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PATENT  
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TOWNSEND and TOWNSEND and CREW LLP

By: /Kay Barclay/  
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**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

Inventor:

Bobbie J. Bowden

Patent No.: 5,474,142

Issued: December 12, 1995

Application No.: 08/050,527

Filed: April 19, 1993

For: Automatic Drilling System

Examiner: Not Assigned

Art Unit: Not Assigned

**REQUEST FOR *EX PARTE***  
**REEXAMINATION UNDER**  
**37 C.F.R. § 1.510**

Mail Stop Ex Parte Reexam  
Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

Sir:

Pason Systems Corporation requests *ex parte* reexamination of U.S. Patent No. 5,474,142 ("the '142 Patent"), entitled "Automatic Drilling System," issued to Bobbie J. Bowden on December 12, 1995. The '142 Patent is owned by National Oilwell Varco, L.P., of Houston, Texas.

Pursuant to 37 C.F.R. § 1.510, this Request includes the following.

1. Pursuant to 37 C.F.R. § 1.510(a), the \$2,520 fee for requesting *ex parte* reexamination set forth in 37 C.F.R. § 1.20(c)(2) is submitted herewith.

2. Pursuant to 37 C.F.R. § 1.510(b)(1), this Request includes a statement pointing out each substantial new question of patentability based on prior patents and printed publications, discussed in detail below in Section I.

3. Pursuant to 37 C.F.R. § 1.510(b)(2), reexamination is requested for claims 1-8 and 11-15 of the '142 Patent. This Request includes a detailed explanation of the pertinence and manner of applying the cited prior art to every claim for which reexamination is requested, discussed in detail below in Section III.

4. Pursuant to 37 C.F.R. § 1.510(b)(3), a copy of every patent or printed publication relied upon is submitted herewith as Exhibits B-G.

5. Pursuant to 37 C.F.R. § 1.510(b)(4), a copy of the '142 Patent is submitted herewith as Exhibit A.

6. Pursuant to 37 C.F.R. § 1.510(b)(5), the signature on this Request certifies that a copy of the Request has been served in its entirety on the patent owner's representative at the address provided for in 37 C.F.R. § 1.33(c) by depositing the Request in an envelope bearing U.S. mail postage in an official U.S. Postal Service repository, on the date set forth below, addressed as follows.

Robert Bowick, Jr.  
The Matthews Firm  
2000 Bering Drive  
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Houston, TX 77057

7. In furtherance to 37 C.F.R. § 1.565(a), the undersigned informs the Office that the '142 Patent was the subject of litigation in United States District Court for the District of Colorado, case number 03-CV-02579-RPM. An appeal is currently pending in the United States Court of Appeals for the Federal Circuit captioned *National Oilwell Varco, LP (formerly known as Varco, L.P.), Plaintiff-Cross Appellant v. Pason Systems USA Corp., Defendant-Appellant*, case no. 2009-1397, 1398.

## REMARKS

### I. Substantial New Questions Of Patentability

At least six substantial new questions of patentability exist regarding the '142 Patent. These questions of patentability rely on U.S. Patents under 35 USC §§ 102(a), 102(b), and 103(a).

The '142 Patent was filed in the U.S. April 19, 1993, and issued as a patent on December 12, 1995. Accordingly, a printed publication with a publication date of April 18, 1992 or earlier will qualify as prior art to the '142 Patent under 35 U.S.C. § 102(b), and may be used to raise a new question of patentability under 35 U.S.C. §§ 102(b) or 103(a). A later publication may qualify as prior art under 35 U.S.C. § 102(a) and may be used to raise a new question of patentability under 35 U.S.C. §§ 102(a) or 103(a), provided it predates the invention date, which is assumed to be no later than April 19, 1993. In order to avoid a § 102(a) prior art reference, an applicant/patentee would have to demonstrate an actual invention date predating the reference.

The '142 Patent is generally related to controlling the advance of a drill string during drilling of a well, for example an oil well. In general, four interrelated variables, sensed or calculated by various means, reveal what is happening where the bit meets the formation: bit weight or the pressure placed on the bit, rotary torque of the rotary table turning the bit or of a rotating mud motor down hole, RPM, and the pressure of the drilling fluid or drilling mud pumped down the hole for lubricating the bit, flushing out cuttings, and, in more recent operations, turning a motor located down hole at the bit. The system of the '142 Patent purports to "regulate[] the drill string of a drilling rig in response to any one of, any combination of, or all of drilling fluid pressure, bit weight, drill string torque, and drill string RPM to achieve an optimal rate of bit penetration." '142 Patent Abstract. The '142 Patent includes both method and apparatus claims. The '142 Patent entered a crowded field when it was filed in 1993. A synopsis of the historical development of automatic drilling regulation is provided in Appendix C.

The new questions of patentability presented below rely on the following prior art patents and printed publications:

U.S. Patent 3,265,359 to J.E. Bowden ("Bowden '359"). Bowden '359 was filed June 7, 1962, and was issued as a patent on August 9, 1966, and is a continuation-in-part of abandoned U.S. Patent Application Serial Number 668,230, which was filed on June 26, 1957.<sup>1</sup> The filing and issue dates of Bowden '359 predate those of the '142 Patent by more than 29 years, and thus Bowden '359 qualifies as prior art under both 35 U.S.C. §§ 102(a) and 102(b). A copy of Bowden '359 is provided as Exhibit B.

U.S. Patent 4,662,608 to Ball ("Ball"). Ball was filed September 24, 1984 and issued as a patent on May 5, 1987. The filing and issue dates of Ball predate those of the '142 Patent by more than eight years, and thus Ball qualifies as prior art under both 35 U.S.C. §§ 102(a) and 102(b). A copy of Ball is provided as Exhibit C.

U.S. Patent 2,005,889 to Dillon et al. ("Dillon"). Dillon was filed November 12, 1932, and was issued as a patent on June 25, 1935. The filing and issue dates of Dillon predate those of the '142 Patent by more than 60 years, and Dillon thus qualifies as prior art to the '142 Patent under both 35 U.S.C. §§ 102(a) and 102(b). A copy of Dillon is provided as Exhibit D.

U.S. Patent 3,550,697 to Hobhouse ("Hobhouse"). Hobhouse was filed April 25, 1967, and issued as a patent on December 29, 1970. The filing and issue dates of Hobhouse predate those of the '142 Patent by more than 24 years, and Hobhouse thus qualifies as prior art to the '142 Patent under both 35 U.S.C. §§ 102(a) and 102(b). A copy of Hobhouse is provided as Exhibit E.

U.S. Patent 1,891,329 to LeCompte et al. ("LeCompte"). LeCompte was filed February 23, 1932, and was issued as a patent on December 20, 1932. The filing and issue dates of LeCompte predate those of the '142 Patent by

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<sup>1</sup> The inventor of the subject matter of Bowden '359, J.E. Bowden, is the father of Bobbie J. Bowden, listed as inventor on the '142 Patent.

more than 61 years, and LeCompte thus qualifies as prior art to the '142 Patent under both 35 U.S.C. §§ 102(a) and 102(b). A copy of LeCompte is provided as Exhibit F.

J.F. Brett, T.M. Warren, and D.E. Walt, "Field Experiences With Computer-Controlled Drilling", Society of Petroleum Engineers publication SPE 20107 (1990) ("Brett/Warren"). This publication bears a 1990 copyright date, and indicates that it was prepared for presentation at the 1990 Permian Basin Oil and Gas Recovery Conference held in Midland, Texas March 8-9, 1990. The publication of Brett/Warren predates the filing of the '142 Patent by more than two years, and Brett/Warren thus qualifies as prior art to the '142 Patent under both 35 U.S.C. §§ 102(a) and 102(b). A copy of Brett/Warren is provided as Exhibit G.

The following patents and publication are referred to herein for historical context, but are not relied upon in forming new questions of patentability:

U.S. Patent 3,223,183 to Varney, ("Varney"). Varney was filed August 7, 1963, and issued as a patent December 14, 1965. Varney qualifies as prior art to the '142 Patent under both 35 U.S.C. §§ 102(a) and 102(b). A copy of Varney is provided as Exhibit H.

F.S. Young, Jr., "Computerized Drilling Control", *Journal of Petroleum Technology*, April 1969 ("Young"). Young qualifies as prior art to the '142 Patent under both 35 U.S.C. §§ 102(a) and 102(b). A copy of Young is provided as Exhibit I.

U.S. Patent 4,854,397 to Warren et al., ("Warren"). Warren was filed September 15, 1988, and issued as a patent August 8, 1989. Warren qualifies as prior art to the '142 Patent under both 35 U.S.C. §§ 102(a) and 102(b). A copy of Warren is provided as Exhibit J.

In addition, the following excerpts from the prosecution history of the '142 Patent are referred to in the remarks below:

Examiner's Action, dated March 8, 1994. A copy is provided as Exhibit

K.

Amendment A, dated June 10, 1994. A copy is provided as Exhibit L.

Second Examiner's Action, dated August 10, 1994. A copy is provided as

Exhibit M.

Amendment After Final Under 37 C.F.R. § 1.116, dated November 7,

1994. A copy is provided as Exhibit N.

**A. Substantial New Question Of Patentability In Light Of Bowden '359 In View Of Ball, Dillon And Hobhouse**

A first substantial new question of patentability is raised for claims 1-8 and 11-15 by Bowden '359, in view of Ball, Dillon and Hobhouse. All of these references qualify as prior art to the '142 Patent under both 35 U.S.C. §§ 102(a) and 102(b). In combination, they teach all of the claim limitations of the '142 Patent, and provide motivation for their combination. Moreover, neither Bowden '359, Dillon, nor Hobhouse is listed among the references of record for the '142 Patent. Ball is listed among the references of record for the '142 Patent, but is presented here in a combination not previously considered by the examiner. Accordingly, these references raise a substantial new question of patentability regarding the '142 Patent under 35 U.S.C. § 103(a).

An analysis of claim 1 follows below in this section. Section III discusses the applicability of Bowden '359, Ball, Dillon, and Hobhouse to other claims for which reexamination is requested.

Claim 1 of the '142 Patent reads as follows:

1. An automatic drilling system for automatically regulating the release of the drill string of a drilling rig during the drilling of a borehole, comprising:
  - a drilling fluid pressure sensor;
  - a drilling fluid pressure regulator coupled to said drilling fluid pressure sensor, said drilling fluid pressure regulator measuring changes in

drilling fluid pressure and outputting a signal representing those changes;  
a relay coupled to said drilling fluid pressure regulator, said relay responsive to the output signal of said drilling fluid pressure regulator to supply a drill string control signal at an output thereof; and  
a drill string controller coupled to said relay wherein a decrease in drilling fluid pressure results in said relay supplying a drill string control signal that operates said drill string controller to effect an increase in the rate of release of said drill string and an increase in drilling fluid pressure results in said relay supplying a drill string control signal that operates said drill string controller to effect a decrease in the rate of release of said drill string.

The combination of Bowden '359, Ball, Dillon, and Hobhouse teaches each and every element of claim 1.

Bowden '359, in combination with prior art admitted in the '142 Patent or Dillon or Hobhouse discloses the first element of claim 1: "An automatic drilling system for automatically regulating the release of the drill string of a drilling rig during the drilling of a borehole, comprising: a drilling fluid pressure sensor." Bowden '359 "relates to automatic well drilling control systems". c. 1, ll. 11-12. The system is controlled "to release a supply of drilling line 136 which, in turn, lowers the top end of the drill pipe string...." c. 9, ll. 31-32. Both Dillon and Hobhouse disclose drilling fluid pressure sensors. Dillon Fig. 1a, elements 106, 107, p. 4, c. 1, ll. 14-32. Hobhouse Fig. 8, elements 103-107, c. 8, ll. 15-29. In addition, the '142 Patent discloses a commercially available fluid pressure sensor. c. 5, ll. 29-38 and Fig. 5.

Bowden '359 discloses the second and third elements of claim 1: "a drilling fluid pressure regulator coupled to said drilling fluid pressure sensor, said drilling fluid pressure regulator measuring changes in drilling fluid pressure and outputting a signal representing those changes; a relay coupled to said drilling fluid pressure regulator, said relay responsive to the output signal of said drilling fluid pressure regulator to supply a drill string control signal at an output thereof." Bowden '359 discloses a regulator-relay combination that operates identically to that of the '142 patent, in the context of bit weight control. The bit weight signal is provided as a pressure signal in Bowden '359. Bowden '359 Fig. 11, elements 105-113. It would have

been trivial for one of skill in the art to couple the regulator and relay of Bowden '359 to a fluid pressure sensor rather than a bit weight sensor.

Bowden '359 discloses the fourth element of claim 1: "a drill string controller coupled to said relay wherein a decrease in drilling fluid pressure results in said relay supplying a drill string control signal that operates said drill string controller to effect an increase in the rate of release of said drill string and an increase in drilling fluid pressure results in said relay supplying a drill string control signal that operates said drill string controller to effect a decrease in the rate of release of said drill string." Bowden '359 discloses drill string controller that operates identically to that of the '142 patent, in the context of bit weight control. Bowden '359 Fig. 11, elements 133-145. When trivially coupled to a drilling fluid pressure sensor (with an easily-accomplished reversal of sensitivity), the system would control the rate of drill string release based on drilling fluid pressure, as suggested by Dillon and Hobhouse. Hobhouse in particular suggests the claimed relationship between drilling fluid pressure and drill string release, describing stopping the sinkage of the drill stem in response to an increase in mud-flush pressure, and increasing the sinkage of the drill stem in response to a decrease in mud-flush fluid pressure. Hobhouse c. 8, ll. 38-49.

Although Bowden '359 does not explicitly state that it controls the rate of release of the drill string, the mechanism for actuating the drill string release in Bowden '359 is identical to that shown in the '142 Patent, and therefore would be identical in effect – namely regulating the rate of release of the drill string. Furthermore, the actuating mechanism shown in both Bowden '359 and the '142 Patent is simply an automated actuation of a conventional drum brake. Any doubt as to whether this mechanism controls the rate of release of the drill string is alleviated by Ball, which states that the "drilling apparatus has a conventional brake operated by a brake handle which operates on the drum to control the rate of feed out of the drill line...." Ball c. 3, ll. 2-5, emphasis added.

The combination of Bowden '359, Ball, Dillon, and Hobhouse teaches each and every limitation of claim 1. One of skill in the art could easily have modified the system disclosed in Bowden '359 to provide control of drill string release based on drilling fluid



pressure, and would have been motivated to do so by either Dillon or Hobhouse, both of which teach control based on drilling fluid pressure.

### **B. Substantial New Question Of Patentability In Light Of LeCompte**

A second substantial new question of patentability is raised for claims 1 and 11 by LeCompte. LeCompte teaches each and every claim element of at least claims 1 and 11 of the '142 Patent. An analysis of claim 1 follows immediately. Section III discusses the applicability of LeCompte to other claims for which reexamination is requested. Moreover, LeCompte is not listed among the references of record for the '142 Patent. Accordingly, it raises a substantial new question of patentability regarding the '142 Patent.

