

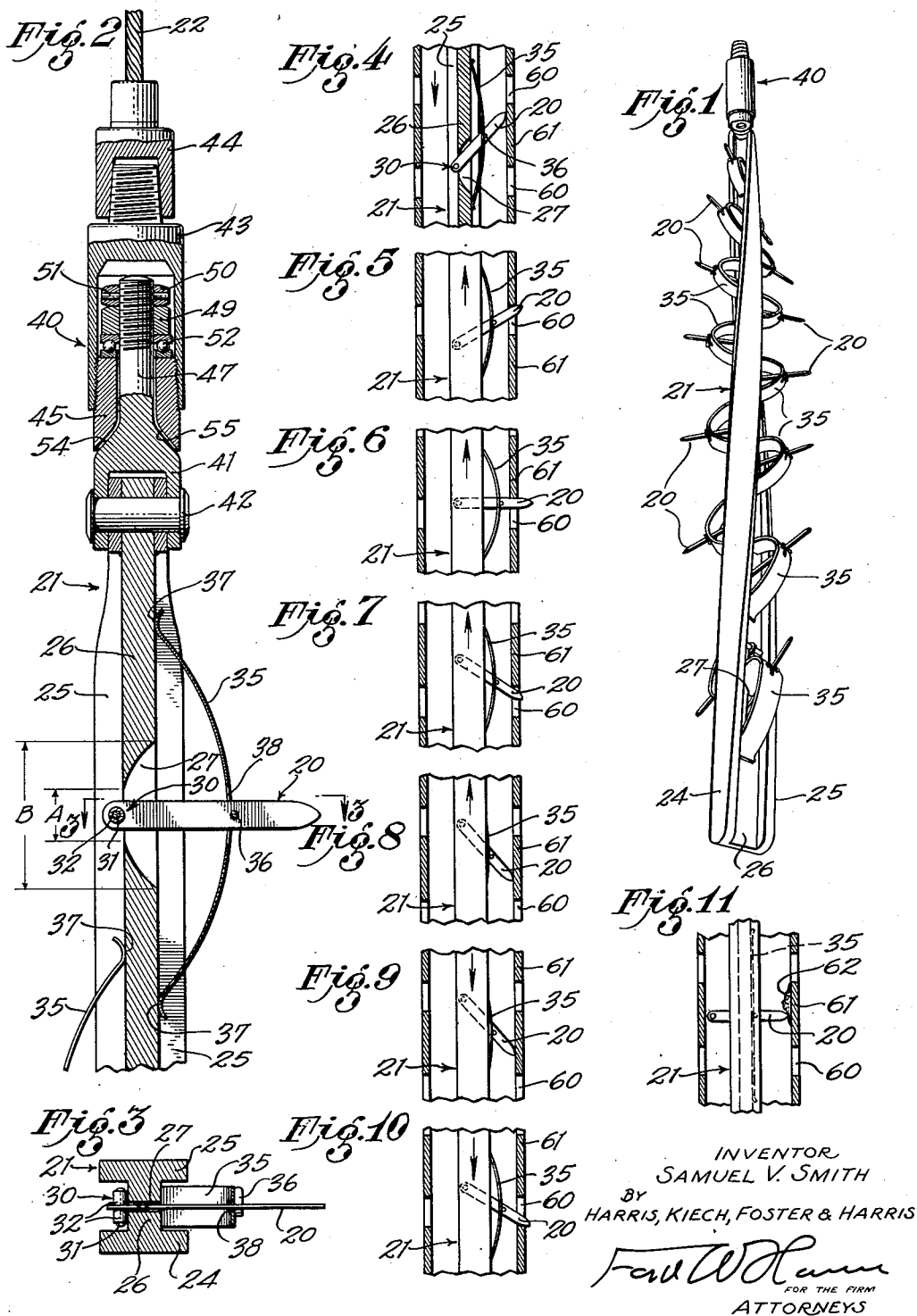
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PERFORATION CLEANER FOR OIL WELLS

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## PERFORATION CLEANER FOR OIL WELLS

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My invention relates to means for servicing oil wells and more particularly is directed to a mechanical device for cleaning perforations in an oil well liner.

