a locking recess within the tubing string of a well. It will be understood that the latch is manipulated from the surface both for locking at the recess and for releasing from the recess by the application of only upward and downward forces applied to the mandrel of the latch. It will be further seen that no rotation of any of the parts of the latch is required for either locking or releasing it.

It will also be seen that the latch comprises a key cage supporting a plurality of radially expandable and contractable keys around a longitudinally movable latch mandrel having locking surface portions for supporting the keys at fully expanded positions. It will be seen that the keys are continuously biased to their expanded positions by key springs and are lockable at such positions by movement of the tool mandrel to a position at which its locking surfaces are disposed behind the keys holding them at fully expanded locking positions. It will be further seen that the tool includes a shear sleeve having a locking ring moved to a locking position when the mandrel is shifted to its key-locking position and the mandrel is subsequently released by severing one or more shear pins coupling the mandrel with the shear sleeve. It will also be seen that the latch includes a lower locking ring adapted to hold the mandrel at a lower key release position after the shear pins have been severed and the mandrel has been moved downwardly for releasing the keys so that the keys remain released until the tool is removed from a well and reset for subsequent use.

It will be further seen that a new and improved tool system has been described and illustrated for installing a well tool in a tubing string at a locking recess therein, for supporting the

tool at the recess, and for removing the tool, with the installation and removal procedures being controlled from the surface. It will be seen that the well system includes latching apparatus and a running and a pulling tool which may comprise either fluid actuated pump-down apparatus or a suitable wireline tool. It will additionally be seen that a specific form of the well tool system for handling by pump-down techniques includes a latch embodying the invention, a seal assembly pivotally connected with the latch for sealing around a flow passage through the latch and seal assembly and a pumpable piston unit adapted to be coupled with and released from the seal assembly such as with a collet so that the latch and seal assembly may be pumped into a tubing string and retrieved from the string by means of the piston which is separated from the seal assembly and latch and removed from the well system when not in use for installation or retrieval of the latch and seal assembly.

The foregoing description of the invention is explanatory only, and changes in the details of the construction illustrated and described may be made by those skilled in the art within the scope of the appended claims without departing from the spirit of the invention.

I claim:

1. A tool system for supporting a well tool in a flow conductor of a well system and for installing and retrieving said well tool from the surface, comprising: latch means adapted to support said well tool and to be releasably locked in said flow conductor, said latch means having locking means for locking said latch means in said flow conductor responsive to a force in one direction only toward a locking shoulder in said flow conductor and having means for releasing said locking means responsive to a force in the opposite direction only; and handling means for supporting and moving said latch means through said conductor during installation and retrieval of said latch means, said handling means being releasable from and reconnectable with said latch means in said flow conductor.

2. The tool system of claim 1 wherein said handling means comprises a piston unit adapted to be displaced through said flow conductor by fluid pressure.

3. A tool system as defined in claim 1 wherein said handling means comprises a wireline running and pulling tool.

4. The tool system as defined in claim 1 wherein said latch means includes radially expandable and contractable keys and a mandrel having key-locking surfaces and movable between key-locking and key-releasing positions.

5. A tool system as defined in claim 4 wherein said mandrel is movable to said key-locking position when said keys engage a downwardly facing shoulder in said flow conductor.

6. A tool system for a well comprising: a latch adapted to be releasably secured in a tubing string at a locking recess having a locking shoulder for supporting a well tool in said string, said latch having means for locking in said string at said locking shoulder responsive to a single direction force only toward said locking shoulder and said locking means being releasable responsive to a single direction force only in the opposite direction; a seal assembly pivotally connected with said latch for sealing above said latch around a flow passage through said latch and said seal assembly; and a pumpable piston unit pivotally and releasably coupled with said seal assembly for pumping said latch and seal assembly into said well and out of said well, said piston unit being released from said seal assembly and removed from said well when not in use for installation or retrieval.