LeCompte discloses the first element of claim 1 of the '142 Patent: "An automatic drilling system for automatically regulating the release of the drill string of a drilling rig during the drilling of a borehole, comprising: a drilling fluid pressure sensor." LeCompte indicates that one object of its invention "resides in the provision of brake actuation mechanism co-acting with the telescopic drill stem section and actuated by the back pressure of the mud laden fluid ... for automatically retarding the lowering of additional drill stem into the hole ... and, if necessary, stop further lowering of drill stem...." LeCompte at p. 1 ll. 49-58. LeCompte includes a drilling fluid pressure sensor, disclosing that a "reference character T designates the mud fluid pressure gauge which gives the reading of pressure that the mud laden fluid is being pumped into mud pipe M and through the drill stem line...", p. 3 c. 1, ll.8-13, and Figure 1. In combination with the back pressure generated from the movements of the length compensator U, and in co-action with the pressure of the drilling fluid pumped through mud pipe M, LeCompte teaches that "[a] mud laden fluid carrying pipe 82, which is a branch from the mud laden fluid conducting pipe M, is also connected with the valve case 83 (*sic*). The valve case 80 is provided with a suitable slidable valve 84 [which] allows the valve to open only sufficiently against a suitable spring 85 to permit steam to pass through valve groove 86 to set the brake..." p. 5, c. 1, ll. 51-61. Therefore, the slidable valve 84, as it interacts with the spring 85, senses the back pressure caused by the interaction of the length compensator U and the mud pumped through

mud pipe M and mud laden fluid carrying pipe 82. Thus, the first element of claim 1 is present in LeCompte – sensing pressure.

LeCompte discloses the second element of claim 1 of the '142 Patent: “a drilling fluid pressure regulator coupled to said drilling fluid pressure sensor, said drilling fluid pressure regulator measuring changes in drilling fluid pressure and outputting a signal representing those changes.” It is important to recognize that the “drilling fluid pressure regulator” of the '142 Patent does not alone regulate or control the pressure of the drilling fluid, but “measures changes in drilling fluid pressure to regulate a drilling operation”. '142 Patent, c 8, l. 10, Fig. 3. As explained above, as the pressure changes, LeCompte's slidable valve 84 presses and releases against spring 85. p. 5, c. 1, ll. 51-61. The slidable valve 84 contains a valve groove 86, that allows "steam to pass through" in varying amounts, depending on the pressure detected. p. 5, c. 1, ll. 51-61. The steam is generated by steam boiler O, is output through steam pipe P, and passes through valve groove 86 in varying amounts depending on the back pressure of the drilling fluid as detected by slidable valve 84 in interaction with spring 85. p. 5, c. 1, ll. 43-63. Thus, the steam, output from the boiler O and transferred by the pipe P, is utilized by the slidable valve 84 as a signal to communicate a particular change in pressure at that point in time, which signal thus represents the change in drilling fluid pressure at that particular point in time. Thus, LeCompte discloses the second element of claim 1 of the Bowden '142 Patent – measuring a pressure change and outputting a signal representing that change.

LeCompte discloses the third element of claim 1 of the '142 Patent: “a relay coupled to said drilling fluid pressure regulator, said relay responsive to the output signal of said drilling fluid pressure regulator to supply a drill string control signal at an output thereof.” As steam exits through the valve groove 86, it is relayed to the braking system, entering cylinder 67, which then acts against piston 70. p. 5, c. 1, l. 14 - p. 6, c. 1, l. 15. The output signal of a particular amount of steam through valve groove 86 is relayed to the brake (the drill string controller) and moves cylinder 67 and piston 70 in varying amounts. Thus, the third element of Claim 1 of the Bowden '142 Patent is satisfied – LeCompte contains a relay system which sends the modified steam signal, based on changes in drilling fluid pressure, to the braking system.

LeCompte discloses the fourth element of claim 1 of the '142 Patent: "a drill string controller coupled to said relay wherein a decrease in drilling fluid pressure results in said relay supplying a drill string control signal that operates said drill string controller to effect an increase in the rate of release of said drill string and an increase in drilling fluid pressure results in said relay supplying a drill string control signal that operates said drill string controller to effect a decrease in the rate of release of said drill string."

LeCompte first discloses its braking mechanism, "a brake setting and releasing mechanism designated generally in Figure 2, as X." p. 3, c.1, ll. 24-26 (emphasis added). LeCompte explains that "the hydraulic brake actuating mechanism ... is also operated by the telescopic movements of the length compensator U connected into the drill stem." p. 4, c. 2, ll. 123-127. LeCompte explains the capabilities of the braking system employed -- one that can increase or decrease the rate of release of the drill string in direct response to the amount of braking force employed -- "[a]s shown in detail in Figure 15, the cable drum brake actuating mechanism embodies a brake setting lever 60, which can be manually actuated through the handle 61, when so desired, instead of being automatically actuated hydraulically ... [t]he brake lever 60 ... is connected with the free end of a brake band 64 riding over the cable drum D by means of a connecting link 65 ... [b]y this arrangement, the brake band can be brought into braking contact with the cable drum D when so desired with any degree of frictional contact when manually operating the brake lever by manipulating the handle thereof for leading off cable from the cable drum, at any desired speed for lowering upper drill stem section in to the well hole bored by the drilling bit." - p. 4, c. 2, l. 128 -- p. 5, c. 1, l. 23 (emphasis added).

As to automatically setting or releasing the brake (decreasing or increasing the rate of release) in response to changes in drilling fluid pressure, LeCompte teaches that "[t]he means for automatically actuating the brake lever comprises a steam cylinder 67 pivotally supported as at 68 to the floor of the derrick A. The steam chamber 69 of the cylinder is provided with piston 70 connected to the lower end of a piston rod 71, which leads upwardly through the upper end of the cylinder. The upper end of the piston is pivotally connected by a removable pin 72 to an arm 73 which arm is pivotally connected, as at 74, to a coupling 75, suitably clamped to the brake lever 60." p. 5, c. 1, ll. 24-35. LeCompte explains that "[a] mud

laden fluid carrying pipe 82, which is a branch from the mud laden fluid conducting pipe M, is also connected with the valve case 83 (*sic*). The valve case 80 is provided with a suitable slidable valve 84 which when the mud pump pressure is normal for safe drilling, the mud pressure against one end of the slidable valve 84 allows the valve to open only sufficiently against a suitable spring 85 to permit steam to pass through valve groove 86 to set the brake with such tension as to allow the cable drum to revolve at a speed to lower upper drill stem (*sic*) at a predetermined speed, and, if for any reason the mud laden fluid pressure increases from normal, due to the collapsible telescopic action of the drill stem length compensator U, the valve will be opened sufficiently to admit more steam into the steam cylinder for quickly raising the piston therein to move the brake lever 60 to quickly set the brake against the cable drum to prevent further lowering of the upper drill stem section into the well hole." p. 5, c. 1, l. 51 – p. 6, c. 2, l. 74 (emphasis added). LeCompte then explains that "[t]he sliding valve action is automatic as to both the mud laden fluid pressure and the steam, thus the setting of the brake is automatic relative to the amount of back pressure developed in the upper drill stem section by the telescopic action of the length compensator U." p. 5, c. 2, ll. 75-81 (emphasis added).

LeCompte then teaches the concept of increasing or decreasing the rate of release (setting or releasing of the brake) of the drill string as follows: "When the compensator device U is fully extended... the normal working pressure of the mud laden fluid... is present... and the steam and mud fluid valve will be in such position as to admit such amount of steam into the cylinder 67 as to set the brake to permit the cable drum to revolve at such speed as to lower upper drill stem into the hole at a predetermined speed." p. 5, c. 2, ll. 82-96. However, "[w]hen the length compensator U has collapsed to a point ... sufficiently to set up a back pressure to the pump... the slidable valve 84 will be slightly moved by the increased pressure of the mud laden fluid, allowing more steam to enter the cylinder 67 having the bleeder valve 87, to further set the brake and slow up feeding of upper drill stem into the hole." p. 5, c. 2, ll. 97-112 (emphasis added). In the event of an additional and more substantial pressure increase, LeCompte discloses the ability to fully engage the brake, further decreasing the rate of release of the drill string to the point where the drill stem is no longer released. In such a circumstance, "the sliding valve 84 will have been fully opened and the pressure entering the cylinder 67 and acting against the

piston 70 will cause the brake band to be fully set against the cable drum, preventing the further lowering of the upper drill stem section H..." p. 5, c. 2, l. 115 – p. 6, c. 1, l. 6.

Notably, LeCompte's system does not simply go into shut-down, but maintains the requisite braking force "until at such time as ... the back pressure [is reduced]... which simultaneously caused the sliding valve to slightly close, admitting less ste[a]m to cylinder and causing a slight let up on the braking action." p. 6, c. 1, ll. 6-16 (emphasis added). In the event that the drilling fluid pressure decreases even more, "sliding valve 84 will be further closed to allow normal lowering of the upper drill stem section H." p. 6, c. 1, ll. 16-30. This setting and releasing of the brake handle increases or decreases the rate of release of the drill string in response to corresponding decreases or increases in drilling fluid pressure as detected by the interaction of the sliding valve 84, spring 85, and valve groove 86, and the steam relayed through cylinder 67 to cause piston 70 to move brake lever 60 to increase or decrease the frictional braking force placed on brake drum D.

Thus, the fourth element of claim 1 of the '142 Patent is disclosed by LeCompte – a controller that reduces the rate of drill string release when drilling fluid pressure increases, and that increases the rate of drill string release when drilling fluid pressure decreases. Requestor recognizes that the system of LeCompte is ultimately intended to control the weight on the drill bit. LeCompte p. 2, ll. 92-95. However, LeCompte measures the weight using a telescopic device that reflects the bit weight in the pressure of the drilling fluid. LeCompte performs its regulation based on drilling fluid pressure, and meets each and every element of at least claims 1 and 11 of the '142 Patent. The fact that the drilling fluid pressure in LeCompte is a proxy for bit weight is irrelevant. As noted, all four parameters involved in the '142 Patent are interrelated means and proxies used to determine the pressure of the bit against the formation.

### **C. Substantial New Question of Patentability In Light Of Brett/Warren**

A third substantial new question of patentability is raised for claims 1 and 11 by Brett/Warren. Brett/Warren teaches each and every claim element of at least claims 1 and 11 of the '142 Patent. An analysis of claim 1 follows immediately. Section III discusses the applicability of Brett/Warren to other claims for which reexamination is requested. Moreover,

Brett/Warren is not listed among the references of record for the '142 Patent. Accordingly, it raises a substantial new question of patentability regarding the '142 Patent.

Brett/Warren discloses the first element of claim 1 of the '142 Patent: "An automatic drilling system for automatically regulating the release of the drill string of a drilling rig during the drilling of a borehole, comprising: a drilling fluid pressure sensor." Brett/Warren is related to "computer controlled drilling", and describes a system wherein several drilling parameters are measured, including pump pressure. Brett/Warren Title, Table 1, p. 207. Pump pressure is designated in table 1 as a "direct control" variable, meaning that the system can be configured to control that parameter. p. 200, c. 1, second full paragraph. Control is accomplished by "vary[ing] the weight on bit so that the controlled parameter was held constant." p. 201, c. 1, second full paragraph. The weight on bit is varied by a hydraulic actuator that applies more or less lifting force to the drill string. p. 199, c. 2, "Actuation" section. One of skill in the art will recognize that this inherently constitutes regulating the rate of release of the drill string. Table 1 of Brett/Warren indicates that the system includes a drilling fluid pressure sensor.

Brett/Warren discloses the second and third elements of claim 1 of the '142 Patent: "a drilling fluid pressure regulator coupled to said drilling fluid pressure sensor, said drilling fluid pressure regulator measuring changes in drilling fluid pressure and outputting a signal representing those changes" and "a relay coupled to said drilling fluid pressure regulator, said relay responsive to the output signal of said drilling fluid pressure regulator to supply a drill string control signal at an output thereof." Brett/Warren's system necessarily measures changes in drilling fluid pressure (the function of the "regulator" of the '142 Patent) so that those changes can be compensated, and necessarily relays a signal indicating the change.

Brett/Warren discloses the fourth element of claim 1 of the '142 Patent: "a drill string controller coupled to said relay wherein a decrease in drilling fluid pressure results in said relay supplying a drill string control signal that operates said drill string controller to effect an increase in the rate of release of said drill string and an increase in drilling fluid pressure results in said relay supplying a drill string control signal that operates said drill string controller to effect a decrease in the rate of release of said drill string." Brett/Warren describes a computer-

controlled hydraulic system to adjust drill string advance. Abstract, p. 199 “actuation” section, Figures 6 and 8.

**D. Substantial New Question Of Patentability In Light Of Hobhouse**

A fourth substantial new question of patentability is raised for claims 1 and 11 by Hobhouse. Hobhouse teaches each and every claim element of at least claims 1 and 11 of the ‘142 Patent. An analysis of claim 1 follows immediately. Section III discusses the applicability of Hobhouse to other claims for which reexamination is requested. Moreover, Hobhouse is not listed among the references of record for the ‘142 Patent. Accordingly, it raises a substantial new question of patentability regarding the ‘142 Patent.

Hobhouse discloses the first element of claim 1 of the ‘142 Patent: “An automatic drilling system for automatically regulating the release of the drill string of a drilling rig during the drilling of a borehole, comprising: a drilling fluid pressure sensor.” Hobhouse indicates that an object of its invention is to “provide a control system for drilling rigs.” c. 1, ll. 39-40. Hobhouse’s system includes hydraulic cylinder “to regulate the sinkage of the drill string”. c. 8, ll. 33-34. The system includes a drilling fluid pressure sensor. Fig. 8, elements 103-107, c. 8, ll. 15-29.

Hobhouse discloses the second element of claim 1 of the ‘142 Patent: “a drilling fluid pressure regulator coupled to said drilling fluid pressure sensor, said drilling fluid pressure regulator measuring changes in drilling fluid pressure and outputting a signal representing those changes.” It is important to recognize that the “drilling fluid pressure regulator” of the ‘142 Patent does not alone regulate or control the pressure of the drilling fluid, but “measures changes in drilling fluid pressure to regulate a drilling operation”. ‘142 Patent, c. 8, ll. 10, Fig. 3. Hobhouse discloses such a device in Figure 8, elements 108 and 109, which are coupled to the pressure sensor (103-107), and output a signal indicative of pressure changes. “Changes in mud-flush pressure beyond determined limits produce a change in pressure in the hydraulic fluid and generate an electric signal from the strain gauges 107. The electrical signal is amplified by an amplifier 108 and used to deflect a needle 109 above or below a norm to make contact with graduated reference contacts 110.” Hobhouse c. 8, ll. 22-27.

Hobhouse discloses the third element of claim 1 of the '142 Patent: "a relay coupled to said drilling fluid pressure regulator, said relay responsive to the output signal of said drilling fluid pressure regulator to supply a drill string control signal at an output thereof." Figure 8 of Hobhouse shows "control console" 111 that receives the electric signal from the pressure sensor and controls cylinder 99. "The control console 111 ... may supply pressure fluid to the underside of the piston 98 in the cylinder 99, to regulate the sinkage of the drill string...." Hobhouse c. 8, ll. 30-34.

Hobhouse discloses the fourth element of claim 1 of the '142 Patent: "a drill string controller coupled to said relay wherein a decrease in drilling fluid pressure results in said relay supplying a drill string control signal that operates said drill string controller to effect an increase in the rate of release of said drill string and an increase in drilling fluid pressure results in said relay supplying a drill string control signal that operates said drill string controller to effect a decrease in the rate of release of said drill string." Hobhouse describes stopping the sinkage of the drill stem in response to an increase in mud-flush pressure, and increasing the sinkage of the drill stem in response to a decrease in mud-flush fluid pressure. Hobhouse c. 8, ll. 38-49. Stopping and increasing the sinkage of the drill string are control of the rate of release of the drill string, as recited in claim 1 of the '142 Patent.

In a previous reexamination of the '142 Patent, the patent owner distinguished another prior art reference ("Varney", U.S. Patent 3,223,183) by arguing that it described only a simple "on-off" control method, and did not regulate the rate of release of the drill string. In fact, Varney described its control system as analogous to "a well known type of pushbutton switch which on successive actuations alternately opens and closes a circuit." Varney c. 10, ll. 8-10. Requester notes that even starting and stopping the release of a drill string necessarily changes the rate at which the drill string is released, and that during acceleration and deceleration, the drill string will experience many different release rates.

