Jan. 8, 1957 R. F. MONTGOMERY ET AL 2,776,564

SELF-PROPELLED BOREHOLE LOGGING TOOL

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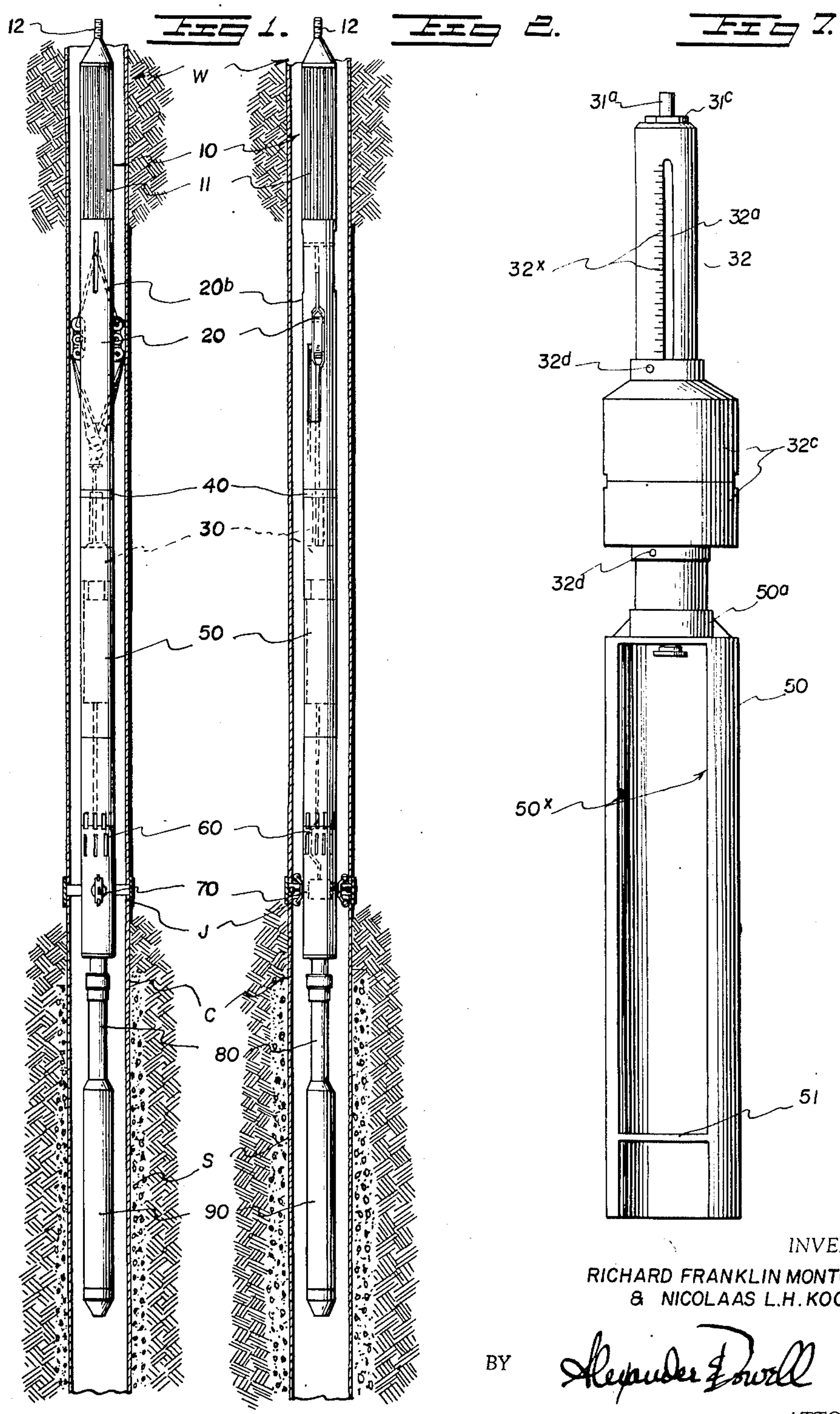

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FIG. 3.

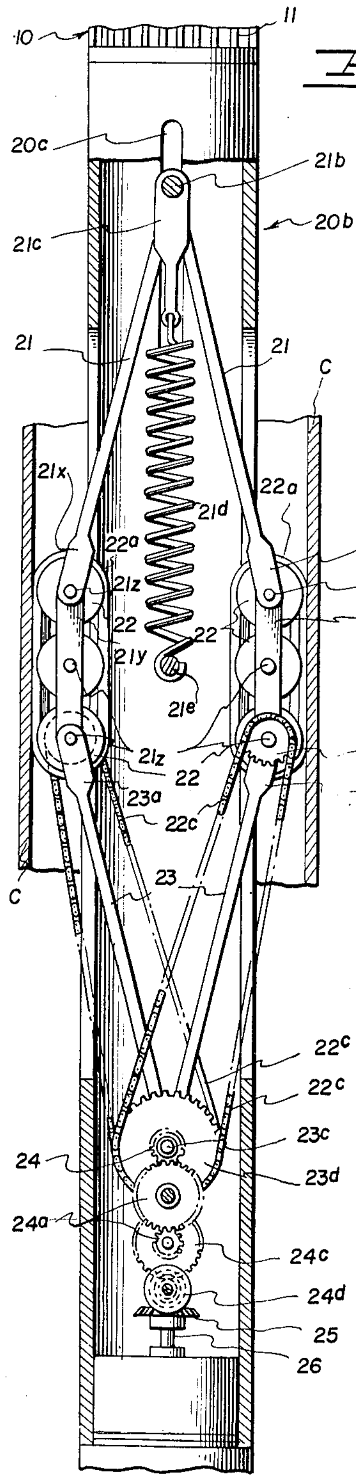

FIG. 4.

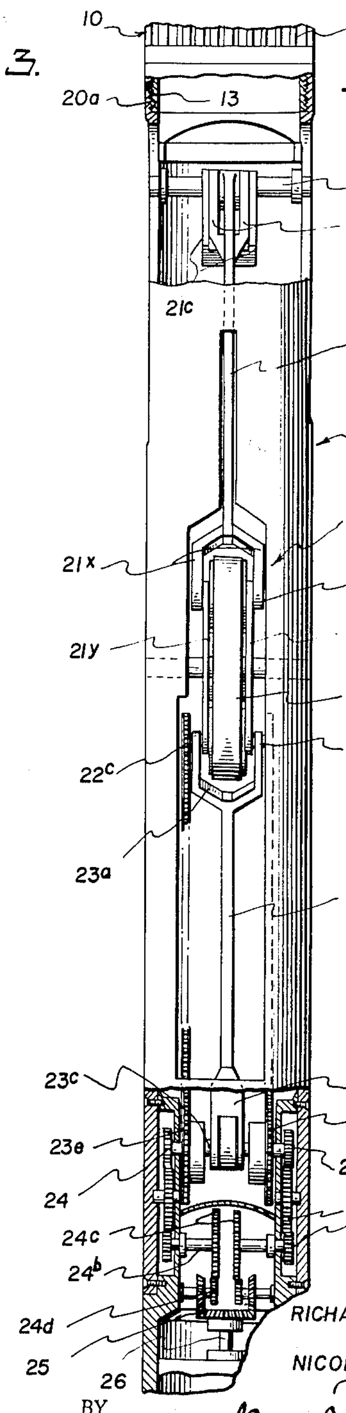

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FIG. 5.