When an oil well is in production the perforations in the oil well liner through which fluids flow from the surrounding formations tend to become clogged with resultant reduction of oil flow. The clogging may be caused by solids from the well strata, by the formation of scale, or by corrosion arising from chemical action. In any event progressive clogging is inevitable under the best operating conditions and periodical cleaning of the perforations is necessary if the production of the well is to be maintained.

Mechanical cleaning of liner perforations, as distinguished from chemical and hydraulic procedures, provides positive action against the clogging material and may be completed in a thorough manner in a relatively short operating period. Mechanical cleaning of liner perforations, however, involves serious difficulties because of the remoteness of the liner from the operator, the multiplicity of the perforations that must be reached mechanically, the relatively small size of the perforations, the tenacity and solid character of the clogging material, the danger of the mechanical cleaning device becoming lodged in the liner, and the possibility of cleaning members binding or breaking off in the liner perforations.

The general object of my invention is to meet these various difficulties in the design of an efficient mechanical device for rapidly and thoroughly cleaning the multiple perforations in an oil well liner.

For the purpose of performing the cleaning operation in a rapid manner, I provide a plurality of cleaning members on a common carrier. One object of my invention is to cause the plurality of cleaning members to reach all of the perforations of a liner. To this end I distribute the cleaning members in radial disposition throughout the whole circumference of the liner. A feature of my invention is the conception that the registration of the cleaning members with the various perforations may be further favored by progressively rotating the cleaner assembly and that such progressive rotation may be derived from the twisting and untwisting of a cable through the medium of a differential swivel.

One object of my invention is to provide prying action to dislodge material from the perforations, the prying action being at least in part

directed inward to force a substantial portion of the clogging material into the interior of the lining. In the preferred form of my invention I propose to apply the prying action alternately from opposite directions against each perforation.

Another object of my invention is to provide a construction for a mechanical perforation cleaner that is yielding in certain unimportant respects to reduce the danger of the device binding in the liner and to reduce the likelihood of cleaning members binding or breaking in the perforations. More specifically stated, it is my object to make the carrier for the cleaning members substantially smaller than the liner in cross section and to mount the cleaning members on the carrier in what may be termed a floating manner, the cleaning members being extended from the carrier and adapted to yield both by retraction and by rotation. It is my further object to employ cleaning members adapted to yield by rotating from one disposition through horizontal to a reverse disposition when directed against and carried past any formidable obstruction on the inner surface of the liner.

The above and other objects of the invention will be apparent from the following detailed description, taken with the accompanying drawing.

In the drawing, which is to be taken as illustrative only:

Fig. 1 is a perspective view of a device comprising the preferred form of my invention;

Fig. 2 is an axial section on a greatly enlarged scale of the upper end of the device, the section including the uppermost perforation-cleaning member;

Fig. 3 is a transverse section taken as indicated by the line 3—3 of Fig. 2;

Fig. 4 is a fragmentary longitudinal section of the device in a perforated liner showing the disposition of a perforation-cleaning member at the end of a downward movement of the carrier;

Figs. 5 to 8 are similar views in side elevation showing successive positions of the perforation-cleaning member at successive points in the subsequent upward movement of the carrier;

Figs. 9 and 10 are similar views showing the disposition of the perforation-cleaning member at successive points in the downward movement of the carrier; and

Fig. 11 is a longitudinal section through an oil well tubing or liner showing the manner in which a perforation-cleaning member may be rotated through horizontal to a reverse position

if the member is forced against an obstruction on the inner surface of a tubing or liner.

The device shown in the drawing comprises a plurality of cleaning members 20 movably and yieldably mounted on a frame or carrier 21, the carrier being adapted for attachment to the lower end of a cable 22. Preferably the cleaning members 20 are in the form of blades and are both retractable and adapted for pivotal movement. It is also to be preferred that the radial dimensions of the blades 20 with respect to the axis of the carrier 21 be distributed through 360°. It is apparent that the indicated relationships and functions may be achieved in various structural arrangements. The particular construction shown in the drawing has outstanding advantages that have made it a success in commercial practice.

The carrier 21 is preferably a metal member that is H-shaped in cross section, the member comprising two longitudinal side walls 24 and 25 interconnected by an intermediate wall or web 26. To permit the blades 20 to retract, the blades are slidably mounted in the carrier 21, and to permit the desired pivotal movement vertically of each blade relative to the carrier, each blade is mounted in a longitudinal slot 27 in the carrier web 26. To achieve the required distribution of the blades, with respect to the circumference of a perforated liner in an oil well, the blades are mounted to extend alternately from the opposite faces of the carrier web 26 and the carrier is formed to what may be termed a twisted configuration, the carrier including the web 26 being progressively twisted 180° about its longitudinal axis between the upper and lower ends of the carrier.