Nonetheless, the system of Hobhouse is not so simplistic. In Hobhouse, the drilling fluid pressure is measured using a strain gauge, which is a continuous device. Hobhouse c. 8, ll. 22-25. The pressure signal is amplified and relayed to the lifting cylinder through a series of "graduated reference contacts 110", which allow differing levels of actuating signal. c.



8, l. 27. Hobhouse thus regulates the rate of release of the drill string, in a way that Varney does not.

**E. Substantial New Question Of Patentability In Light Of Hobhouse In View Of Dillon**

A fifth substantial new question of patentability is raised for claims 2-4 and 12-15 in light of Hobhouse and in view of Dillon. In combination, these references teach all of the elements of at least claims 2-4 and 12-15, and also provide motivation for their combination. Neither is listed among the references of record for the '142 Patent. Accordingly, they raise a substantial new question of patentability regarding the '142 Patent under 35 U.S.C. § 103(a).

As is explained above, Hobhouse anticipates claims 1 and 11, which recite regulation of drill string release based on drilling fluid pressure. The remaining claims claim regulation of drill string release based on various combinations of input variables, including drilling fluid pressure, bit weight, drill string torque, and drill string RPM. Hobhouse discloses regulation of drill string release based on combinations of variables. Dillon indicates that an object of its invention "is to provide for controlling the movement of the drill stem as a function of tension in the drill-stem-supporting hook, the load on the drilling motor, the speed of the drilling motor, and the pressure of the fluid pumped by the mud pump, or any one, or any combination of these factors", and thus suggests all of the combinations of control variables recited in the claims of the '142 Patent. Dillon p. 1, c. 1, ll. 54ff.

Hobhouse measures all of the required variables in addition to drilling fluid pressure: bit weight (c. 5, ll. 30-36), drill string torque (c. 4, ll. 30-40, Fig. 5), and drill string RPM (c. 4, ll. 38-40). Each of the sensors produces an electrical signal. Hobhouse also provides convenient electrical means for combining various control inputs and producing a single control output. ("control module" 111 in Fig. 8 and the circuit of Fig. 7, described at c. 7, l. 23 – c.8, l. 52)

Under the suggestion of Dillon, it would have been a simple matter for one of skill in the art to modify the system of Hobhouse to combine any or all input variables recited by the '142 Patent to effect regulation of drill string release. For example, the electrical circuit of

Figure 7 or a similar circuit could be expanded to control based on combinations of four electrical inputs representing four drilling parameters.

**F. Substantial New Question Of Patentability In Light Of Dillon**

A sixth substantial new question of patentability is raised for claim 14 by Dillon. Dillon teaches each and every claim element of at least claim 14 of the '142 Patent. Moreover, Dillon is not listed among the references of record for the '142 Patent. Accordingly, it raises a substantial new question of patentability regarding the '142 Patent.

Claim 14 recites

14. A method for automatically regulating the release of the drill string of a drilling rig drill, comprising the steps of:
  - measuring drilling fluid pressure and bit weight;
  - producing a first signal in response to changes in drilling fluid pressure, said first signal representing the changes in drilling fluid pressure;
  - producing a second signal in response to changes in bit weight, said second signal representing the changes in bit weight;
  - selecting any one of said first signal, said second signal, and both said first and said second signals to control the release of said drill string; and
  - relaying said selected signal or signals to a drill string controller which regulates the release said drill string in response to said selected signal or signals.

Dillon discloses the first element of claim 14 of the '142 Patent: "A method for automatically regulating the release of the drill string of a drilling rig drill, comprising the steps of: measuring drilling fluid pressure and bit weight." Dillon indicates that an object of its invention is to control the movement of the drill stem as a function of various parameters. Dillon p. 1, c. 1, ll. 54ff. Dillon discloses measuring drilling fluid pressure. Fig. 1a, elements 106, 107, p. 4 c. 1, ll. 14-32. Dillon also discloses measuring bit weight. Fig. 1a, element 33, p. 1, c. 2, ll. 51-53, Figs. 2 and 3, p. 1 c. 2 ll. 29-36.

Dillon discloses the second element of claim 14 of the '142 Patent: "producing a first signal in response to changes in drilling fluid pressure, said first signal representing the changes in drilling fluid pressure." In Dillon, the "pressure of the mud pump is transmitted from

the housing 107 to the piston 106 which, in coaction with a spring moves the position of the iron core 105, thereby varying the reactance of the reactor coil 104.” p. 4, c., 1 ll. 21-25.

Dillon discloses the third element of claim 14 of the ‘142 Patent: “producing a second signal in response to changes in bit weight, said second signal representing the changes in bit weight.” Dillon’s reactor coil 97 outputs a signal representing changes in bit weight. “Any change in the weight on the bottom of the well will change the reactance of the reactor coil 97....” p. 2, c. 2, ll. 6-8.

Dillon discloses the fourth element of claim 14, “selecting any one of said first signal, said second signal, and both said first and said second signals to control the release of said drill string.” For example, “knife switch” 98 shown in Figure 1a may be positioned to include or exclude the influence of drilling fluid pressure on the control system. p. 4, c. 1, ll. 14-32. Furthermore, Dillon indicates that that an object of its invention “is to provide for controlling the movement of the drill stem as a function of ... any one, or any combination of” factors including “tension in the drill-stem-supporting hook ... and the pressure of the fluid pumped by the mud pump.” p. 1, c. 1, ll. 54ff.

Dillon discloses the fifth element of claim 14, “relaying said selected signal or signals to a drill string controller which regulates the release said drill string in response to said selected signal or signals.” As shown in Figure 1, signals from Dillon’s drilling fluid pressure and bit weight sensors are relayed to “control mechanism” 65, which regulates power to “hoisting motor” 26. “The stem will thus be hoisted or lowered, as the case may be, to reestablish a balanced condition....” p. 2, c. 2, ll. 13-16.

There is no requirement in claim 14 that the system regulate the rate of drill stem release, and no particular control relationships are specified.

## **II. Claims For Which Reexamination Is Requested**

Reexamination of claims 1-8 and 11-15 is requested.

### **III. Pertinence And Manner Of Applying Prior Art**

The prior art identified above should be applied to the claims of the '142 Patent as follows to reject these claims. For the Examiner's convenience, comprehensive charts showing where each claim element is taught or suggested in the cited references are given in Appendix B.

#### **A. Claims 1-8 and 11-15 Are Unpatentable Under 35 U.S.C. § 103(a) As Being Obvious In Light Of Bowden '359 and Ball in View of Dillon And Hobhouse**

Bowden '359 teaches a pneumatic system for regulating drill string release nearly identical to the system shown in the '142 Patent, and controls drill string release based on a single pressure signal derived from bit weight. A comparison of the two patents will be instructive. The similarity is striking when Figure 2 of the '142 Patent is compared with Figure 11 of Bowden '359. These two figures are shown below (with added highlighting) for ease of reference.

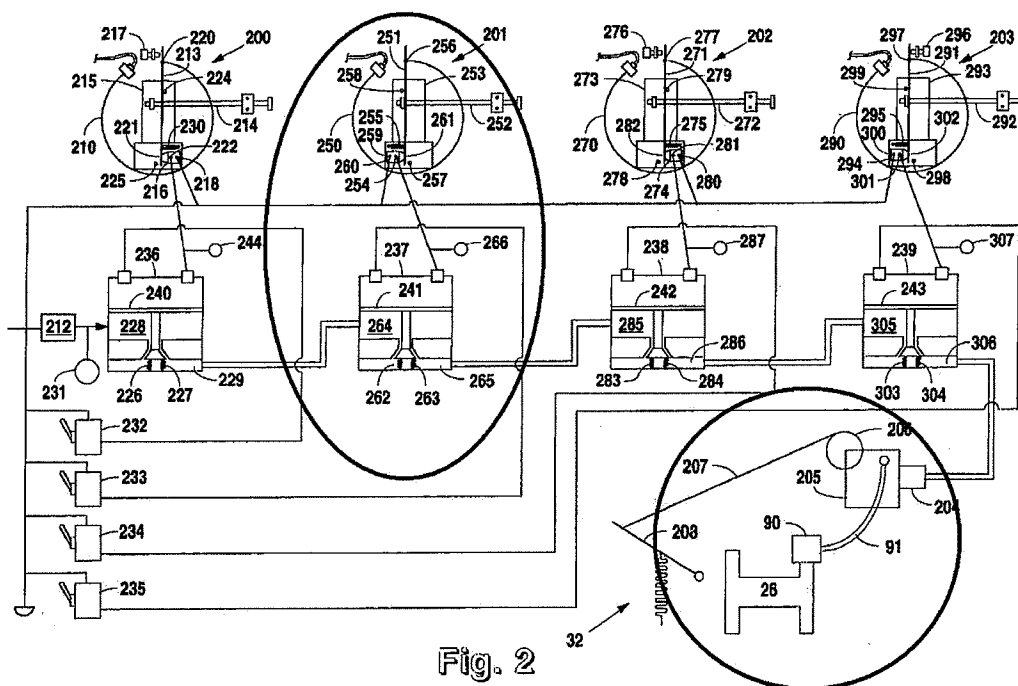


Figure 2 of '142 Patent

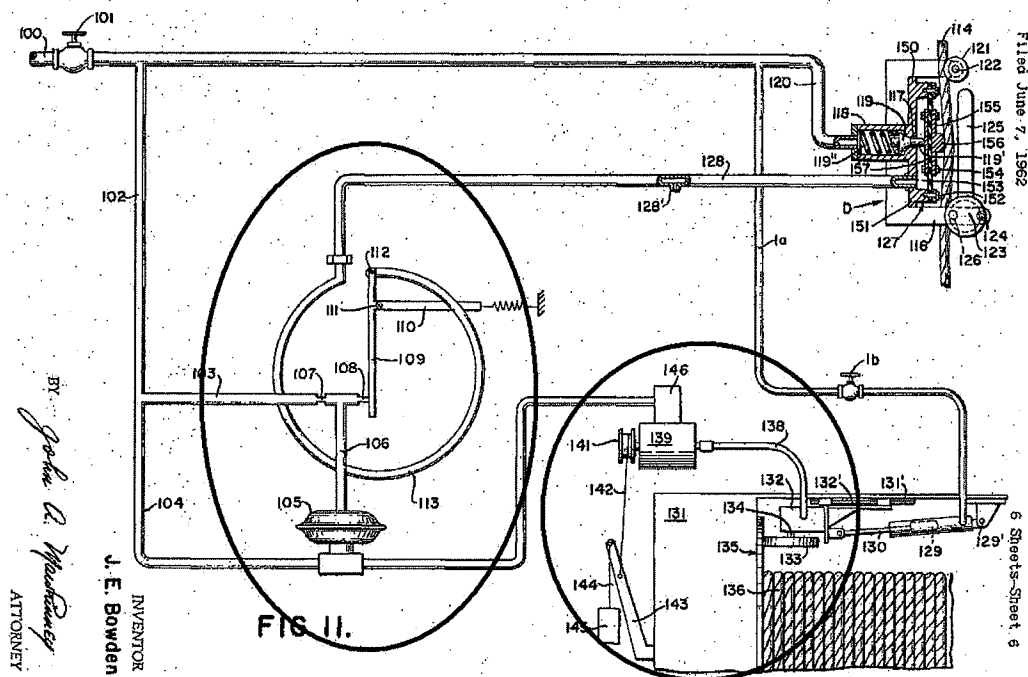


Figure 11 of Bowden '359

In both Bowden '359 and the '142 Patent, a pressure signal representing bit weight is fed to a Bourdon tube (113 in Bowden '359, 250 in the '142 Patent). The Bourdon tube expands and contracts with changes in pressure (bit weight), actuating a flapper (109 in Bowden '359, 251 in the '142 Patent). The flapper pivots to cover a nozzle (108 in Bowden '359, 254 in the '142 Patent), thereby directing more or less of an air supply to a pneumatic valve (105 in Bowden '359, 237 in the '142 Patent), causing the valve to open or close and thereby gating the flow of air from a supply (100 in Bowden '359, 212 in the '142 Patent) through the valve. Output air from the valve ultimately turns a motor (146 in Bowden '359, 204 in the '142 Patent), to control the rate of release of the drill string by controlling the drum brake through a set of planetary or differential gears (139 in Bowden '359, 205 in the '142 Patent). The differential gears (139 in Bowden '359, 205 in the '142 Patent) compare the rotation of the air-driven motor (146 in Bowden '359, 204 in the '142 Patent) with the rotation of the cable drum (135 in Bowden '359, 26 in the '142 Patent). The rotation of the drum is measured by a rotation sensor (133 in Bowden '359, 90 in the '142 Patent) and transmitted to the differential gears by a flexible shaft (138 in Bowden '359, 91 in the '142 Patent). The differential gears rotate an output spool or reel (141 in Bowden '359, 206 in the '142 Patent) that pulls or releases a cable (241 in Bowden '359, 207 in the '142 Patent) to apply more or less braking force to the brake lever (143 in Bowden '359, 208 in the '142 patent). Bowden '359 c. 7, l. 64 - c. 9, l. 68, and '142 Patent c. 7, l. 17 - c. 10, l. 61.

The control system of Bowden '359 inherently controls the rate of release of the drill string, as required by claims 1-8 and 11-13 of the '142 Patent. The rate of rotation of the pneumatic motor (142 in Bowden '359, 204 in the '142 Patent) is driven by the amount of air flowing into the motor, which is in turn controlled by the regulator-relay combination. The rotation of the drum is sensed and compared to the motor rotation by the differential gears, and the braking is controlled to keep the rotations synchronized. And given that the control systems described in Bowden '359 and the '142 Patent are identical in their operation, they must be identical in their effect.<sup>2</sup>

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<sup>2</sup> However the progression of the drill string may still be in fits and starts, and need not be a smooth, continuous motion. Each of the regulator-relay systems shown in Figure 2 of the '142 Patent may halt

Bowden '359 provides control of a single output variable based on a single input pressure variable. Drill string tension is measured to evaluate bit weight, converted to a pressure, and the feed of the drill string is controlled in relation to the pressure. The '142 Patent merely expands in an obvious way on Bowden '359, allowing for control based on other single variables, or combinations of input variables using multiple regulator-relay units of the kind described by Bowden '359.

Claims 1 and 11

The applicability of the references to claim 1 is described above in Section I. Claim 11 is a method claim that parallels claim 1. Claims 1 and 11 of the '142 Patent recite a system and method for controlling the release of the drill string based on a different single variable, drilling fluid pressure. Bowden '359 already describes a system and method of controlling the rate of release of the drill string<sup>3</sup>, based on a single input pressure. Drilling fluid

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release of the drill string as part of its normal operation. See '142 Patent c. 8, l. 29, c. 11, l. 49, c. 14, ll. 32-33, and c. 17, l. 50.

<sup>3</sup> Ball also teaches a system and method for controlling the rate of release of the drill string, based on bit weight. Ball figured prominently in the prosecution of the '142 Patent, and in fact the examiner twice rejected the claims of the '142 Patent as obvious over Ball in combination with other references.