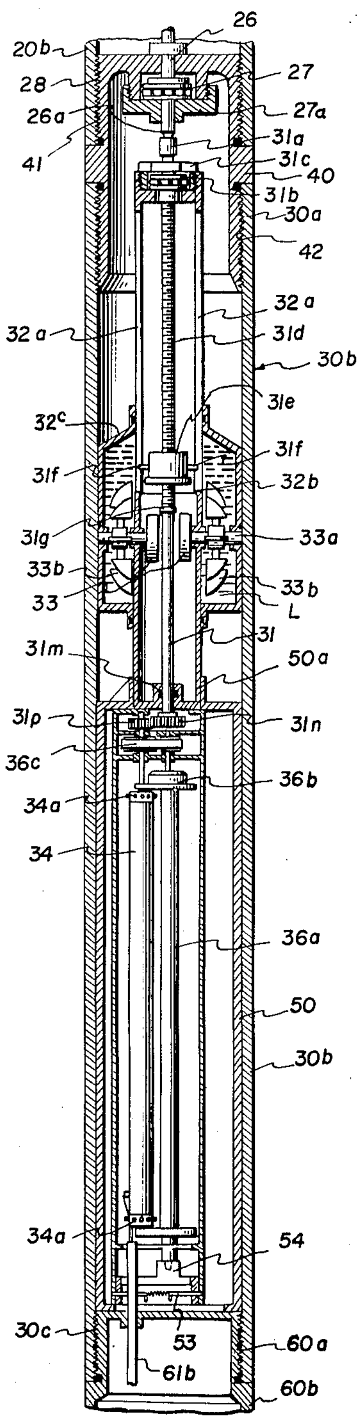

FIG. 6.

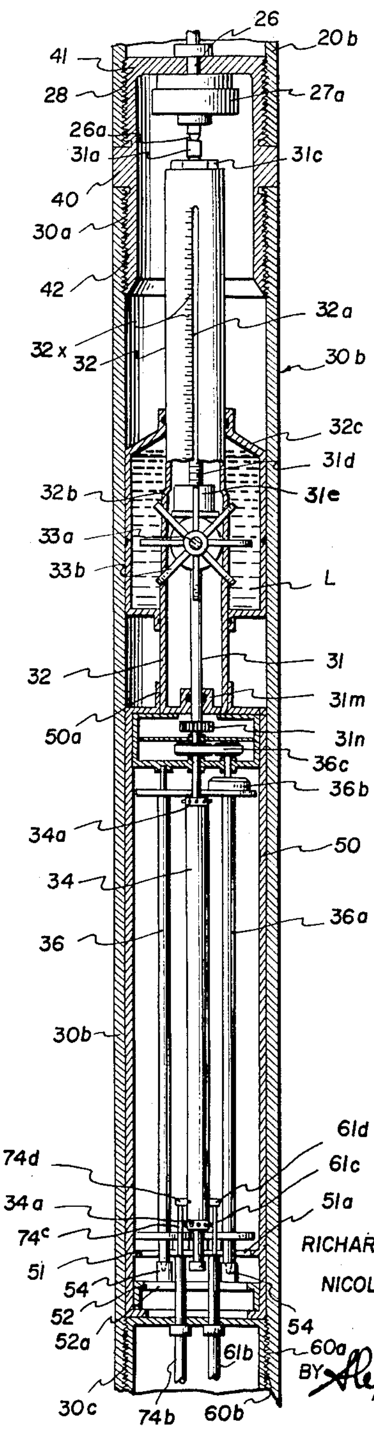

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Fig. 8.

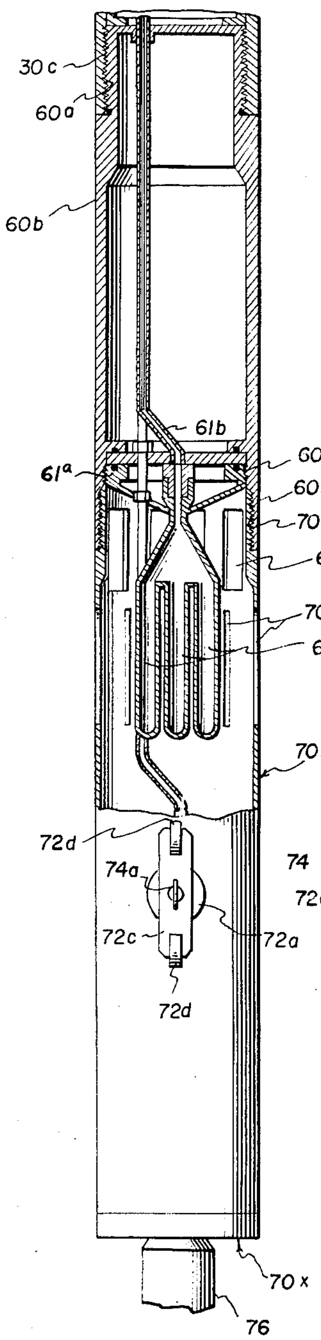

Fig. 9.