To limit the extension or outward movement of each cleaning member or blade 20, stop means 30 is provided at the rear end of the blade to abut the corresponding face of the carrier-web 26. In the particular construction shown, the stop means comprises a pin 31 on which is rotatably mounted a pair of sleeves 32 on opposite sides of the blade to function as rollers and thereby favor free vertical movement of the stop means within the range permitted by the longitudinal slot 27.

Preferably each of the slots 27 is of flaring configuration as viewed in longitudinal section. Fig. 2 shows a slot 27 having a relatively short longitudinal dimension A at one face of the carrier-web 26 and a substantially greater longitudinal dimension B at the opposite face, the shorter dimension being on the face against which the stop means 30 abuts and the longer dimension being on the face from which the blade extends outward from the carrier. It will be noted that a slot 27 of the indicated configuration permits rotation of the corresponding blade 20 through a relatively extensive vertical arc about the stop means 30 as a pivot, but at the same time restricts the vertical movement of the pivot to a range substantially less than the maximum dimension of the slot. I have found that if a blade having a width of approximately  $\frac{5}{8}$ " is to be mounted in a carrier-web approximately  $\frac{1}{2}$ " thick, a slot of the required configuration and dimensions for the blade may be cut with a circular cutter  $3\frac{1}{2}$ " in diameter, the cutter being caused to penetrate the web from one side of the web sufficiently to make a cut approximately  $1\frac{1}{4}$ " long on the other side of the web.

A yielding means for urging the leading or extended end of the blade outward from the car-

rier 21 may comprise a leaf spring 35 of bowed configuration confined between the face of the carrier-web 26 and some projection on the blade, each end of the bowed leaf spring being bent outward to form a foot 37 in sliding contact with the face of the carrier-web. In the particular construction shown, each leaf spring 35 is apertured to receive the corresponding blade 20 and presses outward against a cotter pin 36 that is mounted in the blade. To permit a degree of vertical movement of the blade 20 with respect to the leaf spring 35 the aperture in the leaf spring through which the blade extends may be in the form of an extensive longitudinal slot 38. It will be noted that the range of pivotal movement of the blade permitted by the slot 38 increases if the leaf spring 35 is flattened toward the face of the carrier-web 26, and it will be noted that since the spring is in sliding relationship to the carrier-web, the slot 38 in the spring in no case imposes a final limit on the vertical movement of the blade in either direction.

In the preferred form of the device shown in Fig. 1 the successive blades 20 are disposed on opposite faces of the carrier-web 26. Such an arrangement permits the successive blades to be relatively close together since one bowed leaf spring 35 may longitudinally overlap another without interference in function.

It is apparent that after the carrier 21 is lowered on the cable 22 into a perforated oil well liner, any vertical movement of the carrier will cause some of the blades 20 to register with liner perforations to achieve some cleaning effect. It is contemplated that in the preferred practice of my invention a spudding action will be employed, the cable being reciprocated by a crank or other means at the surface of the well. In the preferred procedure the device will be lowered first to the lower end of the perforated liner, spudded through a suitable range of say 18" for a short operating period, and then raised, say, 12" to 18" for another spudding period, the device being elevated in this manner by stages through the length of the perforation zone.

The variation in the load imposed on the cable 22 when the cable is spudded or reciprocated in the described manner causes the cable to alternately twist and untwist. The lower end of a 5000 foot cable carrying my device may spin as much as fifty revolutions on each of the opposite strokes of the cable. To prevent a torque of undesirable magnitude from being transmitted from the lower end of the cable 22 to the carrier 21, I may attach the carrier to the cable by a swivel connection. A feature of the preferred form of my invention is the concept of incorporating a differential effect in such a swivel whereby the alternate twisting and untwisting of the cable rotates the carrier progressively in one direction to favor thoroughgoing exploration of the liner interior by the plurality of cleaning blades 20.