- a) In making his obviousness conclusion, the examiner recognized that "Ball [U.S. Patent No. 4,662,608] basically teaches the same principle of controlling the rate of release of drill string as being recited in applicant's respective claims with the exception of the drilling fluid pressure sensor, the torque sensor and the rpm sensor." Examiner's Action, dated March 8, 1994, at p. 4.
- b) The examiner then logically concluded that "[i]nclusion of such sensors, in the examiner's opinion, is well within the scope of general engineering design considerations, in that it is well known to one of the ordinary skill in the art of drilling, the drilling fluid pressure, the drilling rpm and the drilling torque are among the important factor [sic] which affect the penetration rate and such has long been taught in the general publication such as Gatlin's Petroleum Engineering." Id. at p. 5.
- c) In response, the applicant urged a strict application of the teaching, suggestion, and motivation test. Amendment A, dated June 10, 1994, at p. 4-5.
- d) Notwithstanding, the examiner again rejected the claims as being obvious under 35 U.S.C. § 103. Specifically, the examiner explained, "[r]egarding the base of claim rejections based on the combination of Ball, Rogers and Gatlin; examiner believes that he has established sufficient grounds supporting a prima facie case of obviousness, specifically Ball and Rogers disclose the technique of automatic drilling control based on limited parameters while Gatlin teaches the importance of a more comprehensive drilling optimization approach which basically provides the theoretical background and the motivation of including a broader drilling factors into the automatic drilling system taught in Ball and Rogers." Second Examiner's Action, dated August 10, 1994, at pp. 6-7.

pressure is just that – a pressure. It would have been trivial for one of skill in the art to substitute the drilling fluid pressure for the pressure derived from bit weight in Bowden '359 (with an easily-accomplished reversal of sensitivity) to arrive at the system and method of claims 1 and 11. The '142 Patent even discloses a "standard" drilling fluid pressure gauge, commercially available before the filing of the '142 Patent, that provides a drilling fluid pressure signal. ('142 Patent c. 5, ll. 29-38 and Fig. 5. All that is missing from Bowden '359 with respect to claims 1 and 11 is some rational basis why one of skill in the art would have thought to control drill string release based on drilling fluid pressure rather than bit weight.

Both Dillon and Hobhouse teach controlling the release of the drill string based on drilling fluid pressure, and thus provide the motivation for the trivial modification of the system of Bowden '359 to control the rate of drill string release based on drilling fluid pressure. See Dillon p. 4, c. 1, ll. 14-32, and Hobhouse c. 7, l. 74 - c. 8, l. 51.

Claims 2-4, 12, and 13

Claims 2-4, 12, and 13 of the '142 Patent teach controlling drill string release based on combinations of variables, including bit weight, drilling fluid pressure, drill string torque, and drill string RPM. Bowden '359 describes a bit weight sensor nearly identical to that shown in the '142 Patent. The '142 Patent describes a suitable commercially available sensor at least for drill string torque. '142 Patent c. 6, ll. 38-50 and Fig. 10. As evidenced by Hobhouse and Dillon, the sensing of drill string RPM was well known in the art long before the "invention" of the '142 Patent. All that is missing from Bowden '359 with respect to the combination control claims of the '142 Patent is some rational basis why one of skill in the art would have thought to control drill string release based on multiple variables.

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- e) In response to the examiner's second rejection, the applicant again urged, "[w]ith respect to claims 1 and 7 [which issued as Claims 1 and 11 respectively], Applicant respectfully submits that the recognition in the Gatlin publication that hydraulic fluid affects the drilling rate does not disclose, teach, or fairly suggest to one of ordinary skill in the art that drilling fluid pressure may be utilized as a parameter to control the release of the drill string." Amendment After Final Under 37 C.F.R. § 1.116, dated November 7, 1994, at p. 8 (emphasis added).



Dillon in particular provides explicit motivation for controlling drill string release based on combinations of the four variables used in the '142 Patent. In fact, the '142 Patent and Dillon contain nearly identical statements of their inventions, as shown in the table below.

Statement from '142 Patent Abstract	Statement from Dillon, p. 1, c. 1, ll. 54ff
An automatic drilling system regulates the drill string of a drilling rig in response to any one of, any combination of, or all of drilling fluid pressure, bit weight, drill string torque, and drill string RPM to achieve an optimal rate of bit penetration.	A still further object of this invention is to provide for controlling the movement of the drill stem as a function of tension in the drill-stem-supporting hook, the load on the drilling motor, the speed of the drilling motor, and the pressure of the fluid pumped by the mud pump, or any one, or any combination of these factors.

Hobhouse also describes controlling drill string advance based on multiple input variables, including torque, bit weight, and their combination. Hobhouse c. 7, ll. 24-73.

One of skill in the art could also have easily adapted the system of Bowden '359 for multivariate control, and would have been motivated to do so especially by Dillon.

#### Claims 5-8

Claims 5-8 of the '142 Patent recite details of the "regulators" that measure the four input variables and "relays" that forward signals from the regulators. Bowden '359 describes a regulator and relay functionally identical to those found in the '142 Patent. The '142 Patent merely replicates the regulator and relay of Bowden '359 for the measurement of other variables. Bowden '359 provides detailed descriptions of the operation of these components at c. 4, ll. 1-38 and c. 9, ll. 12-33.

#### Claims 14 and 15

Claims 14 and 15 of the '142 Patent are method claims that recite regulating the release of a drill string based on combinations of input variables. Claim 14 recites control based on drilling fluid pressure and bit weight, and claim 15 recites control based on all four measured variables – drilling fluid pressure, bit weight, drill string torque, and drill string RPM. The basis for rejecting claims 14 and 15 is similar to that given above for claims 1-4. That is, Bowden

'359 teaches regulation of the drill string release based on bit weight. Dillon and Hobhouse teach regulation of drill string release based on drilling fluid pressure and on combinations of variables. Dillon teaches regulation of drill string release based on RPM and torque, in addition to drilling fluid pressure and bit weight. Dillon provides explicit motivation for the particular combinations of variables recited in claims 14 and 15. One of skill in the art could easily have extended the system of Bowden '359 to perform the control recited in claims 14 and 15, and would have been motivated to do so by at least Dillon.

Claims 14 and 15 differ in two major ways from the other method claims reciting multivariate control.

First, claims 14 and 15 do not include any requirement for controlling the rate of drill string release. For example, claim 14 recites only "relaying said selected signal or signals to a drill string controller which regulates the release [of] said drill string in response to said selected signal or signals."

Second, claims 14 and 15 include a "selecting" step. For example, claim 14 recites producing two signals, one reflecting changes in drilling fluid pressure and one reflecting changes in bit weight, and then

**selecting** any one of said first signal, said second signal, and both said first and said second signals to control the release of said drill string....

Claim 15 recites a similar step for selecting combinations from among four control variables. Requestor believes that the only reasonable interpretation of this language is that it describes the actuation of some selection mechanism, such as "valve selectors" 232-235 shown in Figure 2 of the '142 Patent, that determine which input variable or variables will be considered during automatic regulation of drill string release. See, for example, c. 7, l. 49 - c. 8, l. 6 of the '142 Patent, which indicate that "[v]alve selectors 232-235 control which ones of regulators 200-203 control the drilling operation", and explain how the various combinations may be selected. Column 2 line 22 of the '142 patent indicates that it is the "operator of the automatic driller" that makes the selections.

Both Dillon and Hobhouse provide selection mechanisms analogous to the "valve selectors" of the '142 Patent. In the claim chart below, Requestor has referred to this kind of

selecting as “manual selection”. Dillon describes “knife switch” 98 and other mechanisms for including and excluding the influence of individual control variables on drill string release. Hobhouse describes a “control selector” 42 that enables an operator to select control based on either of two variables, or the combination of them. Thus either or both of Dillon and Hobhouse may be used to teach or suggest this element and to support a case of obviousness of claims 14 and 15.

Requester is aware that the patent owner has proffered a different interpretation of the “selecting” step of claims 14 and 15 in litigation relating to the ‘142 Patent. Under the patent owner’s alternative interpretation, the “selecting” of signals recited in claims 14 and 15 is different than the selection of the set of control variables using “valve selectors” 232-235, and must be something that is performed automatically by the automatic driller.

In the operation of the system of the ‘142 patent, the release of the drill string is controlled by the amount of air flowing through valves 236-239, which are connected in series. Any one of the valves, under control of its corresponding regulator 200-203, can at times constrict the flow of air more than any of the other valves, and therefore take over as the controlling valve, effectuating control based mainly on the control variable corresponding to that particular valve. During setup of the system, the operator may set a “primary” regulator/valve combination to control one variable within a tight tolerance, and set a “secondary” to control a second variable within a looser tolerance. During operation, the system will then control the drill string release based mainly on the primary variable until the secondary variable reaches an undesirable condition, at which time the system intervenes to automatically choose or switch over to the secondary variable as the controlling variable, by actuating the valve corresponding to that variable to constrict the air flow more than the valve corresponding to the primary variable. The patent owner has argued that this automatic switching between controlling variables during operation is the “selecting” recited in claim 14.

Requester disagrees, and notes that nowhere in the ‘142 Patent is this switching between controlling variables referred to as “selecting” anything. A careful reading of the ‘142 Patent shows that nowhere is the word “select” or any derivative of it used in describing this variable-switching process. Furthermore, this kind of “selecting” chooses one variable to

dominate the others, acting essentially as a single control variable so long as its condition is undesirable, and therefore this kind of “selecting” has no way of choosing to control based on both of the variables, as is recited in the claim.

Nonetheless, even under this interpretation of “selecting”, both Dillon and Hobhouse teach “selecting any one of [a] first signal, [a] second signal, and both said first and said second signals to control the release of said drill string”. In the claim chart below, Requester has referred to this kind of “selecting” as “automatic selection”.

For example, Dillon includes an “excess current relay” that triggers hoisting of the drill stem when “the load on the drilling motor becomes greatly excessive.” Dillon p. 4, c. 1, ll. 41-59. One of skill in the art will recognize the in this context, “load” refers to torque. As is seen in Dillon’s Figures 1 and 1a, regardless of which control variables are used to control drill string release through control mechanism 65, if the torque reaches an undesirable condition, the system will automatically switch over to controlling the drill stem based on the torque (current) of the drilling motor. While Dillon does not describe performing such an automatic switchover between the variables used in claim 14 (drilling fluid pressure and bit weight), Dillon does suggest this kind of automatic “selecting”, and explicitly teaches controlling drill string release based on the combination of drilling fluid pressure and bit weight. One of skill in the art could easily have adopted the teachings of Dillon to provide this step of claims 14 and 15.

Hobhouse is even more explicit in its description of automatic “selecting”. Hobhouse shows controls 42(1), 42(2), and 42(3), which choose respectively “torque control”, “weight control”, and “weight/torque combination”. Hobhouse c. 5, ll. 50-69. Each variable can have a limit, “beyond which the system shuts down and locks the cylinder 4 [stopping drill string release].” Hobhouse c. 6, ll. 1-3. Even if, for example, torque is selected as the “dominant” variable, “weight limits would be set”. Hobhouse c. 6, ll. 6-9. Thus, Hobhouse also automatically switches from control based a first variable to control based on a second when the second variable reaches an undesirable condition, and intervenes to control the release of the drill string based on the second variable when necessary. Hobhouse also does not explicitly teach switching between the particular variables recited in claim 14 (drilling fluid pressure and bit weight), but teaches measurement of both of them, teaches control based on them individually,

teaches control based on combinations of variables, and provides a controller that could be easily configured to perform the required switching. Dillon explicitly suggests control based on the combination of drilling fluid pressure and bit weight, and both Dillon and Hobhouse teach automatic “selecting” during operation of their respective systems.

It would have been well within the ability of one skilled in the art to combine the systems of Bowden ‘359, Dillon, and Hobhouse to provide the recited automatic “selecting” between drilling fluid pressure and bit weight as dominant variables, and the references provide motivation to do so.

Under either interpretation of “selecting”, claims 14 and 15 are obvious.

In summary, Bowden ‘359, Ball, Dillon, and Hobhouse teach all of the signals and mechanisms needed to effect regulation of the rate of drill string release as recited in the claims of the ‘142 Patent, including regulation based on any one, or any combination, or all of bit drilling fluid pressure, bit weight, drill string torque, and drill string RPM. Dillon and Hobhouse describe multivariate control, and Dillon especially provides motivation for all of the recited combinations of input control variables. Requestor notes that this is true under either interpretation of the “selecting” step of claims 14, and 15, as discussed below.

At least claims 1-8 and 11-15 of the ‘142 Patent are therefore obvious over the combination of Bowden ‘359, Ball, Dillon, and Hobhouse.

A claim chart detailing where the elements of claims 1-8 and 11-15 are shown Bowden ‘359, Ball, Dillon, and Hobhouse is provided in Appendix A.

### **B. Claims 1 and 11 Are Unpatentable Under 35 U.S.C. § 102(b) As Being Anticipated By LeCompte**

LeCompte discloses each and every element of claims 1 and 11 of the ‘142 Patent. The applicability of the references to claim 1 is described above in Section I. Claim 11 is a method claim that parallels claim 1. For convenience, a claim chart detailing where the elements of claims 1 and 11 are shown by LeCompte is given below.

‘142 Patent Claims	LeCompte Reference
<p>1. An automatic drilling system for automatically regulating the release of the drill string of a drilling rig during the drilling of a borehole, comprising:</p> <p>drilling fluid pressure sensor;</p>	<p>LeCompte indicates that one object of its invention “resides in the provision of brake actuation mechanism co-acting with the telescopic drill stem section and actuated by the back pressure of the mud laden fluid ... for automatically retarding the lowering of additional drill stem into the hole ... and, if necessary, stop further lowering of drill stem....” p. 1, ll. 49-58.</p> <p>Length compensator U; Mud pipe M; Slidable valve 84</p> <p>p. 4, c. 1, ll. 27-31, p. 3, c. 1, ll. 8-13  p. 5, c. 1, l. 14 - p. 6, c. 1, l. 15</p>
<p>a drilling fluid pressure regulator coupled to said drilling fluid pressure sensor, said drilling fluid pressure regulator measuring changes in drilling fluid pressure and outputting a signal representing those changes;</p>	<p>Slidable valve 84; Valve groove 86; spring 85; Steam boiler O; steam pipe P</p> <p>p. 5, c. 1, l. 24 - p. 6, c. 1, l. 15.</p>
<p>a relay coupled to said drilling fluid pressure regulator, said relay responsive to the output signal of said drilling fluid pressure regulator to supply a drill string control signal at an output thereof; and</p>	<p>Slidable valve 84; Steam cylinder 67; piston 70; arm 73</p> <p>p. 5, c. 1, l. 14 - p. 6, c. 1, l. 15</p>
<p>a drill string controller coupled to said relay wherein a decrease in drilling fluid pressure results in said relay supplying a drill string control signal that operates said drill string controller to effect an increase in the rate of release of said drill string and an increase in drilling fluid pressure results in said relay supplying a drill string control signal that operates said drill string controller to effect a decrease in the rate of release of said drill string.</p>	<p>Brake lever 60; cable drum D</p> <p>p. 5, c. 2, l. 82 - p. 6, c. 2, l. 51</p> <p>LeCompte describes that when drilling fluid pressure increases, additional braking is applied to “slow up feeding of upper drill stem into the hole.” p. 5, ll. 97-112. When pressure falls, the brake actuation is relaxed “to allow normal lowering of the upper drill stem section H.” p. 6, ll. 16-30. LeCompte slows or speeds up the drill string release in response to drilling fluid pressure, thereby regulating the <u>rate</u> of release of the drill</p>

'142 Patent Claims	LeCompte Reference
	string.
<p><b>11.</b> A method for automatically regulating the release of the drill string of a drilling rig drill, comprising the steps of:</p> <p>measuring drilling fluid pressure;</p>	<p>LeCompte indicates that one object of its invention “resides in the provision of brake actuation mechanism co-acting with the telescopic drill stem section and actuated by the back pressure of the mud laden fluid ... for automatically retarding the lowering of additional drill stem into the hole ... and, if necessary, stop further lowering of drill stem....” P. 1, ll. 49-58.</p> <p>Length compensator U; Mud pipe M; Slidable valve 84  p. 4, c. 1, ll. 27-31, p. 3, c. 1, ll. 8-13  p. 5, c. 1, l. 14 - p. 6, c. 1, l. 15</p>
<p>producing a signal in response to changes in drilling fluid pressure, said signal representing the changes in drilling fluid pressure;</p>	<p>Slidable valve 84; Valve groove 86; spring 85; Steam boiler O; steam pipe P  p. 5, c. 1, l. 24 - p. 6, c. 1, l. 15</p>
<p>relaying said signal to a drill string controller; and</p>	<p>Slidable valve 84; Steam cylinder 67; piston 70, arm 73  p. 5, c. 1, l. 14 - p. 6, c. 1, l. 15</p>
<p>controlling said drill string controller to increase the rate of release of said drill string when said signal represents a decrease in drilling fluid pressure and to decrease the rate of release of said drill string when said signal represents an increase in drilling fluid pressure.</p>	<p>Brake lever 60; cable drum D  p. 5, c. 2, l. 82 - p. 6, c. 2, l. 51</p> <p>LeCompte describes that when drilling fluid pressure increases, additional braking is applied to “slow up feeding of upper drill stem into the hole.” P. 5 lines 97-112. When pressure falls, the brake actuation is relaxed “to allow normal lowering of the upper drill stem section H.” p. 6, ll. 16-30. LeCompte slows or speeds up the drill string release in response to drilling fluid pressure, thereby regulating the <u>rate</u> of release of the drill string.</p>

**C. Claims 1 and 11 Are Unpatentable Under 35 U.S.C. § 102(b) As Being  
Anticipated By Brett/Warren**

Brett/Warren discloses each and every element of claims 1 and 11 of the '142 Patent. The applicability of the references to claim 1 is described above in Section I. Claim 11 is a method claim that parallels claim 1. For convenience, a claim chart detailing where the elements of claims 1 and 11 are shown by Brett/Warren is given below.