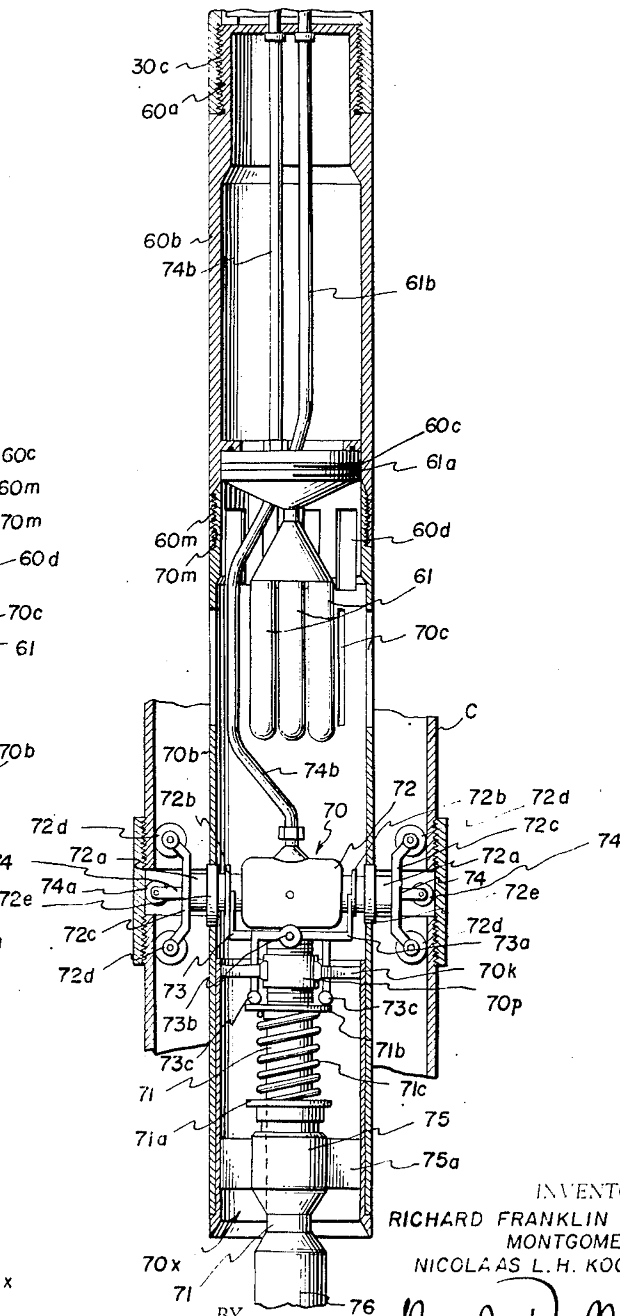

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FIG 10.

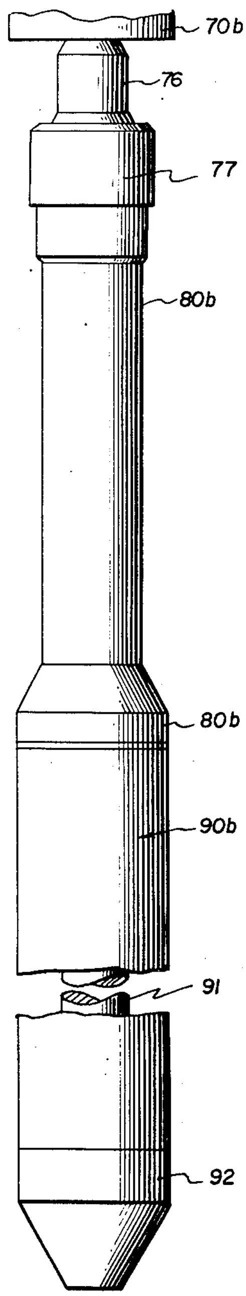
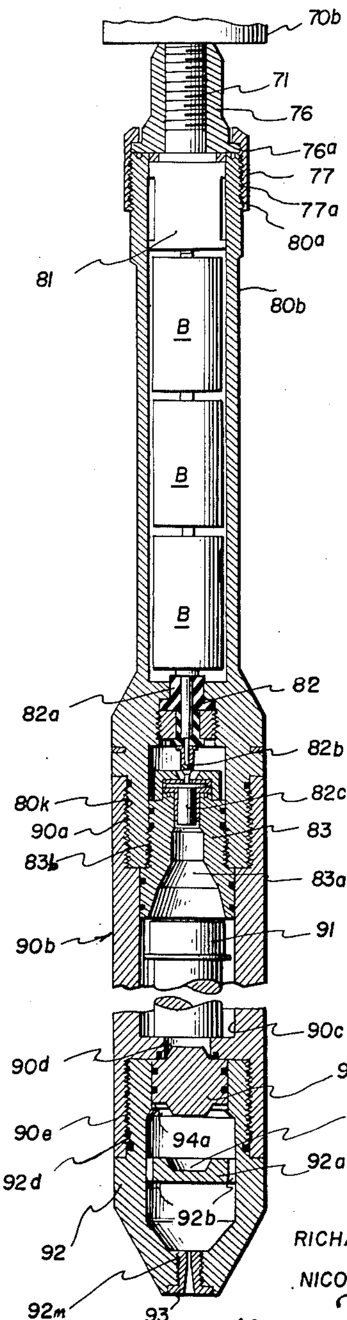


FIG 11.



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United States Patent Office

2,776,564

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SELF-PROPELLED BOREHOLE LOGGING TOOL

Richard Franklin Montgomery, Snyder, and Nicolaas L. H. Koot, Odessa, Tex.

Application September 3, 1954, Serial No. 454,034

20 Claims. (Cl. 73—151)

Our invention is a self-propelled tool for use in bores in the earth, such as oil or gas well bores, the tool being dropped freely into the well and descending at a controllable rate to the bottom, at which time a charge is set off in the lower end of the tool body creating a high-rate gas discharge which passes through a downwardly-directed jet nozzle to propel the tool back up to the surface where it may be caught by any suitable means.

The principal object of our invention is to provide a tool capable of carrying any desired type of measuring and testing equipment, the tool being provided with mechanisms whereby it may be dropped freely into the bore of a well, preferably a cased bore, whereupon the tool will travel downwardly at a metered rate, or at controlled different rates of descent, the downward travel of the tool actuating a recording chart driving mechanism. The tool is provided with a time delay mechanism which sets off a charge in the bottom of the tool so that the tool is returned to the surface by jet propulsion, thereby eliminating the necessity of lowering the tool on a cable and, in turn, eliminating the need for a hoisting winch on the surface of the ground.

In particular, our tool is intended to carry temperature measuring and recording equipment. It is well known that, during the cementing operation of a well, heat is generated as the cement sets which heat warms the casing in the vicinity of the cement and likewise warms the adjacent well liquids within the casing.

It is frequently desirable to know exactly where the upper end of the cement ends so that the operator of the well will know how much of the casing can be salvaged after the well has been worked, the information as to where the cement ends being also useful for other purposes as, for instance, knowing where holes may be milled in the casing in order to expose the well strata.

Our tool is also provided with means for controlling the rate-of-descent of the tool after it has been dropped into the well, such means being useful in saving time during the logging of the well temperatures, as hereinafter explained. For instance, in a well which is 5000 feet deep, the operator will be able to estimate that the top of the cement is at about 4000 feet, and therefore it would save considerable time if the tool could be made to descend quickly, say to 3500 feet, and then slow its rate of descent from 3500 feet down so as to give the temperature-measuring mechanism greater time to react and thereby provide more accurate logging of the temperature in the vicinity of the cemented portion of the well.

In order to provide the tool with a dual rate of descent, we have provided therein spring-loaded arms which carry friction wheels at their outer ends which friction wheels travel on the inner surface of the well casing as the tool descends. The rotation of these friction wheels during descent of the tool is utilized to drive a set of gears within the body of the tool, which gears actuate a lost-motion mechanism and also drive a recording chart. The lost-motion mechanism is in turn connected to an hydraulic drag which, in the embodiment shown in this

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invention, includes a housing filled with a viscose liquid, and paddle wheels journalled within the housing to provide the necessary drag. The aforementioned lost-motion mechanism is adjustable so as to permit the tool to drop uninhibited by the hydraulic drag for the predetermined distance, in the case of this example, 3500 feet. Experiment has shown that the uninhibited rate of descent of the tool in an oil well will be in the neighborhood of 200 to 300 feet per minute. However, when the lost-motion mechanism has reached the ends of its travel, the hydraulic drag will be connected to the gear train so as to retard the rotation of the friction wheels engaging the casing and, according to tests run to determine a desirable rate of descent of the tool, approximately 40 feet per minute has been found satisfactory. The amount of liquid in the housing and its viscosity may be adjusted to determine the amount of retardation imposed upon the friction wheels by the hydraulic drag.