The construction of such a swivel may be understood by referring to Fig. 2. The lower end of the swivel, generally designated 40, is connected with the carrier 21 by a knuckle joint that includes a knuckle member 41 and a pin 42. The upper end of the swivel 40 is connected to the cable 22 by a tool joint, the upper end of the swivel being formed as a pin collar 43 to engage a box collar 44 that is mounted on the end of the cable.

The pin collar 43 is hollow and is threaded onto a special bearing bushing 45 at its lower

end. A shank 47 of the knuckle member 41 extends axially through the bushing 45 into the interior of the pin collar 43, and screw-threadedly carries on its inner end a nut or threaded collar 49 to serve as a thrust collar, the nut or collar 49 being secured against rotation by a lock nut 50 carrying a cross pin 51. To minimize friction and encourage the desired differential effect, a ball-bearing 52 is interposed between the thrust collar 49 and the upper end of the bearing bushing 45. The knuckle member 41 is tapered just below the shank 47 to form a conical shoulder 54, and the lower end of the bearing bushing 45 is cut away to form a conical seat 55 complementary to the shoulder 54.

The maximum load imposed on the cable 22 is at the end of the downward stroke and the beginning of the upward stroke at which time the inertia of the descending carrier is overcome and the upward movement is initiated. The cable untwists for a number of revolutions as this load rises to maximum. The untwisting rotation at the lower end of the cable has relatively little direct effect on the carrier 21, since any torque transmitted must pass through the ball-bearing 52. At the end of the upward stroke and the beginning of the downward stroke, the load imposed on the cable drops sharply and the inertia of the upwardly moving carrier tends to carry the conical shoulder 54 into at least momentary engagement with the conical seat 55. At the time of contact between the shoulder and the seat the drop in the load on the cable permits the cable to twist back toward unstressed disposition, the lower end of the cable turning in the direction of tightened twist, and at such time the relatively high friction caused by the contact between the shoulder 54 and the seat 55 causes appreciable torque to be transmitted from the cable to the carrier 21. It is apparent that because of this temporary friction the twisting action of the cable at the top of the cable reciprocation has a greater rotative effect on the carrier than the untwisting action of the cable at the bottom of the reciprocation. In consequence the carrier tends to be rotated progressively by the successive reciprocations of the cable 22, especially if the reciprocation is at a sufficiently rapid rate to favor frictional contact between the conical shoulder 54 and the conical seat 55.

The operation of my invention may be readily understood from the foregoing description and may be further appreciated by considering Figs. 4 to 10. Fig. 4 taken at the bottom of a downward stroke of the device shows an upwardly pointing blade 20 just below a perforation 60 in an oil well liner 61. Fig. 5 taken in the early part of the subsequent upward stroke shows the blade 20 extending into the perforation 60, the blade pressing against the upper end of the perforation in a highly effective manner. The perforation may be either a circular aperture or a longitudinal slot. As indicated in Fig. 6 the engagement of the blade with the perforation 60 causes the blade to be swung through a horizontal position as the carrier 21 proceeds upward from the position of Fig. 5. With continued upward movement, the blade is swung downward through horizontal to the position indicated by Fig. 7, and it is to be particularly noted that as the blade swings downward between the positions of Fig. 6 and Fig. 7 and continues to swing downward to withdraw from the perforation 60, the blade performs a prying operation, the fulcrum of the prying action being at the upper end of the per-

foration and the prying action being such that the blade tends to force material from the perforation into the interior of the liner 61. The prying action is positive and there is no possibility of the inwardly displaced material subsequently clogging the perforated liner.

As the reciprocation of the device is continued, the same blade or some other blade approaches the same perforation 60 in a downward direction as indicated in Fig. 9 to penetrate with cleaning action the lower end of the perforation 60 and then to exert a prying action from the lower end of the perforation. It is apparent that when the device is properly operated, each perforation will be alternately penetrated from above and below in the manner described. By periodically shifting the range of reciprocation upwardly, the perforated extent of the liner is eventually traversed in a thoroughgoing manner.

The blades 20 will be effective for clearing the perforations whether the blades are pointed or not. The blades should be pointed, however, to facilitate penetration and in the preferred form of my invention I provide rounded points. The rounded configuration of the leading end of the blade permits the blade to ride over minor irregularities in the inner surface of the liner 61 without binding.