<b>'142 Patent Claims</b>	<b>Brett/Warren Reference</b>
<p><b>1.</b> An automatic drilling system for automatically regulating the release of the drill string of a drilling rig during the drilling of a borehole, comprising:</p> <p>a drilling fluid pressure sensor;</p>	<p>Brett/Warren is related to "computer controlled drilling". (Title). Control is accomplished by "vary[ing] the weight on bit so that the controlled parameter was held constant." p. 201, c. 1, second full paragraph. The weight on bit is varied by a hydraulic actuator that applies more or less lifting force to the drill string. p. 199, c. 2, "Actuation" section. One of skill in the art will recognize that this inherently constitutes regulating the rate of release of the drill string.</p> <p>Brett/Warren discloses a drilling fluid pressure sensor: Pump pressure is designated as a "direct control" variable. p. 207, Table 1.</p>
<p>a drilling fluid pressure regulator coupled to said drilling fluid pressure sensor, said drilling fluid pressure regulator measuring changes in drilling fluid pressure and outputting a signal representing those changes;</p>	<p>See Nomenclature: p. 204, c. 1-2  Analog Control (Fig. 10/11) p. 200  Integral Control (Equations 1-4) p. 205</p>
<p>a relay coupled to said drilling fluid pressure regulator, said relay responsive to the output signal of said drilling fluid pressure regulator to supply a drill string control signal at an output thereof; and</p>	<p>Analog Control (Fig. 10/11) p. 200  Integral Control (Equations 1-4) p. 205</p>
<p>a drill string controller coupled to said relay wherein a decrease in drilling fluid pressure results in said relay supplying a drill string</p>	<p>100kip manual, servo, or computer controlled hydraulic hoist; hoist actuation system (Fig. 8) p. 199</p>



'142 Patent Claims	Brett/Warren Reference
control signal that operates said drill string controller to effect an increase in the rate of release of said drill string and an increase in drilling fluid pressure results in said relay supplying a drill string control signal that operates said drill string controller to effect a decrease in the rate of release of said drill string.	Analog Control (Fig. 10/11) p. 200 Integral Control (Equations 1-4) p. 205
<p><b>11.</b> A method for automatically regulating the release of the drill string of a drilling rig drill, comprising the steps of:</p> <p>measuring drilling fluid pressure;</p>	<p>Brett/Warren is related to “computer controlled drilling”. (Title). Control is accomplished by “vary[ing] the weight on bit so that the controlled parameter was held constant.” p. 201, c. 1, second full paragraph. The weight on bit is varied by a hydraulic actuator that applies more or less lifting force to the drill string. p. 199, c. 2, “Actuation” section. One of skill in the art will recognize that this inherently constitutes regulating the rate of release of the drill string.</p> <p>Brett/Warren discloses a drilling fluid pressure sensor: Pump pressure is designated as a “direct control” variable. p. 207, Table 1.</p>
producing a signal in response to changes in drilling fluid pressure, said signal representing the changes in drilling fluid pressure;	See Nomenclature: p. 204, c. 1-2 Analog Control (Fig. 10/11) p. 200 Integral Control (Equations 1-4) p. 205
relaying said signal to a drill string controller; and	See Nomenclature: p. 204, c. 1-2 Analog Control (Fig. 10/11) p. 200 Integral Control (Equations 1-4) p. 205
controlling said drill string controller to increase the rate of release of said drill string when said signal represents a decrease in drilling fluid pressure and to decrease the rate of release of said drill string when said signal represents an increase in drilling fluid pressure.	<p>100kip manual, servo, or computer controlled hydraulic hoist; hoist actuation system (Fig. 8) p. 199</p> <p>Analog Control (Fig. 10/11) p. 200 Integral Control (Equations 1-4) p. 205</p>

**D. Claims 1 and 11 Are Unpatentable Under § 102(b) As Being Anticipated By Hobhouse**

Hobhouse discloses each and every element of claims 1 and 11 of the '142 Patent. The applicability of the references to claim 1 is described above in Section I. Claim 11 is a method claim that parallels claim 1. For convenience, a claim chart detailing where the elements of claims 1 and 11 are shown by Hobhouse is given below.

'142 Patent Claims	Hobhouse Reference
<p><b>1.</b> An automatic drilling system for automatically regulating the release of the drill string of a drilling rig during the drilling of a borehole, comprising:</p> <p>a drilling fluid pressure sensor;</p>	<p>Hobhouse indicates that an object of its invention is to "provide a control system for drilling rigs." c. 1, ll. 39-40. Hobhouse's system includes hydraulic cylinder "to regulate the sinkage of the drill string". c. 8, ll. 33-34. The system includes a drilling fluid pressure sensor. Fig. 8, elements 103-107, c. 8 ll. 15-29.</p>
<p>a drilling fluid pressure regulator coupled to said drilling fluid pressure sensor, said drilling fluid pressure regulator measuring changes in drilling fluid pressure and outputting a signal representing those changes;</p>	<p>Hobhouse discloses such a device in Figure 8, elements 108 and 109, which are coupled to the pressure sensor (103-107), and output a signal indicative of pressure changes. c. 8, ll. 22-27.</p>
<p>a relay coupled to said drilling fluid pressure regulator, said relay responsive to the output signal of said drilling fluid pressure regulator to supply a drill string control signal at an output thereof; and</p>	<p>Figure 8 of Hobhouse shows "control console" 111 that receives the electric signal from the pressure sensor and controls cylinder 99. "The control console 111 ... may supply pressure fluid to the underside of the piston 98 in the cylinder 99, to regulate the sinkage of the drill string...." c. 8, ll. 30-34.</p>
<p>a drill string controller coupled to said relay wherein a decrease in drilling fluid pressure results in said relay supplying a drill string control signal that operates said drill string controller to effect an increase in the rate of release of said drill string and an increase in drilling fluid pressure results in said relay supplying a drill string control signal that operates said drill string controller to effect a</p>	<p>Figure 8 of Hobhouse shows "control console" 111 that receives the electric signal from the sensors and controls cylinder 99. "The control console 111 ... may supply pressure fluid to the underside of the piston 98 in the cylinder 99, to regulate the sinkage of the drill string...." c. 8, ll. 30-34. Hobhouse describes stopping the sinkage of the drill stem in response to an increase in</p>

'142 Patent Claims	Hobhouse Reference
decrease in the rate of release of said drill string.	mud-flush pressure, and increasing the sinkage of the drill stem in response to a decrease in mud-flush fluid pressure. c. 8, ll. 38-49. Stopping and increasing the sinkage of the drill string are control of the rate of release of the drill string. The control is through "graduated reference contacts" 110. c. 8, l. 27 and Fig. 8.
<p>11. A method for automatically regulating the release of the drill string of a drilling rig drill, comprising the steps of:</p> <p>measuring drilling fluid pressure;</p>	Hobhouse indicates that an object of its invention is to "provide a control system for drilling rigs." c. 1, ll. 39-40. Hobhouse's system includes hydraulic cylinder "to regulate the sinkage of the drill string". c. 8, ll. 33-34. The system includes a drilling fluid pressure sensor. Fig. 8, elements 103-107, c. 8, ll. 15-29.
producing a signal in response to changes in drilling fluid pressure, said signal representing the changes in drilling fluid pressure;	"Changes in mud-flush pressure beyond determined limits produce a change in pressure in the hydraulic fluid and generate an electrical signal from the strain gauges 107." c. 8, ll. 22-25.
relaying said signal to a drill string controller; and	Figure 8 of Hobhouse shows "control console" 111 that receives the electric signal from the pressure sensor and controls cylinder 99. "The control console 111 ... may supply pressure fluid to the underside of the piston 98 in the cylinder 99, to regulate the sinkage of the drill string...." c. 8, ll. 30-34.
controlling said drill string controller to increase the rate of release of said drill string when said signal represents a decrease in drilling fluid pressure and to decrease the rate of release of said drill string when said signal represents an increase in drilling fluid pressure.	Hobhouse describes stopping the sinkage of the drill stem in response to an increase in mud-flush pressure, and increasing the sinkage of the drill stem in response to a decrease in mud-flush fluid pressure. c. 8, ll. 38-49. Stopping and increasing the sinkage of the drill string are control of the rate of release of the drill string, in the in the relationship claimed in the '142 Patent. c. 8, ll. 30-51. The control is through "graduated reference contacts" 110. c. 8, l. 27 and

<b>'142 Patent Claims</b>	<b>Hobhouse Reference</b>
	Figure 8.

**E. Claims 2-4 and 12-15 Are Unpatentable Under 35 U.S.C. § 103(a) As Being Obvious In Light Of Hobhouse In View Of Dillon**

As explained above, Hobhouse teaches each and every element of claim 1 and 11, and therefore anticipates claims 1 and 11. Claims 1 and 11 describe controlling drill string advance as a function of drilling fluid pressure. Claims 2-4 and 12-15 add additional input variables, including bit weight, drill string torque, and drill string RPM. In these claims, drill string advance is controlled based on various combinations of the four input variables. Hobhouse teaches control of drill string advance based on weight, torque, and drilling fluid pressure individually, and based on the combination of weight and torque. Hobhouse c. 7, l. 23 - c. 8, l. 51. The combination of weight and torque, without other variables, is not explicitly claimed in the '142 Patent.

Hobhouse measures all four of the pertinent variables: drilling fluid pressure (Fig. 8, elements 103-107, c. 8, ll. 15-29), bit weight (c. 5, ll. 30-36), drill string torque (c. 4, ll. 30-40, Fig. 5), and drill string RPM (c. 4, ll. 38-40). Each of these sensors produces an electrical signal. Hobhouse also provides convenient electrical means for combining various control inputs and producing a single control output. ("control module" 111 in Figure 8 and the circuit of Figure 7, described at c. 7, l. 23 – cl. 8, l. 52)

Hobhouse thus provides a mechanism to control the rate of drill string advance in response to multiple inputs, and provides all of the necessary inputs to regulate the rate of drill string advance based on the combinations of inputs claimed in the '142 Patent. One of skill in the art could easily have configured the system of Hobhouse to perform the claimed controls. For example, the electrical circuit of Figure 7 or a similar circuit could be expanded to control based on combinations of four electrical inputs representing four drilling parameters. All that is missing from Hobhouse is the motivation to control based on the particular combinations recited in the '142 Patent claims.

Dillon explicitly provides the needed motivation, noting that one of its objects “is to provide for controlling the movement of the drill stem as a function of tension in the drill-stem-supporting hook, the load on the drilling motor, the speed of the drilling motor, and the pressure of the fluid pumped by the mud pump, or any one, or any combination of these factors.” Dillon p. 1, c. 1, ll. 54ff.

The claim chart below details where all of the pertinent claim elements are found in Hobhouse. Dillon is relied upon only for motivating the particular combinations of control variables recited in the pertinent claims of the ‘142 Patent.

<b>‘142 Patent Claims</b>	<b>Hobhouse Reference</b>
<b>2. The automatic drilling system according to claim 1, further comprising:</b>  a bit weight sensor;	Hobhouse uses cylinder pressure to sense bit weight. c. 5, ll. 30-36.
a bit weight regulator coupled to said bit weight sensor, said bit weight regulator measuring changes in bit weight and outputting a signal representing those changes;	Bit weight is indicated by a “signal from pressure transducer 63” in the cylinder. c. 7, ll. 42-43. See also c. 5, ll. 30-36.
a relay coupled to said bit weight regulator, said relay responsive to the output signal of said bit weight regulator to supply a drill string control signal at an output thereof; and	Hobhouse must necessarily relay its bit weight signal to the drill string controller. See c. 7, ll. 40-47, relays 80, 81, and solenoid valve 71.
said drill string controller coupled to said relay wherein a decrease in bit weight results in said relay supplying a drill string control signal that operates said drill string controller to effect an increase in the rate of release of said drill string and an increase in bit weight results in said relay supplying a drill string control signal that operates said drill string controller to effect a decrease in the rate of release of said drill string.	The length of cylinder 4 is automatically adjusted to raise or lower the drill string, to keep weight-on-bit substantially constant. c. 5, ll.59-63. Raising and lowering the drill string is control of the rate of release of the drill string. The control is through “graduated reference contacts” 110. c. 8, l. 27 and Fig. 8.
<b>3. The automatic drilling system according to claim 1 further comprising:</b>  a drill string torque sensor;	Torque transducer 8 measures the torque on the drive shaft 9. c. 4, ll. 30-40, Fig. 5.

'142 Patent Claims	Hobhouse Reference
a drill string torque regulator coupled to said drill string torque sensor, said drill string torque regulator measuring changes in drill string torque and outputting a signal representing those changes;	Torque transducer 8 produces an "actual torque signal". c. 4, l. 31, c. 7, l. 30.
a relay coupled to said drill string torque regulator, said relay responsive to the output signal of said drill string torque regulator to supply a drill string control signal at an output thereof; and	"The strain gauges [used to measure torque] are connected to the console...." c. 4, ll. 37-38. See also c. 7, ll. 28-39, relays 78, 80, 81, solenoid valve 71.
a drill strings controller coupled to said relay wherein a decrease in drill string torque results in said relay supplying a drill strings control signal that operates said drill strings controller to effect an increase in the rate of release of said drill string and an increase in drill string torque results in said relay supplying a drill strings control signal that operates said drill strings controller to effect a decrease in the rate of release of said drill string.	Figure 8 of Hobhouse shows "control console" 111 that receives the electric signal from the sensors and controls cylinder 99. "The control console 111 ... may supply pressure fluid to the underside of the piston 98 in the cylinder 99, to regulate the sinkage of the drill string...." c. 8, ll. 30-34. One of skill in the art will recognize that the inherently preferred relationship is to slow the rate of drill string release when torque increases, and to accelerate the rate of drill string release when torque decreases.
4. The automatic drilling system according to claim 1 further comprising:  a drill string RPM sensor;	Hobhouse measures drill string RPM. An "electromagnetic pickup is included to give an accurate measurement of the speed of the shaft 9." c. 4, ll. 38-40.
a drill string RPM regulator coupled to said drill string RPM sensor, said drill string RPM regulator measuring changes in drill string RPM and outputting a signal representing those changes;	The "accurate measurement of the speed of the shaft" is necessarily an output signal that reflects any changes in the speed of the shaft. c. 4, ll. 38-40.
a relay coupled to said drill string RPM regulator, said relay responsive to the output signal of said drill string RPM regulator to supply a drill strings control signal at an output thereof; and	Hobhouse necessarily must relay its RPM signal to console 111, as Hobhouse currently controls drill string RPM. c. 4, ll. 52-54.
a drill strings controller coupled to said relay wherein an increase in drill string RPM results in said relay supplying a drill strings control	Figure 8 of Hobhouse shows "control console" 111 that receives the electric signal from the sensors and controls cylinder 99.