An important advantage of our device is that after the tool has reached the last section of the casing and the timing clock explodes the jet-propulsion charge, the escape of the gas from the jet nozzle will stir up any heavy mud or cement slurry at the bottom of the casing so as to free the tool therefrom and assist it to start on its way toward the surface and toward a suitable latch mechanism which may be provided at the head of the well or casing string to engage a fishing head on the top of the tool so as to retain it in an easily accessible position. The use of the jet charge to return the tool to the head of the casing thus prevents the tool from getting stuck in the settled out mud or cement slurry at the bottom of the casing.

The tool itself is constructed of light-weight materials such as aluminum or manganese, and is, in addition, provided with a light-weight buoyancy section which may be filled with any suitable material such as cork so as to, at least partially, counteract the weight of the tool and make it more buoyant, so that when the charge has burned out the tool will become buoyant with respect to the well liquids, the buoyancy section also serving to ease the load which the jet propulsion must overcome in returning the tool toward the surface.

Another object of our invention is to provide the tool with a casing-joint counter, which counter also actuates a recording means for recording on the rotating chart a suitable indication each time the tool passes a casing joint, thereby double-checking the depth to which the tool descends. As stated above, the chart is driven by the friction wheels and gearing associated therewith, and a gear ratio is provided such that for instance one inch of chart will equal fifty feet of depth. A ratchet clutch mechanism is provided in the portion of the gear train which drives the recording chart so that the chart will be rotated only during downward travel of the tool in the well, and will stand motionless during upward travel thereof.

The recording on the chart is performed by two stylus members, one of which is actuated by a mercury-filled temperature-measuring element, and the other of which is actuated by hydraulic means which transmits from the casing counter an impulse every time the casing counter passes a joint.

Another object of our invention is to provide the tool with a self-centering feature as follows: The inside of the well casing is contacted by a pair of oppositely-disposed friction wheels, and is also contacted by another pair of oppositely-disposed casing-counter rollers, the rollers of the casing counter being disposed ninety degrees out of alignment with the friction rollers so as to maintain the tool substantially centered in the well casing.

Another very important object of our invention is to provide a tool of the type above specified wherein the recording chart chamber may be quickly and easily opened for the purpose of changing the chart, and wherein the explosive jet propulsion portion of the tool may be quickly and easily disconnected from the main body of the tool and disassembled so as to place therein a new propulsion charge and so as to facilitate setting of the time clock mechanism.

Other objects and advantages of our invention will become apparent during the following discussion of the drawings wherein:

Figure 1 is a cut-away view through the bore of a well, showing the casing and casing joints therein, and showing the self-propelled measuring and recording tool descending within the casing.

Fig. 2 is a view similar to Fig. 1 but showing the tool rotated through ninety degrees.

Fig. 3 is a section view through the body of the tool, showing the friction-wheel drive mechanism and a portion of the gearing associated therewith.

Fig. 4 is an elevational view of the same portion of the tool as shown in Fig. 3 but rotated through ninety degrees, the lower end of the figure being broken away to show the gearing associated with the friction wheels.

Fig. 5 is a section view of the lost-motion and hydraulic-drag mechanisms and of the chart-drive mechanism, all of which mechanisms are driven by the friction wheels.

Fig. 6 is a section view similar to Fig. 5, but rotated through ninety degrees.

Fig. 7 is a detail elevation view showing the inner casing which houses the lost-motion and hydraulic-drag mechanisms and also the chart mechanism.

Fig. 8 is an elevation view partially in section of the portion of the body of the tool which houses the mercury temperature-measuring mechanism, the view also showing the outer portion of the casing-joint counter mechanism.

Fig. 9 is a section view similar to Fig. 8 but rotated ninety degrees, the outer wall of the body of the tool being broken away to show the temperature-measuring mechanism, the casing-joint counter mechanism, and the stylus-actuating tubes associated therewith.

Fig. 10 is an elevation view of the lower portion of the tool body which houses the timing and jet-propulsion mechanism.

Fig. 11 is a section view through the timing and jet-propulsion portion of the tool to show a more detailed assembly of these mechanisms.

Referring now to the drawings, Figs. 1 and 2 show a well W having a casing C sunk thereinto, the casing having a plurality of joints J connecting the individual sections of the casing C. Behind the lower portion of the casing C is cement S, these elements being well known and forming no part of the present invention.

Within the casing C is shown a tool according to our invention, which includes an upper buoyancy member **10** connected at its lower end to a friction-wheel assembly **20**, which in turn is joined to the lost-motion and hydraulic-drag mechanisms **30** by a threaded collar **40**. Below the lost-motion and hydraulic-drag mechanisms **30** is located a recording-chart section **50** including two recording-stylus members, one of which is actuated by a mercury-type thermometer **60** and the other of which is actuated by a casing joint counter **70**. Below the casing joint counter **70** is located a timing clock and percussion-cap firing mechanism **80** from which depends the jet propulsion and jet nozzle means **90**. Each of the above members will be hereinafter described in greater detail.

In the particular embodiment of our invention shown in the drawings the buoyancy member **10** is shown in Figs. 1 and 2 comprises a slotted cylinder **11**, at the upper end of which is located a fishing tip **12** which may be used in conjunction with any suitable latch mechanism (not shown) which may be located at the upper end of the well W for the purpose of catching the tool when it has propelled itself back to the surface. The slotted cylinder **11** is filled with a light material, such as cork, for the purpose of counteracting some of the weight of the tool, this material not being shown in detail in the drawings since the particular material is not of importance. As shown in Fig. 4, the lower end of the slotted cylinder **11** is internally threaded as at **13** to engage complementary external threads **20***a* at the upper end of the casing **20***b* which houses the friction-wheel mechanism **20**.

As shown in detail in Figs. 3 and 4, the friction-wheel mechanism includes upper arms **21** which are forked at their upper ends as at **21***a* and joined together thereat by a pin **21***b* which rides in a pair of slots **20***c* on each side of the casing **20***b*. A yoke **21***c* is also journaled on the pin **21***b* and is attached at its lower end to a tension spring **21***d* which is in turn anchored at its lower end to the casing **20***b* by a pin **21***e*. The lower end of each of the arms **21** is forked as at **21***x*, the forks **21***x* being connected, respectively, to two pairs of bearing plates **21***y* through which are passed a plurality of axles **21***z* on which are journaled a plurality of friction wheels **22**, each having V-clotted peripheries adapted to receive rubber V-belts **22***a* which engage and travel on the casing C of the well and are rotated thereby. The respective lower friction wheels **22** each carries a sprocket wheel **22***b*, the sprocket wheels **22***b* respectively engaging drive chains **22***c* for the purpose hereinafter discussed.