In the preferred form of my invention the length of each of the blades 20 is slightly less than the inside diameter of the perforated liner 61 into which the device is to be lowered. The purpose of this dimensional relationship is to permit a blade to be rotated past horizontal when the leading end of the blade is blocked by some formidable obstruction in the liner. Fig. 11, for example, shows a deposit or projection 62 on the inner surface of the liner 61 that blocks the path that would normally be taken by the point of a blade 20 as the carrier 21 moves upward. My yielding construction permits the blade to retract and pivot about the obstruction, the blade in pivoting swinging through a horizontal position and then pointing downward to ride over the obstruction as the blade continues to be carried upward by the carrier. It is apparent that a blade floatingly mounted to yield in the various ways described above will not jam in the liner nor in the perforations of the liner. Notwithstanding the yielding construction, positive and effective cleaning action may be obtained by using leaf springs of proper strength. If it is desirable to increase the strength of the leaf spring action for employment in some particular well, a relatively strong set of leaf springs may be substituted for the usual leaf springs, but in my preferred practice I merely superimpose a second leaf spring on each of the original leaf springs to provide two springs acting on each blade.

One of the features of my invention is that it may be employed for the purpose of exposing an oil well to ascertain the depth of a perforated liner in the oil well. The faces of the blades 20 become scratched or otherwise visibly worn only when they penetrate perforations in oil well liners. It does not require any special skill to note the condition of the blades prior to lowering of the device in a well and then again to note the condition of the blades after the device is withdrawn from the well to ascertain whether or not the blades have penetrated perforations. In one practice I coat the blades with paint or some quick drying material prior to the lowering of the device into the well, and after the device is withdrawn only a glance is necessary to ascer-

tain whether or not the coating on the faces of the blades has been scratched. The device is lowered to successively lower levels in the oil well and withdrawn to note the condition of the blades after each of the successive levels is reached. Whenever the process progresses to the actual level of the perforated liner fresh marks are scratched on the blades and are observed by the operator in the course of the next inspection at the top of the well.

The foregoing description of a preferred form of my invention given in specific detail for the purpose of illustration and disclosure will suggest to those skilled in the art various changes, modifications, and substitutions that do not depart from my underlying inventive concept, and I reserve the right to all such changes, modifications, and substitutions that properly come within the scope of my appended claims.

I claim as my invention:

1. A device for cleaning perforations in an oil well liner, including: a carrier adapted for up-and-down movement in the liner; a plurality of cleaning members extending laterally from the carrier, each of said cleaning members being mounted on the carrier for both pivotal movement and bodily shift towards the carrier; and yielding means acting between the carrier and said cleaning members to urge the cleaning members bodily outward from the carrier towards extended positions of the cleaning members thereby to cause the cleaning members to enter perforations in said liner.

2. A device for cleaning perforations in an oil well liner, including: a carrier adapted for up-and-down movement in the liner; a plurality of pivot members; yielding means normally extending laterally from the carrier and yieldingly urging said pivot members outward from the carrier; and a plurality of cleaning members retractably extending outward from said carrier, each of said cleaning members being mounted on one of said pivot members to rotate about the axis of the cleaning member.

3. A device for cleaning perforations in an oil well liner, including: a carrier adapted for up-and-down movement in the liner, said carrier having a plurality of longitudinal slots of flaring configuration in longitudinal section; a plurality of cleaning members slidably mounted respectively in said slots and extending laterally from the carrier in the directions in which said slots are flared; a plurality of leaf springs, each of said leaf springs being slidably mounted on said carrier in engagement with one of said cleaning members to urge the cleaning member outward from the carrier into liner perforations; and stop means to limit said outward movement of each cleaning member at an extended position and to provide a pivot for the extended cleaning member to rotate with a prying action in a liner perforation.

4. A combination as set forth in claim 3 in which each of said stop means is movable vertically within a range permitted by the length of the corresponding longitudinal slot in the carrier and in which each of said cleaning members extends through a longitudinal slot in the corresponding leaf spring.

5. A device for cleaning perforations in an oil well liner, including: a carrier adapted for up-and-down movement in the liner; a plurality of cleaning members extending laterally from said carrier, each of said cleaning members being slidably mounted in said carrier; yielding means

acting between said cleaning members and carrier to urge the cleaning members outward from the carrier into liner perforations; and means to limit the outward movement of each cleaning member at an extended position and to provide a pivot for the extended cleaning member to permit the extended cleaning member to rotate with a prying action in a liner perforation.