<b>'142 Patent Claims</b>	<b>Hobhouse Reference</b>
signal that operates said drill strings controller to effect an increase in the rate of release of said drill string and a decrease in drill string RPM results in said relay supplying a drill strings control signal that operates said drill strings controller to effect a decrease in the rate of release of said drill string.	"The control console 111 ... may supply pressure fluid to the underside of the piston 98 in the cylinder 99, to regulate the sinkage of the drill string...." c. 8, ll. 30-34. One of skill in the art will recognize that the inherently preferred relationship is to slow the rate of drill string release when RPM decreases, and to accelerate the rate of drill string release when RPM increases.
<b>12.</b> The method according to claim 11 further comprising the steps of:  measuring drill string torque;	Torque transducer 8 measures the torque on the drive shaft 9. c. 4, ll. 30-40, Fig. 5.
producing a signal in response to changes in drill string torque, said signal representing the changes in drill string torque; and	"... an amplifier receives ... the actual torque signal from the transducer..." c. 7, ll. 28-29.
relaying said signal to a drill string controller;	"The strain gauges [used to measure torque] are connected to the console...." c. 4, ll. 37-38. See also c. 7, ll. 28-39, relays 78, 80, 81, solenoid valve 71.
controlling said drill string controller to increase the rate of release of said drill string when said signal represents a decrease in drill string torque and to decrease the rate of release of said drill string when said signal represents an increase in drill string torque.	Figure 8 of Hobhouse shows "control console" 111 that receives the electric signal from the sensors and controls cylinder 99. "The control console 111 ... may supply pressure fluid to the underside of the piston 98 in the cylinder 99, to regulate the sinkage of the drill string...." c. 8, ll. 30-34. One of skill in the art will recognize that the inherently preferred relationship is to slow the rate of drill string release when torque increases, and to accelerate the rate of drill string release when torque decreases.
<b>13.</b> The method according to claim 11 further comprising the steps of:  measuring drill string RPM;	An "electromagnetic pickup is included to give an accurate measurement of the speed of the shaft 9." c. 4, ll. 38-40.
producing a signal in response to changes in drill string RPM, said signal representing the changes in drill string RPM;	An "electromagnetic pickup is included to give an accurate measurement of the speed of the shaft 9." c. 4, ll. 38-40.

<b>'142 Patent Claims</b>	<b>Hobhouse Reference</b>
relaying said signal to a drill string controller;	Fig. 3, console 1, rotary table speed meter 37, c. 5, ll. 40-43.
controlling said drill string controller to increase the rate of release of said drill string when said signal represents a increase in drill string RPM and to decrease the rate of release of said drill string when said signal represents an decrease in drill string RPM.	Figure 8 of Hobhouse shows "control console" 111 that receives the electric signal from the sensors and controls cylinder 99. "The control console 111 ... may supply pressure fluid to the underside of the piston 98 in the cylinder 99, to regulate the sinkage of the drill string..." c. 8, ll. 30-34. One of skill in the art will recognize that the inherently preferred relationship is to slow the rate of drill string release when RPM decreases, and to accelerate the rate of drill string release when torque increases.
<p><b>14.</b> A method for automatically regulating the release of the drill string of a drilling rig drill, comprising the steps of:</p> <p>measuring drilling fluid pressure and bit weight;</p>	<p>Hobhouse indicates that an object of its invention is to "provide a control system for drilling rigs." c. 1, ll. 39-40. Hobhouse's system includes hydraulic cylinder "to regulate the sinkage of the drill string". c. 8, ll. 33-34. The system includes a drilling fluid pressure sensor. Fig. 8, elements 103-107, c. 8, ll. 15-29.</p> <p>Hobhouse uses cylinder pressure to sense bit weight. c. 5, ll. 30-36.</p>
producing a first signal in response to changes in drilling fluid pressure, said first signal representing the changes in drilling fluid pressure;	"Changes in mud-flush pressure beyond determined limits produce a change in pressure in the hydraulic fluid and generate an electrical signal from the strain gauges 107." c. 8, ll. 22-25.
producing a second signal in response to changes in bit weight, said second signal representing the changes in bit weight;	Hobhouse uses cylinder pressure to sense bit weight. c. 5, ll. 30-36. A signal is produced. c. 7, ll. 41-47, relays 80, 81, and solenoid valve 71.
selecting any one of said first signal, said second signal, and both said first and said second signals to control the release of said drill string; and	<p><u>Manual Selection</u></p> <p>Control selector 42, shown in Figs. 3 and 7, selects either or both of two control signals to control release of the drill string. c. 5, ll. 49-76, c. 7, ll. 23-74.</p>



'142 Patent Claims	Hobhouse Reference
	<p><u>Automatic Selection</u></p> <p>Even when one control parameter is “dominant”, limits are set for other parameters, and drill string release is stopped when any limit is exceeded. c. 6, ll. 1-9.</p> <p>Thus Hobhouse provides for the manual selection from among several signals of combinations of signals on which to control drill string release, and also teaches automatic selection between primary and secondary control variables during operation.</p>
<p>relaying said selected signal or signals to a drill string controller which regulates the release said drill string in response to said selected signal or signals.</p>	<p>Figure 8 of Hobhouse shows “control console” 111 that receives the electric signal from the sensors and controls cylinder 99. “The control console 111 ... may supply pressure fluid to the underside of the piston 98 in the cylinder 99, to regulate the sinkage of the drill string...” c. 8, ll. 30-34.</p>
<p><b>15.</b> The method according to claim 14, further comprising the steps of:</p> <p>measuring drill string torque and drill string RPM;</p>	<p>Torque transducer 8 measures the torque on the drive shaft 9. c. 4, ll. 30-40, Fig. 5.</p> <p>An “electromagnetic pickup is included to give an accurate measurement of the speed of the shaft 9.” c. 4, ll. 38-40.</p>
<p>producing a third signal in response to changes in drill string torque, wherein said third signal represents the changes in drill string torque;</p>	<p>“Torque transducer” 8 produces an “actual torque signal”. c. 4, l. 31, c. 7, l. 30. See also c. 7, ll. 28-39, relays 78, 80, 81, solenoid valve 71.</p>
<p>producing a fourth signal in response to changes in drill string RPM, wherein said fourth signal represents the changes in drill string RPM;</p>	<p>An “electromagnetic pickup is included to give an accurate measurement of the speed of the shaft 9.” c. 4, ll. 38-40.</p>
<p>selecting any one of said first, second, third, and fourth signals, a combination of said first, second, third, and fourth signals, and all of said first, second, third, and fourth signals to regulate the release of said drill string; and</p>	<p><u>Manual Selection</u></p> <p>Control selector 42, shown in Figs. 3 and 7, selects either or both of two control signals to control release of the drill string. c. 5, ll. 49-76, c. 7, ll. 23-74.</p> <p><u>Automatic Selection</u></p>

'142 Patent Claims	Hobhouse Reference
	<p>Even when one control parameter is “dominant”, limits are set for other parameters, and drill string release is stopped when any limit is exceeded. c. 6, ll. 1-9.</p> <p>Thus Hobhouse provides for the manual selection from among several signals of combinations of signals on which to control drill string release, and also teach automatic selection between primary and secondary control variables during operation of their respective systems.</p>
<p>relaying said selected signal or signals to a drill string controller which regulates the release said drill string in response to said selected signal or signals.</p>	<p>Figure 8 of Hobhouse shows “control console” 111 that receives the electric signal from the sensors and controls cylinder 99. “The control console 111 ... may supply pressure fluid to the underside of the piston 98 in the cylinder 99, to regulate the sinkage of the drill string....” c. 8, ll. 30-34.</p>

**F. Claim 14 Is Unpatentable Under § 102(b) As Being Anticipated By**

**Dillon**

Dillon discloses each and every element of claim 14 of the '142 Patent. The applicability of the references to claim 14 is described above in Section I. For convenience, a claim chart detailing where the elements of claim 14 are shown by Dillon is given below.

'142 Patent Claims	Dillon Reference
<p><b>14.</b> A method for automatically regulating the release of the drill string of a drilling rig drill, comprising the steps of:</p> <p>measuring drilling fluid pressure and bit weight;</p>	<p>Dillon indicates that an object of its invention is to control the movement of the drill stem as a function of various parameters, including drilling fluid pressure and bit weight. p. 1, col. 1 line 54ff. Dillon includes a sensor that measures drilling fluid pressure. Fig. 1a, elements 106, 107, p. 4, c. 1, ll. 14-32.</p> <p>Springs 109, levers 110, iron core 111, and reactor coil 97 shown in Figure 1a cooperate</p>

'142 Patent Claims	Dillon Reference
	to measure bit weight. p. 3, c. 1, ll. 68-74.
producing a first signal in response to changes in drilling fluid pressure, said first signal representing the changes in drilling fluid pressure;	Dillon's sensor and associated circuitry produce a signal representing changes in fluid pressure. "The pressure of the mud pump is transmitted from the housing 107 to the piston 106 which, in coaction with a spring moves the position of the iron core 105, thereby varying the reactance of the reactor coil 104." p. 4, c. 1, ll. 21-25.
producing a second signal in response to changes in bit weight, said second signal representing the changes in bit weight;	Reactor coil 97 outputs a signal representing changes in bit weight. "Any change in the weight on the bottom of the well will change the reactance of the reactor coil 97...." p. 2, c. 2, ll. 6-8.
selecting any one of said first signal, said second signal, and both said first and said second signals to control the release of said drill string; and	<p><u>Manual Selection</u></p> <p>"Knife switch" 98 can disable the influence of fluid pressure on drill string release. p. 4, c. 1, ll. 33-36. Coils 64 and 79, carrying signals relating to torque and speed, also can be disconnected. p. 4, col. 1, ll. 37-40. Dillon can control based on any one, all, or any combination of four inputs that include drilling fluid pressure, bit weight, motor load, and motor speed. p. 1, col. 1, ll. 54ff.</p> <p><u>Automatic Selection</u></p> <p>Upon an indication that the load (torque, as indicated by current) on the drilling motor is "excessive", Dillon's system automatically overrides control based on other variables and hoists the drill stem. p. 4, c. 1, ll. 41-59.</p> <p>Thus Dillon provides for the manual selection from among several signals of combinations of signals on which to control drill string release, and also teaches automatic selection between primary and secondary control variables during operation.</p>
relaying said selected signal or signals to a drill string controller which regulates the	Signals from Dillon's drilling fluid pressure and bit weight sensors are relayed to "control

'142 Patent Claims	Dillon Reference
release said drill string in response to said selected signal or signals.	mechanism" 65, regulates power to "hoisting motor" 26. "The stem will thus be hoisted or lowered, as the case may be, to reestablish a balanced condition...." p. 2, c. 2, ll. 13-16.

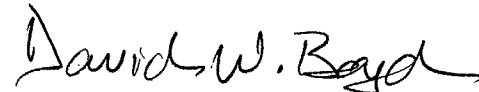
#### IV. Conclusion

The prior art newly cited in this request thus provides ample motivation for multivariate control of the rate of drill string advance, and a multitude of mechanisms for doing so, including each and every element recited in claims 1-8 and 11-15 of the '142 Patent.

This Request raises numerous substantial new questions of patentability. Further, this Request provides valid rejections for claims 1-8 and 11-15 of the '142 Patent. Claims 1-8 and 11-15 are invalid because these claims are anticipated by and/or obvious over the prior art for reasons provided above. Accordingly, reexamination of all patent claims is requested.

Respectfully submitted,

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## APPENDIX A

### Claim Chart Corresponding to First Substantial Question of Patentability Obviousness over Bowden '359, Ball, Dillon, and Hobhouse

'142 Patent Claims	Prior Art
<p><b>1.</b> An automatic drilling system for automatically regulating the release of the drill string of a drilling rig during the drilling of a borehole, comprising:</p> <p>a drilling fluid pressure sensor;</p>	<p><b>Bowden '359</b></p> <p>Bowden '359 describes regulating the rate of drill string release based on a pressure signal derived from bit weight. c. 2, l. 27 - c. 3, l. 53, and Fig. 1. The system could be trivially adapted to measure drilling fluid pressure, as the system of Bowden '359 already operates on a pressure signal. Both Dillon and Hobhouse teach controlling drill string release based on drilling fluid pressure. Dillon . p. 1, col. 1 line 54ff, Hobhouse c. 8, ll. 38-49.</p> <p><b>Dillon</b></p> <p>Dillon includes a drilling fluid pressure sensor. Fig. 1a, elements 106, 107, p. 4, c. 1, l. 14-32.</p> <p><b>Hobhouse</b></p> <p>Hobhouse includes a drilling fluid pressure sensor. Fig. 8, elements 103-107, c. 8, l.15-29.</p>
<p>a drilling fluid pressure regulator coupled to said drilling fluid pressure sensor, said drilling fluid pressure regulator measuring changes in drilling fluid pressure and outputting a signal representing those changes;</p>	<p><b>Bowden '359</b></p> <p>Bowden '359 describes a "regulator" sensitive to a pressure signal, in the context of bit weight measurement. Fig. 11 elements 107-113 make a regulator nearly identical to that described in the '142 Patent. c. 7, l. 66 – c. 8, l. 16. Also, Fig. 1 elements 4-6a, 24a, and 66. c. 2, l. 43-67. The device of Bowden '359 could trivially be adapted to output a signal representing changes in drilling fluid pressure.</p>

'142 Patent Claims	Prior Art
<p>a relay coupled to said drilling fluid pressure regulator, said relay responsive to the output signal of said drilling fluid pressure regulator to supply a drill string control signal at an output thereof; and</p>	<p><b>Bowden '359</b></p> <p>Bowden '359 describes a pneumatic relay system nearly identical to that of the '142 Patent, in the context of bit weight measurement. Fig. 11 element 105. c. 7, ll. 71-74. The relay of Bowden '359 would be usable without change in a system that controls based on drilling fluid pressure.</p>
<p>a drill string controller coupled to said relay wherein a decrease in drilling fluid pressure results in said relay supplying a drill string control signal that operates said drill string controller to effect an increase in the rate of release of said drill string and an increase in drilling fluid pressure results in said relay supplying a drill string control signal that operates said drill string controller to effect a decrease in the rate of release of said drill string.</p>	<p><b>Bowden '359</b></p> <p>Bowden '359 describes a drill string controller that operates nearly identically to that of the '142 Patent, and inherently regulates the rate of drill string release. See c. 4, l. 74 - c. 5, l. 50.</p> <p><b>Ball</b> provides further evidence that the system of Bowden '359, which automates the actuation of a conventional drum brake, regulates the <u>rate</u> of drill string release. Ball states that its "drilling apparatus has a conventional brake operated by a brake handle which operates on the drum to control the <u>rate</u> of feed out of the drill line...." c. 3, ll. 2-5, emphasis added.</p>
<p><b>2. The automatic drilling system according to claim 1, further comprising:</b></p> <p>a bit weight sensor;</p>	<p><b>Bowden '359</b></p> <p>Bowden '359 describes a bit weight sensor producing a pressure signal. Fig. 1, element 16. c. 3, ll. 45-49. Also Figure 11, element D. c. 8, ll. 28-58.</p> <p><b>Dillon</b> provides explicit motivation for control of drill string release based on the combination of drilling fluid pressure and bit weight. p. 1, c. 1, ll. 54ff.</p>
<p>a bit weight regulator coupled to said bit weight sensor, said bit weight regulator measuring changes in bit weight and outputting a signal representing those changes;</p>	<p><b>Bowden '359</b></p> <p>Fig. 11 elements 107-113 make a regulator nearly identical to that described in the '142 Patent. c. 7, l. 66 – c. 8, l. 16. Also, Fig. 1 elements 4-6a, 24a, and 66. c. 2, ll. 43-67.</p>