The lower ends of the respective bearing plates **21***y* are confined between the upper forked ends **23***a* of the lower arms **23**, the lower ends **23***b* of which are connected together and pivoted to the housing **20***b* by a pin **23***c*. The lower ends of the drive chains **22***c* are respectively connected to lower sprocket wheels **23***d* and **23***e*, which sprocket wheels are connected through oppositely-directed ratchet drives (not shown) to small gears **24** which, as shown best in Fig. 3, drive gear trains **24***a*, the lower gears of which are connected to two shafts **24***b* carrying gears **24***c* at their inner ends. These gears in turn drive a beveled gear **25** connected to a vertically disposed shaft **26** mounted, as shown in Figs. 5 and 6, in ball bearings **27**, the ball bearings **27** being maintained in place by a threaded ring **27***a*.

At the lower end of the casing **20***b* are internal threads **28** adapted to engage the external threads **41** of a connecting member **40**. At the lower end of the connecting member **40** is another set of external threads **42** which engage internal threads **30***a* of the next lower casing **30***b*.

The shaft **26** extends below the ball bearing **27** and terminates at its lower end in a splined or flattened tip **26***a* which fits into a complementary socket **31***a* at the top of the shaft **31** so as to transmit rotation from the friction wheels **22** to the shaft **31** through the gear train **24—25**. The shaft **31** is supported at its upper end in a ball bearing **31***b* which is removably held in place by a nut **31***c*. The shaft **31** has a threaded portion **31***d* on which is located a traveling nut **31***e* having two outwardly extending pins **31***f* which travel in oppositely-disposed slots **32***a* in the upper wall of the casing **32**.

The pins **31***f* prevent rotation of the walking nut **31***e* so long as the pins are engaged in the slots **32***a*, but it will be noted in Figs. 5 and 6 that the casing **32** enlarges in internal diameter at **32***b* so that when the traveling nut **31***e* has reached the lower limit of the threaded section **31***d* of the shaft **31**, the pins **31***f* will disengage from the slots **32***a* and permit the walking nut to rotate freely with the shaft **31**. The lower end of the walking nut **31***e* abuts against a shoulder **31***g* on the shaft **31**, at which time the lower end of the walking nut engages rubber rollers **33** mounted on axles **33***a* which pass through the wall of the casing **32** on which they are journaled, and which axles **33***a* support paddle wheels **33***b* which are immersed in a liquid L which fills a housing **32***c* supported on the casing **32**. By reference to Fig. 7 it will be seen that the housing **32***c* is divided into upper and lower sections to permit disassembly of the housing **32***c* from the casing **32**, the upper and lower sections of the housing **32c** being maintained in place on the casing **32** by set screws **32d**, Fig. 7.

As shown in Figs. 5 and 6, the shaft **31** extends downwardly through a bearing **31m**, and supports at its lower end a gear **31n**, which in turn drives a gear **31p** to rotate a chart-feeding roller **34** having at each end a collar with chart-driving pins **34a** adapted to engage perforated holes along the upper and lower edges of a chart (not shown).

The casing **32** connects at its lower end with the upper end of the casing **50** as at **50a**, the shape of which casing **50** is also shown in Fig. 7. Within the casing **50** is a chart-supply spool **36** and a chart-takeup spool **36a**, the supply spool **36** being journaled on bearings within the casing **50**, and the takeup spool **36a** being also journaled therein but being driven by a friction drive **36b**, which is in turn rotated by a belt **36c** to which rotational motion is supplied from a gear **31p**.

The outside casing **30b** is internally threaded at its lower end as at **30c** and engages the external threads at the upper end **60a** of the next lower casing **60b**.

Near the lower end of the casing **50** is a web **51** which serves to journal the lower end of the chart-drive roller **34** and which is apertured as at **51a** to permit the lower ends of the spools **36** and **36a** to pass therethrough. Below the web **51** is a removable plate **52**, which plate is removably maintained in the lower end of the casing **50** by a snap-spring lock **53**. The plate **52** has on its upper surface two bearings **54** in which are journaled the lower ends of the spools, a portion of the plate **52** being cut away as at **52a** for the purpose hereinafter explained.

Referring now to Figs. 8 and 9, the casing **60b** which is connected to the casing **30b**, as shown in Figs. 5 and 6, houses a set of temperature cylinders **61** which are filled with mercury and are connected to an annular ring **61a** which screws into the complementary threads **60c** in the casing **60b**. The upper end of the cylinder assembly **61** is connected with a tube **61b** which extends upwardly through the upper end of the casing **60b** into the casing **50** wherein is located the recording chart. The upper end of the tube **61b** has a piston-and-rod assembly **61c** which carries at its upper end a spring-loaded stylus **61d** which engages the chart (not shown) as it passes over the chart-feeding roller **34**.

The tube **61b** and the cylinder **61** are filled with mercury which expands and contracts according to temperature changes in the well-fluids flowing therepast and causes the stylus **61d** to fluctuate up and down on the chart in accordance with the temperature variations. In order to insure efficient circulation of well-fluids past the temperature-measuring cylinders **61** we have provided the casing **60b** with a plurality of slots **60d**, and, in addition, have provided the casing **70b** with slots **70c**, the well-fluids entering the lower end of the casing **70b**, as shown by the arrow **70x**, and passing upwardly past the temperature-measuring cylinders **61**, and outwardly through the slots **60d** and **70c**, the cylinders **60b** and **70b** being secured together by complementary threads **60m** and **70m**.

Within the casing **70b** is located the casing-joint counter mechanism **70** which includes a vertically disposed rod **71** having a shoulder **71a** and having a washer **71b** with a coil spring **71c** compressed therebetween, the washer **71b** being capable of vertical motion on the rod **71** and being pressed upwardly by the spring **71c**. Within the casing **70b** is a web **70k** which supports an internally-threaded boss **70p** into which the rod **71** is screwed.

The upper end of the rod **71** supports a housing **72** which has a pair of transversely-disposed plungers **72a** reciprocally mounted therein. Each of the plungers **72a** has a shoulder **72b** thereon against which a pair of forks **73** and **73a** press outwardly, the forks being pivotally supported on rod **71** by pin **73b**, and the lower ends of the forks pressing against the washer **71b** as at **73c** so that upward motion of the ring **71b** will produce transverse outward motion of the plungers **72a**. At the outer ends of the plungers **72a** are located roller carriers **72c** carrying rollers **72d** which engage the inner wall of the well casing C. The plungers **72a** are given further support by bearings **72e** which are supported in the wall of the casing **70b**. Within each of the plungers **72a** is located a small piston **74** having a well casing engaging roller **74a** at its outer end, which roller is caused to reciprocate each time a well casing-joint is passed, the pistons **74** extending inwardly into the housing **72**. The fluctuations of the pistons **74** cause hydraulic fluid to fluctuate within the tubing **74b** which extends upwardly past the temperature-recording cylinder **61** and into the recording chart casing **50**, the tubing **74b** having in its upper end a piston rod **74c** which carries at its upper end a recording stylus **74d** adapted to contact the chart (not shown) as it passes over the chart-feeding roller **34**, the stylus placing thereon a small pulse mark each time a well casing-joint is encountered by a roller **74a** at the outer end of a piston **74**.