7. The well tool system of claim 6 wherein said latch includes radially expandable and contractable locking keys biased outwardly toward their fully expanded positions; and a longitudinally movable mandrel having a longitudinal flow passage therethrough and adapted to be moved in a longitudinal direction between key-releasing and key-locking positions by application of longitudinal forces to the upper end of the mandrel.

8. The well tool system of claim 7 wherein said mandrel includes key-locking surfaces aligned in key-locking relationships within said keys when said mandrel is at an upper position and said surfaces are misaligned at key release positions when said mandrel is at a lower position.

9. A latch adapted to be releasably locked at a locking recess within a flow conductor comprising: locking key means receivable in said locking recess and supported for radial expansion and contraction between locking and releasing positions; means biasing said key means outwardly toward an expanded locking position; mandrel means longitudinally movable within said key means between key means release and key means locking positions, said mandrel means having locking surfaces aligned at key means locking positions within said key means at a first longitudinal position of said mandrel means for holding said key means expanded in said locking recess and aligned at key means release positions within said key means at a second longitudinal position of said mandrel means permitting said key means to be compressed inwardly around said mandrel means for release from said locking recess; first locking means associated with said mandrel means for locking said mandrel means at said first longitudinal position; and second locking means associated with said mandrel means for locking said mandrel means at said second longitudinal position.

10. A latch in accordance with claim 9 including means for holding said mandrel means at said first longitudinal position until a force of predetermined value is applied to said mandrel means for releasing said mandrel means for movement to said second longitudinal position.

11. A latch in accordance with claim 9 including key-supporting means comprising cage means around said mandrel means and having a slot means in which said key means are disposed for radial expansion and contraction.

12. A latch as defined in claim 11 including spring means associated with said key means for continuously biasing said key means radially outwardly.

13. A latch as defined in claim 12 including means connected with opposite ends of said mandrel means for coupling said latch with a running and pulling tool at one end and for supporting a well tool from said latch at the other end.

14. A latch adapted to be releasably locked at a locking recess in a flow conductor in operative response to longitudinal forces comprising: a plurality of radially expandable and contractable locking keys receivable in said locking recess of said flow conductor when at their expanded positions, said locking keys having inner locking surface portions; biasing springs connected between said keys continuously biasing all of said keys outwardly toward expanded positions; an operating mandrel disposed within said keys for longitudinal movement between key-locking and key-releasing positions, said mandrel having key-locking surfaces engageable with said inner locking surfaces of said keys at one longitudinal position of said mandrel for holding said keys at radially expanded positions, said mandrel key-locking surfaces being movable with said mandrel to key release positions misaligned from said inner locking surfaces of said keys at another longitudinal position of said mandrel; a first mandrel lock associated with said mandrel and actuated responsive to movement of said mandrel to said key-locking position for holding said mandrel against movement in one longitudinal direction while said keys are locked at expanded positions; a second mandrel lock associated with said mandrel for holding said mandrel against longitudinal movement in an opposite direction when said keys are at said expanded positions and when said keys are released for inward movement; said first and second mandrel locks limiting the movement of said mandrel whereby said mandrel remains at a key-locking position until a predetermined longitudinal force is applied to said mandrel in one longitudinal direction; force responsive connecting means holding said mandrel against movement to a key release position until a force in excess of a predetermined value is applied to said mandrel for release from said first mandrel lock to permit said mandrel to move to said key release position at which said second mandrel lock is activated to hold said mandrel at said

key release position for removal of said latch from said flow conductor; means at one end of said latch for coupling a running and pulling tool thereto; and means at the other end of said latch for supporting a well tool from said latch.

15. A latch in accordance with claim 14 including a tubular key cage having key slots for receiving said keys and a bore for receiving said mandrel for supporting said keys and said mandrel for movement within said keys.

16. A latch in accordance with claim 15 including a shear sleeve coupled between said mandrel and said key cage and releasably lockable on said key cage by said first mandrel lock when said mandrel is at a key-locking position, and shearable means connecting said shear sleeve with said mandrel.