'142 Patent Claims	Prior Art
a relay coupled to said bit weight regulator, said relay responsive to the output signal of said bit weight regulator to supply a drill string control signal at an output thereof; and	<b>Bowden '359</b> Fig. 11 element 105. c. 7, ll. 71-74. Also, Fig. 1 element 8. c. 2, ll. 62-67.
said drill string controller coupled to said relay wherein a decrease in bit weight results in said relay supplying a drill string control signal that operates said drill string controller to effect an increase in the rate of release of said drill string and an increase in bit weight results in said relay supplying a drill string control signal that operates said drill string controller to effect a decrease in the rate of release of said drill string.	<b>Bowden '359</b> See c. 4, l. 74 - c. 5, l. 50.
<b>3.</b> The automatic drilling system according to claim 1 further comprising:  a drill string torque sensor;	<b>Dillon</b> One of the objects of Dillon's invention is "to provide for controlling the movement of the drill stem as a function of ... the load on the drilling motor ...." p. 1, c. 1, ll. 54 ff. Dillon provides a signal proportional to the current of the drilling motor. p. 3, c. 1, ll. 44-46. One of skill in the art will recognize that motor current is closely related to torque.  <b>Hobhouse</b> Torque transducer 8 measures the torque on the drive shaft 9. c. 4, ll. 30-40, Fig. 5.  Additionally, the '142 Patent itself discloses a commercially available torque sensor that produces a pressure signal indicating torque. c. 6, ll. 38-50, Fig. 10.  <b>Dillon</b> provides explicit motivation for control of drill string release based on the combination of drilling fluid pressure and drill string torque. p. 1, c. 1, ll. 54ff.
a drill string torque regulator coupled to said drill string torque sensor, said drill string	<b>Bowden '359</b>

'142 Patent Claims	Prior Art
torque regulator measuring changes in drill string torque and outputting a signal representing those changes;	<p>Bowden '359 discloses a regulator easily adaptable to use in controlling based on any variable. Fig. 11 elements 107-113, c. 7, l. 66 – c. 8, l. 16. Also, Fig. 1 elements 4-6a, 24a, and 66. c. 2, ll. 43-67.</p> <p><b>Dillon</b></p> <p>A signal representing the motor current is output through conductor 63. p. 3, c. 1, ll. 29-46.</p> <p><b>Hobhouse</b></p> <p>“Torque transducer” 8 produces an “actual torque signal”. c. 4, l. 31, c. 7, l. 30.</p>
a relay coupled to said drill string torque regulator, said relay responsive to the output signal of said drill string torque regulator to supply a drill string control signal at an output thereof; and	<p><b>Bowden '359</b></p> <p>Bowden '359 discloses a pneumatic relay easily adaptable to control based on any variable. Fig. 11 element 105. c. 7, ll. 71-74. Also, Fig. 1 element 8. c. 2, ll. 62-67.</p> <p><b>Dillon</b></p> <p>The current signal is relayed to reactor coil 64 at “control mechanism” 65, which outputs a signal to control the feed of the drill stem. p. 3, c. 1, ll. 29-46. Relays H and L further transmit the signal. p. 3, c. 2, l. 30 - p. 4, c. 1, l. 32.</p> <p><b>Hobhouse</b></p> <p>“The strain gauges [used to measure torque] are connected to the console....” c. 4, ll. 37-38. See also c. 7, ll. 28-39, relays 78, 80, 81, solenoid valve 71.</p>
a drill strings controller coupled to said relay wherein a decrease in drill string torque results in said relay supplying a drill strings control signal that operates said drill strings controller to effect an increase in the rate of release of said drill string and an increase in drill string torque results in said relay supplying a drill strings control signal that operates said drill	<p><b>Bowden '359</b></p> <p>Bowden '359 describes a drill string controller that operates nearly identically to that of the '142 Patent, and inherently regulates the rate of drill string release. See c. 4, l. 74 - c. 5, l. 50. One of skill in the art would recognize that these are inherently the</p>



'142 Patent Claims	Prior Art
strings controller to effect a decrease in the rate of release of said drill string.	correct control relationships.
<p><b>4.</b> The automatic drilling system according to claim 1 further comprising:</p> <p>a drill string RPM sensor;</p>	<p><b>Dillon</b></p> <p>Dillon provides a signal related to drill string RPM. p. 3, c. 1, ll. 47-62.</p> <p><b>Hobhouse</b></p> <p>An "electromagnetic pickup is included to give an accurate measurement of the speed of the shaft 9." c. 4, ll. 38-40.</p> <p><b>Dillon</b> provides explicit motivation for control of drill string release based on the combination of drilling fluid pressure and drill string RPM. p. 1, c. 1, ll. 54ff.</p>
a drill string RPM regulator coupled to said drill string RPM sensor, said drill string RPM regulator measuring changes in drill string RPM and outputting a signal representing those changes;	<p><b>Bowden '359</b></p> <p>Bowden '359 discloses a regulator easily adaptable to use in controlling based on any variable. Fig. 11 elements 107-113, c. 7, l. 66 – c. 8, l. 16. Also, Fig. 1 elements 4-6a, 24a, and 66. c. 2, ll. 43-67.</p> <p><b>Dillon</b></p> <p>Dillon provides a signal related to drill string RPM. p. 3, c. 1, ll. 47-62. Dillon's signal is relayed to coil 79, shown in Figure 1a.</p>
a relay coupled to said drill string RPM regulator, said relay responsive to the output signal of said drill string RPM regulator to supply a drill strings control signal at an output thereof; and	<p><b>Bowden '359</b></p> <p>Bowden '359 discloses a pneumatic relay easily adaptable to control based on any variable. Fig. 11 element 105. c. 7, ll. 71-74. Also, Fig. 1 element 8. c. 2, ll. 62-67.</p> <p><b>Dillon</b></p> <p>Relays H and L further transmit the signal.</p>
a drill strings controller coupled to said relay wherein an increase in drill string RPM results in said relay supplying a drill strings control signal that operates said drill strings controller to effect an increase in the rate of release of	<p><b>Bowden '359</b></p> <p>Bowden '359 describes a drill string controller that operates nearly identically to that of the '142 Patent in relation to bit weight, and inherently regulates the rate of</p>

'142 Patent Claims	Prior Art
said drill string and a decrease in drill string RPM results in said relay supplying a drill strings control signal that operates said drill strings controller to effect a decrease in the rate of release of said drill string.	drill string release. See c. 4, l. 74 - c. 5, l. 50. One of skill in the art would recognize that these are inherently the correct control relationships.
<p><b>5.</b> The automatic drilling system according to claim 1 wherein said drilling fluid pressure regulator, comprises:</p> <p>a Bourdon tube coupled to said drilling fluid pressure sensor to measure changes in drilling fluid pressure;</p>	<p><b>Bowden '359</b></p> <p>Bowden '359 discloses, in the context of bit weight measurement, a system nearly identical to the regulator of the '142 Patent. See Figure 11, elements 107-113. Element 113 is a Bourdon tube. c. 7, l. 66 – c. 8, l. 16. Also, Fig. 1 elements 4-6a, 24a, and 66. c. 2, ll. 43-67. The regulator of Bowden '359 could trivially be adapted for use in control based on drilling fluid pressure.</p>
a flapper coupled at one end to said Bourdon tube wherein said flapper pivots about a pivot point in response to changes in drilling fluid pressure measured by said Bourdon tube; and	<p><b>Bowden '359</b></p> <p>Figure 11, element 109 is a pivoted “flapper”. c. 8, ll. 15-16. Also, Figure 1, element 6a. c. 5, ll. 6-16; c. 4, ll. 1-38 and c. 9, ll. 12-33.</p>
means responsive to the pivoting of said flapper for outputting to said relay a signal representative of changes in drilling fluid pressure.	<p><b>Bowden '359</b></p> <p>Figure 11 and c. 7, l. 66 – c. 8, l. 20. Also Figure 1 and c. 2, ll. 36-68; c. 4, ll. 1-38 and c. 9, ll. 12-33.</p>
<p><b>6.</b> The automatic drilling system according to claim 2 wherein said bit weight regulator, comprises:</p> <p>a Bourdon tube coupled to said bit weight sensor to measure changes in bit weight;</p>	<p><b>Bowden '359</b></p> <p>Bowden '359 discloses a system nearly identical to the “bit weight regulator” of the '142 Patent. See Figure 11, elements 107-113. Element 113 is a Bourdon tube. c. 7, l. 66 – c. 8, l. 16. Also Figure 1, element 24a. c. 4, ll. 4-5.</p>
a flapper coupled at one end to said Bourdon tube wherein said flapper pivots about a pivot point in response to changes in bit weight measured by said Bourdon tube; and	<p><b>Bowden '359</b></p> <p>Figure 11, element 109 is a pivoted “flapper”. c. 8, ll. 15-16. Also Figure 1, element 6a. c. 2, l. 51; c. 4, ll. 1-38 and c. 9, ll. 12-33.</p>
means responsive to the pivoting of said flapper for outputting a signal to said relay representative of changes in bit weight.	<p><b>Bowden '359</b></p> <p>Figure 11 and c. 7, l. 66 - c. 8, l. 20. Also</p>

'142 Patent Claims	Prior Art
	Figure 1 and c. 2, ll. 36-68; c. 4, ll. 1-38 and c. 9, ll. 12-33.
<p><b>7.</b> The automatic drilling system according to claim 3 wherein said drill string torque regulator, comprises:</p> <p>a Bourdon tube coupled to said drill string torque sensor to measure changes in drill string torque;</p>	<p><b>Bowden '359</b></p> <p>Bowden '359 discloses, in the context of bit weight measurement, a system nearly identical to the regulator of the '142 Patent. See Figure 11, elements 107-113. Element 113 is a Bourdon tube. c. 7, l. 66 – c. 8, l. 16. Also Figure 1, element 24a. c. 4, ll. 4-5. The regulator of Bowden '359 could easily be adapted for use in control based on drill string torque.</p>
<p>a flapper coupled at one end to said Bourdon tube wherein said flapper pivots about a pivot point in response to changes in drill string torque measured by said Bourdon tube; and</p>	<p><b>Bowden '359</b></p> <p>Figure 11, element 109 is a pivoted “flapper”. c. 8, ll. 15-16. Also, Figure 1, element 6a. c. 5, ll. 6-16; c. 4, ll. 1-38 and c. 9, ll. 12-33.</p>
<p>means responsive to the pivoting of said flapper for outputting a signal to said relay representative of changes in drill string torque.</p>	<p><b>Bowden '359</b></p> <p>Figure 11 and c. 7, l. 66 - c. 8, l. 20. Also Figure 1 and c. 2, ll. 36-68; c. 4, ll. 1-38 and c. 9, ll. 12-33.</p>
<p><b>8.</b> The automatic drilling system according to claim 4 wherein said drill string RPM regulator, comprises:</p> <p>a Bourdon tube coupled to said drill string RPM sensor to measure changes in drill string RPM;</p>	<p><b>Bowden '359</b></p> <p>Bowden '359 discloses, in the context of bit weight measurement, a system nearly identical to the regulator of the '142 Patent. See Figure 11, elements 107-113. Element 113 is a Bourdon tube. c. 7, l. 66 – c. 8, l. 16. Also Figure 1, element 24a. c. 4, ll. 4-5. The regulator of Bowden '359 could easily be adapted for use in control based on drill string RPM.</p>
<p>a flapper coupled at one end to said Bourdon tube wherein said flapper pivots about a pivot point in response to changes in drill string RPM measured by said Bourdon tube; and</p>	<p><b>Bowden '359</b></p> <p>Figure 11, element 109 is a pivoted “flapper”. c. 8, ll. 15-16. Also, Figure 1, element 6a. c. 5, ll. 6-16; c. 4, ll. 1-38 and c. 9, ll. 12-33.</p>
<p>means responsive to the pivoting of said flapper for outputting a signal to said relay</p>	<p><b>Bowden '359</b></p>

'142 Patent Claims	Prior Art
representative of changes in drill string RPM.	Figure 11 and c. 7, l. 66 – c. 8, l. 20. Also Figure 1 and c. 2, ll. 36-68; c. 4, ll. 1-38 and c. 9, ll. 12-33.
<p><b>11.</b> A method for automatically regulating the release of the drill string of a drilling rig drill, comprising the steps of:</p> <p>measuring drilling fluid pressure;</p>	<p><b>Bowden '359</b></p> <p>Bowden '359 describes regulating drill string release based on a pressure signal. c. 2, l. 27 – c. 3, l. 53, and Fig. 1. Bowden '359 uses a pressure signal derived from bit weight, but could be trivially adapted to use a drilling fluid pressure signal.</p> <p><b>Dillon</b></p> <p>Dillon includes a sensor that measures drilling fluid pressure. Fig. 1a, elements 106, 107, p. 4, c. 1, ll. 14-32.</p> <p><b>Hobhouse</b></p> <p>Hobhouse includes a drilling fluid pressure sensor. Fig. 8, elements 103-107, c. 8, ll. 15-29.</p> <p>In addition, the '142 Patent discloses a commercially available fluid pressure sensor. c. 5, ll. 29-38 and Fig. 5.</p>
producing a signal in response to changes in drilling fluid pressure, said signal representing the changes in drilling fluid pressure;	<p><b>Bowden '359</b></p> <p>Bowden '359 describes a “regulator” sensitive to a pressure signal. Fig. 11 elements 107-113 make a regulator nearly identical to that described in the '142 Patent. c. 7, l. 66 – c. 8, l. 16. Fig. 1 elements 4-6a, 24a, and 66 also show the regulator. c. 2, ll. 43-67.</p> <p><b>Dillon</b></p> <p>Dillon's sensor and associated circuitry produce a signal representing changes in fluid pressure. “The pressure of the mud pump is transmitted from the housing 107 to the piston 106 which, in coaction with a spring moves the position of the iron core 105, thereby varying the reactance of the</p>

'142 Patent Claims	Prior Art
	<p>reactor coil 104.” p. 4, c. 1, ll. 21-25.</p> <p><b>Hobhouse</b></p> <p>“Changes in mud-flush pressure beyond determined limits produce a change in pressure in the hydraulic fluid and generate an electrical signal from the strain gauges 107.” c. 8, ll. 22-25.</p>
<p>relaying said signal to a drill string controller; and</p>	<p><b>Bowden '359</b></p> <p>Bowden '359 describes a pneumatic relay system nearly identical to that of the '142 Patent. Fig. 11 element 105. c. 7, ll. 71-74. Fig. 1 element 8. c. 2, ll. 62-67.</p> <p><b>Dillon</b></p> <p>Reactor coil 104 shown in Figure 1a relays the fluid pressure signal to reactor coil 198 at “control mechanism” 65, which outputs a signal to control the feed of the drill stem. Relays H and L further transmit the signal. p. 3, c. 2, l. 30 - p. 4, c. 1, l. 32.</p> <p><b>Hobhouse</b></p> <p>The electrical signal from strain gauges 107 is sent to a “control console 111.” c. 8, ll. 25-29.</p>
<p>controlling said drill string controller to increase the rate of release of said drill string when said signal represents a decrease in drilling fluid pressure and to decrease the rate of release of said drill string when said signal represents an increase in drilling fluid pressure.</p>	<p><b>Bowden '359</b></p> <p>Bowden '359 describes a drill string controller that operates nearly identically to that of the '142 Patent, and inherently regulates the rate of drill string release. See c. 4, l. 74 - c. 5, l. 50.</p> <p><b>Hobhouse</b></p> <p>Hobhouse describes stopping the sinkage of the drill stem in response to an increase in mud-flush pressure, and increasing the sinkage of the drill stem in response to a decrease in mud-flush fluid pressure. c. 8, ll. 38-49. Figure 8 of Hobhouse shows “control console” 111 that receives the electric signal</p>