The lower end of the rod **71** is supported by a second sleeve **75** which in turn is held rigidly by a web **75a** similar to the web **70k** and boss **70p**.

Referring now to Figs. 10 and 11 it will be seen that the vertically-disposed rod **71** extends downwardly beyond the lower end of the casing **70b** and is threaded at its lower end to receive a coupling ring **76** which has a shoulder **76a** at its lower end on which is captivated a coupling sleeve **77**. The coupling sleeve **77** is internally threaded as at **77a** to engage complementary external threads **80a** on the upper end of the timing assembly casing **80b**.

Inside the casing **80b** at the upper end thereof is a timing clock mechanism **81** having an electric contact therein which grounds the upper end of the batteries B to the casing **80b** after a predetermined time for which the clock is set has elapsed. The lower end of the casing **80b** contains the firing mechanism which includes a firing-pin **82** in contact with the lower end of the batteries B and insulated from the casing **80b** by insulation **82a**. The lower end of the firing-pin **82** carries a contact **82b** which contacts the upper end of a firing-cap **82c**, the outside casing of which is in electrical contact with the casing **80b**.

The lower end of the cap **82c** is directed downwardly through an orifice **83a** in the plug **83** which is screwed into the lower end of the casing **80b** as at **83b**. At the lower end of the timing casing **80b** are threads **80k** which engage complementary threads **90a** of the charge casing **90b**. Within the casing **90b** is located the main gas-generating charge **91**, the upper end of which faces the orifice **83a** so that the downward discharge of the cap **82c** will be directed onto the top of the gas-generating charge **91** to ignite the latter. The charge **91** is contained in the bore **90c** in the casing **90b** which has a shoulder near the lower end of the bore **90c** to support the charge **91**, the shoulder having an orifice **90d** through its lower end. At the lower end of the casing **90b** are internal threads **90e** which engage complementary external threads at the upper end **92d** of the nozzle-carrying plug **92**.

In the bore of the nozzle-carrying plug **92** is a partition **92a** which has a plurality of apertures **92b** around its outer periphery to permit the gas generated by the charge **91** to pass downwardly in the direction of the nozzle **93** at the bottom of the plug **92**. The partition **92a** has in its upper side a socket **92c** adapted to receive the complementarily-shaped lower end of the piston plug **94**, which piston plug normally seals the bore **94a** through the nozzle-carrying plug **92** and serves the purpose hereinafter explained. The nozzle **93** screws into an axially-disposed threaded opening **92m** at the lower end of the plug **92** so that the nozzle may be easily changed when worn.

Operation

In the drawings, Figs. 1 and 2, are shown views of the complete measuring tool and propulsion means, showing the tool located within the well casing, the lower end of the tool extending downwardly within the portion of the casing adjacent the top of the cement. As shown in these views, the tool is still in the process of descending, the body of the tool being centered within the casing by means of the friction wheels near the upper end of the tool and the casing-joint counter rollers near the lower end of the tool.

The tool includes propulsion means and measuring means, the propulsion means including the friction wheel drive **20**, the hydraulic drag means **30**, the timing means **80** and the jet propulsion means **90**, as well as the buoyancy section **10** which tends to counteract some of the weight of the tool.

At the top of the tool is a fishing head **12** to cooperate with latch means adapted to catch the tool as it reaches the end of its upward travel by latching on to the fishing head **12** so as to retain the tool in an easily accessible position to be retrieved by the well operators.

In operating the tool, it is first inserted into the upper end of the casing of the well, the friction-wheel **20** being self-adjusting so as to move transversely outwardly of the tool until it contacts the inner periphery of the casing.

As shown in Fig. 3, the actual drive assembly, including the wheels **22** and the belts **22*a***, is supported on upper arms **21** and lower arms **23**. The casing is actually contacted by the belts **22*a***, which in turn transmit the drive to the friction wheels **22** and to the sprocket wheels **22*b***. The drive from these sprocket wheels is transferred to the chains **22*c*** which drive the lower sprocket wheels **23*d*** and **23*e*** which have associated therewith oppositely operating ratchet means whereby drive from the belts **22*a*** will be transferred to the gears **24** only during descent of the tool in the casing, said ratchet means slipping during ascent of the tool in the well casing so as to permit the drive gears **24** and **24*a*** to stand still as well as the entire chart drive mechanism when the tool is ascending.

As the tool descends in the well casing, drive from the belts **22*a*** is furnished to the beveled gear **25** and thence to the shaft **26**, which shaft is journaled in ball bearings **27**, as shown in Figs. 5 and 6. The drive from the shaft **26** is furnished through coupling **26*a*—31*a*** to the shaft **31**, which shaft extends downwardly through the lost-motion mechanism casing **32**.

The lost-motion mechanism casing **32** supports on its outer surface a hydraulic drag housing **32*c***, which housing is filled with a liquid wherein is immersed the paddle wheels **33*b***. The upper end of the casing **32** has two slots **32*a*** disposed longitudinally on each side thereof, the slots being located opposite the threaded portion **31*d*** of the shaft **31**. The walking nut **31*e*** travels on the threaded section **31*d*** of the shaft and has a pair of oppositely-disposed pins **31*f*** which travel in the slot **32*a*** down as far as the internal shoulder **32*b*** of the casing **32**. A set of calibrations **32*x*** is provided along the length of the slot **32*a***, which calibrations correspond to feet-of-depth of the well.

Before the tool is dropped into the well it is disassembled at the threaded joint **30*a*—42**, and the casing **32** is pulled upwardly out of the casing **30*b***, in which position the slot **32*a*** and the calibrations **32*x*** are plainly visible. In this position an electric motor or other means may be used to rotate the shaft **31** to travel the walking nut **31*e*** upwardly until the pins **31*f*** appear in the slots **32*a*** opposite the calibration **32*x*** representing a predetermined depth. The setting of the walking nut **31*e*** at such predetermined position in the slot **32*a*** determines the depth to which the tool will descend before the hydraulic drag means will become operative and slow down its rate of descent.