17. A latch in accordance with claim 16 wherein said first mandrel lock comprises a split locking ring supported between said shear sleeve and said key cage and said second mandrel lock comprises a split locking ring supported between said key cage and said mandrel.

18. A latch for releasably locking at a locking recess in a flow conductor and adapted to lock and release responsive to longitudinal forces only comprising: a cylindrical key cage having a plurality of circumferentially spaced key-receiving slots and provided along a first upper end portion with external first and second longitudinally spaced locking ring recesses and longitudinally extending circumferentially spaced internal mandrel guide slots; said cage being provided along a second end portion with an internal locking ring recess; a radially expandable and contractable locking key disposed in each of said locking key slots of said key cage for movement between a contracted release position and an expanded locking position at which the keys are received in said locking recess of said flow conductor for holding said latch against longitudinal movement; said keys having spaced upper and lower internal locking surface portions and an intermediate internal recess portion; biasing springs within said key cage connected between said keys for continuously biasing said keys radially outwardly toward expanded positions; an operating mandrel longitudinally disposed through said key cage within said springs and said keys for movement between key-locking and key release positions, said mandrel having upper locking bosses having external locking surfaces engageable with said upper locking surfaces of said keys when said mandrel is at a first key-locking position within said keys, said upper mandrel locking bosses being received in said internal recesses of said keys when said mandrel is at a key release position, said mandrel having lower external key-locking surfaces engageable with said lower locking surfaces of said keys when said mandrel is at said key-locking position within said keys; said mandrel having circumferentially spaced longitudinal guide ribs along the external surface thereof received within said guide slots of said key cage for holding said mandrel and said key cage against rotation relative to each other; said mandrel having lower external first and second locking ring receiving recesses along a lower portion thereof for receiving a locking ring in said key cage when said mandrel is at key-locking and key release positions, the upper of said lower locking ring recesses on said mandrel providing a locking shoulder engaged by a locking ring when said mandrel is moved to a key release position for holding said mandrel against movement relative to said cage at said key release position; a locking ring in said lower internal locking ring recess of said cage for coaction with said lower locking ring recesses of said mandrel for selectively holding said mandrel against upward movement relative to said key cage at key release and key-locking positions of said mandrel; a cylindrical shear sleeve disposed on said mandrel and telescopically engaged over the upper end of said key cage, said shear sleeve having longitudinal slots for receiving said guide ribs on said mandrel for holding said shear sleeve against rotation relative to said mandrel, said shear sleeve having an internal locking ring recess for supporting a locking ring therein; a locking ring disposed in said recess of said shear sleeve movable with said shear sleeve to a locking position with said key cage for locking said sleeve and said mandrel relative to said key cage when said mandrel is at a key-locking position within said keys; and shear means connecting said shear sleeve and said mandrel adapted to hold said mandrel against longitudinal movement relative said shear sleeve and release said mandrel for movement relative to said shear sleeve responsive to a predetermined force applied to said mandrel whereby said mandrel is returnable to a key release position for release of said keys and removal of said latch from said flow conductor.

19. A latch as defined in claim 18 connected at one end with a well tool adapted to be supported in said flow conductor from said latch and releasably coupled at the other end with a running and pulling tool for installing and retrieving said latch.

20. A latch for releasably locking at a downwardly facing shoulder in a flow conductor comprising: body means; radially expandable and contractable locking keys supported with said body means; and a mandrel supported with said body means for movement relative to said locking keys, said mandrel having key-locking surfaces and being movable from a first running-in key release position upwardly to a second key-locking position for holding said keys expanded responsive to engagement of said keys with said downwardly facing shoulder in said flow conductor and downwardly to a third key release position permitting contraction of said keys to release said latch from said shoulder.

21. A latch as defined in claim 20 including lock means associated between said mandrel and said locking keys for locking said mandrel at said second key-locking position and means coupling said mandrel against movement relative to said keys until a predetermined downward force is applied to said mandrel to release said mandrel for movement to said third key release position; and means for locking said mandrel at said third key release position.