6. A device for cleaning perforations in an oil well liner, including: a carrier adapted for up-and-down movement in the liner; a plurality of laterally directed cleaning members, each cleaning member being mounted on said carrier for both pivotal movement and movement longitudinally of the cleaning member; and yielding means acting between the carrier and said cleaning members to urge the cleaning members laterally outward from the carrier thereby to cause the cleaning members to enter perforations in said liner, each of said cleaning members being shorter than the internal diameter of said liner to permit the cleaning member to retract and swing through a horizontal position when the carrier moves the outer end of the cleaning member against an obstruction in the liner.

7. A device for cleaning perforations in an oil well liner, including: a carrier having a plurality of longitudinal slots; a plurality of cleaning members, each of said members being slidably mounted in one of said slots to move outward and inward relative to the carrier and being adapted for pivotal movement up-and-down in the slot; and yielding means to urge each of said cleaning members outward from the carrier into a liner perforation.

8. A device for cleaning perforations in an oil well liner, including: a carrier having a plurality of longitudinal slots; a plurality of cleaning members directed laterally from said carrier, each of said cleaning members being slidably mounted in one of said slots for outward and inward movement relative to the carrier and for up-and-down swinging movement; stop means near the inner end of each cleaning member to limit the outward movement of the cleaning member; and yielding means engaging each of said cleaning members at a point spaced outward from said stop, said yielding means being adapted to urge the cleaning member outward to penetrate a liner perforation.

9. A device as set forth in claim 8 in which said yielding means comprising a spring means with a slot embracing said cleaning member and in which said spring means exerts force against means projecting from the cleaning member.

10. A device as set forth in claim 1 in which each of said cleaning members is shaped in profile at its outer end to ride over minor irregularities in the inner liner surface when the cleaning member is forced along said surface with its outer end foremost.

11. A device for cleaning perforations in an oil well liner, including: a carrier having a plurality of longitudinal slots, said carrier being of twisted configuration to dispose said slots in various radial directions relative to said liner; a plurality of cleaning members, each of said members being slidably mounted in one of said slots to move outward and inward relative to the carrier and being adapted for pivotal movement up-and-down in the slot; and yielding means to urge each of said cleaning members outward from the carrier into a liner perforation.

12. A device as set forth in claim 11 in which said carrier in configuration is twisted through

at least approximately 180° and in which cleaning members of said plurality of cleaning members extend from opposite faces of the carrier whereby the directions in which the cleaning members extend range through 360°.

13. A device for cleaning perforations in an oil well liner, including: a carrier adapted for up-and-down movement in the liner; a plurality of members mounted on said carrier for movement outward from the carrier into perforations of the liner; means to attach the carrier to a cable for lowering into said liner and subsequent reciprocation in the liner; and a differential bearing between the carrier and said attaching means offering substantially greater resistance to relative rotation in one direction than in the opposite direction thereby to cause the alternate twisting of the cable in the course of said reciprocation to cause progressive rotation of the carrier in one rotary direction.

14. In an apparatus for cleaning perforations in an oil well liner including a cable, a carrier connected with the cable and a plurality of members on the carrier for penetrating the liner perforations, the combination therewith of: a thrust bearing for transmitting force in one direction between said cable and carrier; and a second thrust bearing for transmitting force in the opposite direction between said cable and carrier,

said second thrust bearing being adapted to provide greater resistance than the first thrust bearing to relative rotation between the cable and carrier whereby alternate twist in the cable when the cable is reciprocated will cause the carrier to rotate progressively in one rotary direction.

15. The method of employing a device with perforation-penetrating members to explore an oil well to ascertain the location of a perforated liner therein, said method comprising the steps of: noting the condition of surfaces of said perforation-penetrating members; lowering said device into a well to a known depth; withdrawing the device from the well; and noting the condition of the surfaces of said perforation-penetrating members to ascertain whether or not said surfaces have been scratched by the penetration of perforations by said members.

16. The method of employing a device with perforation-penetrating members to explore an oil well to ascertain the location of a perforated liner therein, said method including the steps of: coating surfaces of said members that make contact with the material of a liner when the members penetrate perforations of the liner; lowering said device into the well to a known depth; and withdrawing the device from the well to note the condition of said coating.

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