This function is accomplished in the following manner: As the tool descends in the well casing, drive is furnished to the shaft **31** through the gear train **24** from the belts **22*a***. As the shaft **31** rotates, the walking nut **31*e*** travels downwardly on the threaded portion **31*d*** until the pins **31*f*** disengage from the slots **32*a*** at the shoulder **32*b***. In this position the traveling nut **31*e*** engages the shoulder **31*g*** on the shaft **31** and the lower periphery of the walking nut **31*e*** engages the rubber drive wheels **33**. At the time when the walking nut engages the rubber drive wheels **33**, the tool will have traveled downwardly in the well casing a distance equal to the predetermined setting of the pins **31*f*** opposite the chosen calibration **32*x***. When the walking nut **31*e*** engages the rubber wheels **33**, the pins **31*f*** will have disengaged from the slots **32*a***, and the walking nut **31*e*** will then rotate with the shaft **31**, and in so doing will drive the paddle wheels **33*b*** within the liquid in the housing **32*c***. The amount of drag caused by the liquid on the paddle wheels **33*b*** may be predetermined by the viscosity of the liquid L and by the level thereof in the housing **32*c***. In any event the drag imposed on the paddle wheels **33*b*** by the liquid L is transferred through the rubber wheels **33** to the walking nut **31*d*** and thence to the shaft **31**, shaft **26**, gear train **24** and belts **22*a***. As a result of this drag, the rate of downward travel of the tool in the well casing will be greatly reduced.

The drive furnished to the shaft **31** from the belts **22*a*** is also transferred downwardly through the gears **31*n*** and **31*p*** to drive the chart-feeding roller **34** and the takeup reel **36*a***, the latter being driven by the belt **36*c*** through a friction clutch **36*b***. This assembly is located in the casing **50**, Fig. 7, which casing is normally enclosed within the outer body casing **30*b*** of the tool.

In order to gain access to the casings **32** and **50**, the outer body casing **30*b*** is unscrewed from the connecting casing **40** at **30*a*—42**, and the casings **32** and **50** are pulled upwardly out of the casing **30*b***, at which time the chart and chart drive assemblies will be exposed to view through the opening **50*x*** in the casing **50**, Fig. 7. The lower ends of the chart reels **36** and **36*a*** are supported in bosses **54** which are a part of the removable plate **52** secured in the lower end of the casing **50** by the spring latch mechanism **53**, Fig. 5. When the casing **50** is removed from the outer casing **30*b*** the latch means **53** may be easily released to remove the plate **52** and thereby free the lower ends of the chart reels **36** and **36*a*** to facilitate removal of the chart reels from the casing **50**.

Since the sprockets **23*d*** and **23*e*** drive the gear trains **24** only during descent of the tool in the well casing, the shaft **31** rotates only during descent thereof, and the chart is advanced from the storage reel **36** over the chart drive drum **34** and on to the takeup reel **36*a*** only during descent of the tool in the well, this assembly standing still during ascent of the tool.

The chart is marked by the stylus **61*d*** located at the upper end of the piston **61*c*** which travels in the tube **61*b*** in accordance with fluctuations in the volume of the mercury located within the temperature-measuring cylinder **61**. The chart is also marked by the stylus **74*d*** carried by the upper end of the piston **74*c*** which travels in the tube **74*b*** in accordance with variations in the hydraulic fluid filling the tube **74*b*** and actuated by the casing-joint counter **70**.

The housing **72** is filled with a liquid such as oil, which is compressed or expanded by the fluctuations of the pistons **74** which are coaxially mounted within the plungers **72**. The plungers are urged outwardly by the outward pressing of the upper ends of the forks **73—73*a*** against the collars **72*b***, the forks being pivoted on a pin **73*b*** at a point near the upper end of the vertical rod **71**, which rod supports at its upper end the housing **72**.

Near the lower end of the rod **71** is a coupling collar

76 secured to the rod 71 and secured to the timing housing 80*b* of the propulsion means by the sleeve 77, a spacing being left between the lower end of the casing 70*b* and the rod 71, as at 70*x* so as to permit well-fluids to circulate upwardly through the space 70*x* and outwardly through the slots 70*c* and 60*d* so as to insure good circulation of well-fluids past the temperature-measuring cylinders 61.

Within the timing casing 80*b* is located a clock 81 which acts as a switch to furnish electric power from the batteries B through the firing pin 82 to the cap 82*c*, the clock 81 being set for a time interval somewhat greater than the time estimated to be required by the tool to descend within the well casing, so that when the tool has reached bottom the electric circuit will be made from the batteries B to the cap 82*c*, which cap is exploded and fires a high-temperature cap downwardly through the orifice 83*a* onto the upper end of the main propulsion charge 91. When this propulsion charge 91 is ignited the gas pressure therefrom forces the piston plug 94 downwardly into the socket 82*c* so as to open the way for the gas pressures from the burning charge 91 to pass through the openings 92*b* and outwardly through the jet nozzle 93 located at the lower end of the plug 92.

This assembly is connected together in such a manner that it may be quickly and easily disassembled so as to permit resetting of the clock and replacement of the cap 82*c* and the main propulsion charge 91. When the collar 77 is unscrewed from the body 80*b*, as at 77*a*—80*a*, the clock may be withdrawn upwardly out of the upper end of the timing body 80*b*. At the same time, the timing body 80*b* may be unscrewed from the charge-holding body 90*b*, as at 80*k*—90*a*, so as to place a new charge 91 into the bore 90*c* of the body 90*b*. By unscrewing the plug 83 from the threaded section 83*b*, the cap 83*c* may be replaced.

In addition, the plug 92 may be unscrewed from the body 90*b* as at 90*e*—92*d*, and the piston 94 may be unseated from the socket 92*c* and moved upwardly to again plug the passageway 94*a*, the piston 94 being a tight fit in the passage 94*a*.

It is highly desirable to prevent the entry of the well-fluid into the body of the tool except as above stated at 70*x*—70*c*—60*d*, and at the upper end of the tool around the friction-wheel-assembly. Therefore, all of the various joints in the casings of the tool are provided with rubber O-rings fitting into the rectangular grooves shown in the drawings, this means of sealing a joint being well known in the prior art.

We do not limit our invention to the exact form shown in the drawings, for obviously changes may be made therein within the scope of the claims.

We claim:

1. A self-propelled tool to be sent below the ground surface in a well bore having walls, comprising a body of smaller diameter than said bore; rate-of-descent controlling means comprising friction wheels transversely reciprocably attached to said body and yieldably urged outwardly thereof to maintain said wheels in frictional contact with said walls, drag means in said body and drive means connecting said drag means and said friction wheels for applying drag to said wheels to retard the descent of the tool; and timing and propulsion means comprising a delayed action igniter and a gas generating propulsion charge in said body, the charge being in communication with a downwardly directed nozzle in the bottom of the body, whereby when said charge is ignited the gas generated thereby will discharge downwardly through the nozzle and propel the tool back up toward the ground surface.

2. In a tool as set forth in claim 1, said drive means including lost-motion coupling means connected between said wheels and said drag means, said lost-motion coupling means delaying the coupling of said drag means to said wheels for an adjustable interval to permit the wheels to turn freely during the initial descent of the tool in the well; and one-way clutch means in said drive means to disengage the latter during upward travel of the tool in the well.

3. In a tool as set forth in claim 1 for use in a well having jointed casing, a chart in said body; means to rotate said chart and connected to said drive means; and well-characteristic measuring devices each actuating a stylus in contact with said chart, said devices including a casing joint counter.

4. In a tool as set forth in claim 1, a quick-disconnect joint in said body above said timing and propulsion means to facilitate separation of the latter from the upper part of the tool.

5. In a tool as set forth in claim 1, said body having a passageway between said charge and said nozzle; and a plug in said passageway normally sealing the latter, the plug being dislodged by the generated gas to clear the passageway when the charge is ignited.

6. A self-propelled tool to be sent below the ground surface in a well bore having walls, comprising a body of diameter smaller than said bore; rate-of-descent controlling means comprising annularly spaced sets of vertically spaced wheels, bearing plates rotatably supporting the wheels of each set to travel along the walls of the bore in a direction axial thereof, an upper arm and a lower arm connected at their outer ends to each bearing plate, the inner ends of the lower arms being pivoted to the body and the inner ends of the upper arms being connected together and secured to said body by a pivot capable of sliding axially of said body, spring means urging said pivot downwardly toward the pivotal connection of the inner ends of the lower arms, said upper and lower arms forming toggle supports to urge said wheels outwardly against said walls, controllable hydraulic drag means, and drive means connecting the drag means to the wheels of each set to retard the descent of the tool; and upward propulsion means comprising a downwardly directed nozzle at the lower end of said body, a gas generating charge in said body above said nozzle, and a time-delayed igniter in communication with said charge and adapted to ignite the charge after the tool has reached the bottom of the well so that the generated gas will discharge downwardly through the nozzle and propel the tool upwardly toward the ground surface.

7. In a tool as set forth in claim 6, said drive means including lost-motion coupling means connected between said wheels and said drag means, said lost-motion coupling means delaying the coupling of said drag means to said wheels for an adjustable interval to permit the wheels to turn freely during the initial descent of the tool in the well; and one-way clutch means in said drive means to disengage the latter during upward travel of the tool in the well.

8. In a tool as set forth in claim 6 for use in a well having jointed casing, a chart in said body; means to rotate said chart and connected to said drive means; and well-characteristic measuring devices each actuating a stylus in contact with said chart, said devices including a casing joint counter.

9. In a tool as set forth in claim 6, said body having a passageway between said charge and said nozzle; and a plug in said passageway normally sealing the latter, the plug being dislodged by the generated gas to clear the passageway when the charge is ignited.

10. In a tool as set forth in claim 6, said hydraulic drag comprising a housing within said body; paddle wheel means journaled in said housing and connected with said drive means to be rotated thereby; and a viscose liquid in said housing, the level and viscosity of the liquid determining the amount of drag.

11. A self-propelled tool to be sent below the ground surface in a liquid filled well-bore having walls, com-

prising a body of smaller diameter than said bore and having a buoyancy section to reduce the effective weight of the tool in said liquid; rate-of-descent controlling means comprising friction wheels transversely reciprocably attached to said body and yieldably urged outwardly thereof to maintain said wheels in frictional contact with said walls, drag means in said body and drive means connecting said drag means and said friction wheels for applying drag to said wheels to retard rotation thereof; and timing and propulsion means comprising a delayed action igniter and a gas generating propulsion charge in said body, the charge being in communication with a downwardly directed nozzle in the bottom of the body, whereby when said charge is ignited the gas generated thereby will discharge downwardly through the nozzle and propel the tool back up toward the ground surface, the tool becoming buoyant in said liquid when said charge has burned out.

12. In a tool as set forth in claim 11, said drive means including lost-motion coupling means connected between said wheels and said drag means, said lost-motion coupling means delaying the coupling of said drag means to said wheels for an adjustable interval to permit the wheels to turn freely during the initial descent of the tool in the well; and one-way clutch means in said drive means to disengage the latter during upward travel of the tool in the well.

13. In a tool as set forth in claim 11, a quick-disconnect joint in said body above said timing and propulsion means to facilitate separation of the latter from the upper part of the tool.

14. In a tool as set forth in claim 11, said body having a passageway between said charge and said nozzle; and a plug in said passageway normally sealing the latter, the plug being dislodged by the generated gas to clear the passageway when the charge is ignited.

15. A self-propelled tool to be sent below the ground surface in a liquid filled well bore having walls, comprising a body of diameter smaller than said bore and having a buoyancy section to reduce the effective weight of the tool in said liquid; rate-of-descent controlling means comprising annularly spaced sets of vertically spaced wheels, bearing plates rotatably supporting the wheels of each set to travel along the walls of the bore in a direction axial thereof, an upper arm and a lower arm connected at their outer ends to each bearing plate, the inner ends of the lower arms being pivoted to the body and the inner ends of the upper arms being connected together and secured to said body by a pivot capable of sliding axially of said body, spring means urging said pivot downwardly toward the pivotal connection of the inner ends of the lower arms, said upper and lower arms forming toggle supports to urge said wheels outwardly against said walls, controllable hydraulic drag means, and drive means connecting the drag means to the wheels of each set to retard the rotation of said wheels; and upward propulsion means comprising a downwardly directed nozzle at the lower end of said body, a gas generating charge in said body above said nozzle, and a time-delayed igniter in communication with said charge and adapted to ignite the charge after the tool has reached the bottom of the well so that the generated gas will discharge downwardly through the nozzle and propel the tool upwardly toward the ground surface, the tool becoming buoyant in said liquid when said charge has burned out.

16. In a tool as set forth in claim 15, said drive means including lost-motion coupling means connected between said wheels and said drag means, said lost-motion coupling means delaying the coupling of said drag means to said wheels for an adjustable interval to permit the wheels to turn freely during the initial descent of the tool in the well; and one-way clutch means in said drive means to disengage the latter during upward travel of the tool in the well.

17. In a tool as set forth in claim 15, a quick-disconnect joint in said body above said timing and propulsion means to facilitate separation of the latter from the upper part of the tool.

18. In a tool as set forth in claim 15, said body having a passageway between said charge and said nozzle; and a plug in said passageway normally sealing the latter, the plug being dislodged by the generated gas to clear the passageway when the charge is ignited.

19. A self-propelled tool to be sent below the ground surface in a well bore having walls, comprising a body receivable in said bore; drag means on said body and contacting said walls to slow the descent of the tool in the bore; and retrieving means in said body comprising charge means for generating a downwardly directed fluid jet; a nozzle through the lower end of the body below said charge means; a passageway between said charge means and said nozzle; a plug in said passageway normally sealing the latter, the plug being dislodged to clear the passageway by the generation of said fluid jet; and control means for initiating the generating of said jet when said tool has descended to the desired depth.

20. In a tool as set forth in claim 19, said well being filled with a liquid, said retrieving means including a buoyant section in said body to reduce the effective weight of the tool in said liquid whereby said fluid jet will propel the tool back up toward the surface and the tool will become buoyant in said liquid when said charge has burned out.

References Cited in the file of this patent

UNITED STATES PATENTS

2,177,886	Halliburton	Oct. 31, 1939
2,219,512	Cooper et al.	Oct. 29, 1940
2,292,938	Hennessy	Aug. 11, 1942
2,590,982	Long	Apr. 1, 1952