'142 Patent Claims	Prior Art
	<p>from the sensors and controls cylinder 99. "The control console 111 ... may supply pressure fluid to the underside of the piston 98 in the cylinder 99, to regulate the sinkage of the drill string...." c. 8, ll. 30-34. Stopping and increasing the sinkage of the drill string are control of the rate of release of the drill string. The control is through "graduated reference contacts" 110. c. 8, l. 27 and Fig. 8.</p>
<p><b>12.</b> The method according to claim 11 further comprising the steps of:</p> <p>measuring drill string torque;</p>	<p><b>Dillon</b></p> <p>Dillon provides a signal proportional to the current of the drilling motor. p. 3, c. 1, ll. 44-46. One of skill in the art will recognize that motor current is closely related to torque.</p> <p><b>Hobhouse</b></p> <p>Torque transducer 8 measures the torque on the drive shaft 9. c. 4, ll. 30-40, Fig. 5.</p> <p><b>Dillon</b> provides explicit motivation for control of drill string release based on the combination of drilling fluid pressure and drill string torque. p. 1, c. 1, ll. 54ff.</p>
<p>producing a signal in response to changes in drill string torque, said signal representing the changes in drill string torque; and</p>	<p><b>Bowden '359</b></p> <p>Fig. 11 elements 107-113 make a regulator nearly identical to that described in the '142 Patent. c. 7, l. 66 – c. 8, l. 16. Fig. 1 elements 4-6a, 24a, and 66 also show the regulator. c. 2, ll. 43-67.</p> <p><b>Dillon</b></p> <p>A signal representing the motor current is output through conductor 63. p. 3, c. 1, ll. 29-46.</p> <p><b>Hobhouse</b></p> <p>"... an amplifier receives ... the actual torque signal from the transducer..." c. 7, ll. 28-29.</p>
<p>relaying said signal to a drill string controller;</p>	<p><b>Bowden '359</b></p>

'142 Patent Claims	Prior Art
	<p>Bowden '359 describes a pneumatic relay system nearly identical to that of the '142 Patent. Fig. 11 element 105. c. 7, ll. 71-74. Fig. 1 element 8. c. 2, ll. 62-67.</p> <p><b>Dillon</b></p> <p>The current signal is relayed to reactor coil 64 at "control mechanism" 65, which outputs a signal to control the feed of the drill stem. p. 3, c. 1, ll. 29-46. Relays H and L further transmit the signal. p. 3, c. 2, l. 30 - p. 4, c. 1, l. 32.</p> <p><b>Hobhouse</b></p> <p>"The strain gauges [used to measure torque] are connected to the console...." c. 4, ll. 37-38. See also c. 7, ll. 28-39, relays 78, 80, 81, solenoid valve 71.</p>
<p>controlling said drill string controller to increase the rate of release of said drill string when said signal represents a decrease in drill string torque and to decrease the rate of release of said drill string when said signal represents an increase in drill string torque.</p>	<p><b>Bowden '359</b></p> <p>Bowden '359 describes a drill string controller that operates nearly identically to that of the '142 Patent, and inherently regulates the rate of drill string release. See c. 4, l. 74 – c. 5, l.50. One of skill in the art would recognize that these are inherently the correct control relationships. Additionally, at least Dillon teaches this relationship between drill string release and torque. p. 4, c. 1, ll. 50-59.</p> <p><b>Dillon</b></p> <p>Dillon's "control mechanism" 65 regulates power to "hoisting motor" 26, which raises and lowers the drill string. Excess torque results in a reduction of feed or even retraction of the drill stem. p. 4, c. 1, ll. 50-59.</p>
<p><b>13.</b> The method according to claim 11 further comprising the steps of:</p>	<p><b>Bowden '359</b></p> <p>Fig. 11 elements 107-113 make a regulator nearly identical to that described in the '142</p>

'142 Patent Claims	Prior Art
measuring drill string RPM;	<p>Patent. c. 7, l. 66 – c. 8, l. 16. Fig. 1 elements 4-6a, 24a, and 66 also show the regulator. c. 2, ll. 43-67.</p> <p><b>Dillon</b></p> <p>Dillon provides a signal related to drill string RPM. p. 3, c. 1, ll. 47-62.</p> <p><b>Hobhouse</b></p> <p>An “electromagnetic pickup is included to give an accurate measurement of the speed of the shaft 9.” c. 4, ll. 38-40.</p> <p><b>Dillon</b> provides explicit motivation for control of drill string release based on the combination of drilling fluid pressure and drill string RPM. p. 1, c. 1, ll. 54ff.</p>
producing a signal in response to changes in drill string RPM, said signal representing the changes in drill string RPM;	<p><b>Bowden ‘359</b></p> <p>Fig. 11 elements 107-113 make a regulator nearly identical to that described in the ‘142 Patent. c. 7, l. 66 – c. 8, l. 16. Fig. 1 elements 4-6a, 24a, and 66 also show the regulator. c. 2, ll. 43-67.</p> <p><b>Dillon</b></p> <p>Dillon provides a signal related to drill string RPM. p. 3, c. 1, ll. 47-62.</p> <p><b>Hobhouse</b></p> <p>An “electromagnetic pickup is included to give an accurate measurement of the speed of the shaft 9.” c. 4, ll. 38-40.</p>
relaying said signal to a drill string controller;	<p><b>Dillon</b></p> <p>Accelerating resistors 76/77; drilling table 4; coil 79; 2 leads of the secondary winding of drilling motor 7; conductor 78, reactor coil 75; conductor 80; balancing mechanism 65; contact members 115 and 118; contact members 114 and 115  p. 3, c. 1, ll. 48-62; Fig. 1a  p. 3, c. 2., l. 34 – p. 4, c. 1, l. 3.</p>



'142 Patent Claims	Prior Art
	<p><b>Hobhouse</b></p> <p>Fig. 3, console 1, rotary table speed meter 37, c. 5, ll. 40-43.</p>
<p>controlling said drill string controller to increase the rate of release of said drill string when said signal represents a increase in drill string RPM and to decrease the rate of release of said drill string when said signal represents an decrease in drill string RPM.</p>	<p><b>Bowden '359</b></p> <p>Bowden '359 describes a drill string controller that operates nearly identically to that of the '142 Patent in relation to bit weight, and inherently regulates the rate of drill string release. See c. 4, l. 74 - c. 5, l. 50. One of skill in the art would recognize that these are inherently the correct control relationships.</p> <p><b>Dillon</b></p> <p>Dillon's "control mechanism" 65 regulates power to "hoisting motor" 26, which raises and lowers the drill string, responding in part to RPM. Dillon is not explicit as to the relationship between speed and drill string advance, but one of skill in the art will recognize that this is inherently the correct relationship.</p>
<p><b>14.</b> A method for automatically regulating the release of the drill string of a drilling rig drill, comprising the steps of:</p> <p>measuring drilling fluid pressure and bit weight;</p>	<p><b>Bowden '359</b></p> <p>Bowden '359 describes regulating the rate of drill string release based on a pressure signal derived from bit weight. c. 2, l. 27 - c. 3, l. 53, and Fig. 1.</p> <p><b>Dillon</b></p> <p>Dillon includes a sensor that measures drilling fluid pressure. Fig. 1a, elements 106, 107, p. 4, c. 1, ll. 14-32.</p> <p><b>Hobhouse</b></p> <p>Hobhouse includes a drilling fluid pressure sensor. Fig. 8, elements 103-107, c. 8, ll. 15-29.</p> <p>In addition, the '142 Patent discloses a commercially available fluid pressure sensor.</p>

'142 Patent Claims	Prior Art
	<p>c. 5, ll. 29-38 and Fig. 5.</p> <p><b>Dillon</b> provides explicit motivation for control of drill string release based on the combination of drilling fluid pressure and bit weight. p. 1, c. 1, ll. 54ff.</p>
<p>producing a first signal in response to changes in drilling fluid pressure, said first signal representing the changes in drilling fluid pressure;</p>	<p><b>Bowden '359</b></p> <p>Bowden '359 describes a "regulator" sensitive to a pressure signal, in the context of bit weight measurement. Fig. 11 elements 107-113 make a regulator nearly identical to that described in the '142 Patent. c. 7, l. 66 – c. 8, l. 16. Also, Fig. 1 elements 4-6a, 24a, and 66 also show the regulator. c. 2, ll. 43-67. The regulator of Bowden '359 could be trivially adapted to operate on a drilling fluid pressure signal.</p> <p><b>Dillon</b></p> <p>Dillon's sensor and associated circuitry produce a signal representing changes in fluid pressure. "The pressure of the mud pump is transmitted from the housing 107 to the piston 106 which, in coaction with a spring moves the position of the iron core 105, thereby varying the reactance of the reactor coil 104." p. 4, c. 1, ll. 21-25.</p> <p><b>Hobhouse</b></p> <p>"Changes in mud-flush pressure beyond determined limits produce a change in pressure in the hydraulic fluid and generate an electrical signal from the strain gauges 107." c. 8, ll. 22-25.</p>
<p>producing a second signal in response to changes in bit weight, said second signal representing the changes in bit weight;</p>	<p><b>Bowden '359</b></p> <p>Fig. 1 elements 4-6a, 24a, and 66 make a regulator nearly identical to that described in the '142 Patent, that produces a signal representing changes in bit weight. c. 2, ll. 43-67. Fig. 11 elements 107-113 also show the regulator. c. 7, l. 66 – c. 8, l. 16.</p>

'142 Patent Claims	Prior Art
<p>selecting any one of said first signal, said second signal, and both said first and said second signals to control the release of said drill string; and</p>	<p><b>Dillon – Manual Selection</b></p> <p>“Knife switch” 98 can disable the influence of fluid pressure on drill string release. p. 4, c. 1, ll. 33-36. Coils 64 and 79, carrying signals relating to torque and speed, also can be disconnected. p. 4, c. 1, ll. 37-40. Dillon can control based on any one, all, or any combination of four inputs that include drilling fluid pressure, bit weight, motor load, and motor speed. p. 1, c. 1, ll. 54ff.</p> <p><b>Hobhouse – Manual Selection</b></p> <p>Control selector 42, shown in Figs. 3 and 7, selects either or both of two control signals to control release of the drill string. c. 5, ll. 49-76, c. 7, ll. 23-74.</p> <p><b>Dillon – Automatic Selection</b></p> <p>Upon an indication that the load (torque, as indicated by current) on the drilling motor is “excessive”, Dillon’s system automatically overrides control based on other variables and hoists the drill stem. p. 4, c. 1, ll. 41-59.</p> <p><b>Hobhouse – Automatic Selection</b></p> <p>Even when one control parameter is “dominant”, limits are set for other parameters, and drill string release is stopped when any limit is exceeded. c. 6, ll. 1-9.</p> <p>Thus both Dillon and Hobhouse provide for the manual selection from among several signals of combinations of signals on which to control drill string release, and also teach automatic selection between primary and secondary control variables during operation of their respective systems.</p>
<p>relaying said selected signal or signals to a drill string controller which regulates the release said drill string in response to said selected signal or signals.</p>	<p><b>Bowden ‘359</b></p> <p>Bowden ‘359 describes a drill string controller that operates nearly identically to that of the ‘142 Patent, and inherently</p>

'142 Patent Claims	Prior Art
	regulates the rate of drill string release, in the context of bit weight control. See c. 4, l. 74 - c. 5, l. 50.
<p><b>15.</b> The method according to claim 14, further comprising the steps of:</p> <p>measuring drill string torque and drill string RPM;</p>	<p><b>Dillon</b></p> <p>One of the objects of Dillon's invention is "to provide for controlling the movement of the drill stem as a function of ... the load on the drilling motor, the speed of the drilling motor...." p. 1, c. 1, ll. 54 ff. Dillon provides a signal proportional to the current of the drilling motor. p. 3, c. 1, ll. 44-46. One of skill in the art will recognize that motor current is closely related to torque.</p> <p>Dillon provides a signal related to drill string RPM. p. 3, c. 1, ll. 47-62.</p> <p><b>Hobhouse</b></p> <p>Torque transducer 8 measures the torque on the drive shaft 9. c. 4, ll. 30-40, Fig. 5.</p> <p>An "electromagnetic pickup is included to give an accurate measurement of the speed of the shaft 9." c. 4, ll. 38-40.</p> <p><b>Dillon</b> provides explicit motivation for control of drill string release based on the combination of drilling fluid pressure, bit weight, drill string torque, and drill string RPM. p. 1, c. 1, ll. 54ff.</p>
<p>producing a third signal in response to changes in drill string torque, wherein said third signal represents the changes in drill string torque;</p>	<p><b>Dillon</b></p> <p>A signal representing the motor current is output through conductor 63. p. 3, c. 1, ll. 29-46. One of skill in the art will recognize that motor current is closely related to torque.</p> <p><b>Hobhouse</b></p> <p>"Torque transducer" 8 produces an "actual torque signal". c. 4, l. 31, c. 7, l. 30. See also c. 7, ll. 28-39, relays 78, 80, 81, solenoid</p>

'142 Patent Claims	Prior Art
<p>producing a fourth signal in response to changes in drill string RPM, wherein said fourth signal represents the changes in drill string RPM;</p>	<p>valve 71.</p> <p><b>Dillon</b>  Dillon provides a signal related to drill string RPM. p. 3, c. 1, ll. 47-62.</p> <p><b>Hobhouse</b>  An "electromagnetic pickup is included to give an accurate measurement of the speed of the shaft 9." c. 4, ll. 38-40.</p>
<p>selecting any one of said first, second, third, and fourth signals, a combination of said first, second, third, and fourth signals, and all of said first, second, third, and fourth signals to regulate the release of said drill string; and</p>	<p><b>Dillon – Manual Selection</b>  "Knife switch" 98 can disable the influence of fluid pressure on drill string release. p. 4, c. 1, ll. 33-36. Coils 64 and 79, carrying signals relating to torque and speed, also can be disconnected. p. 4, c. 1, ll. 37-40. Dillon can control based on any one, all, or any combination of four inputs that include drilling fluid pressure, bit weight, motor load, and motor speed. p. 1, c. 1, ll. 54ff.</p> <p><b>Hobhouse – Manual Selection</b>  Control selector 42, shown in Figs. 3 and 7, selects either or both of two control signals to control release of the drill string. c. 5, ll. 49-76, c. 7, ll. 23-74.</p> <p><b>Dillon – Automatic Selection</b>  Upon an indication that the load (torque, as indicated by current) on the drilling motor is "excessive", Dillon's system automatically overrides control based on other variables and hoists the drill stem. p. 4, c. 1, ll. 41-59.</p> <p><b>Hobhouse – Automatic Selection</b>  Even when one control parameter is "dominant", limits are set for other parameters, and drill string release is stopped when any limit is exceeded. c. 6, ll. 1-9.</p> <p>Thus both Dillon and Hobhouse provide for the manual selection from among several</p>

'142 Patent Claims	Prior Art
	signals of combinations of signals on which to control drill string release, and also teach automatic selection between primary and secondary control variables during operation of their respective systems.
relaying said selected signal or signals to a drill string controller which regulates the release said drill string in response to said selected signal or signals.	<b>Bowden '359</b> Bowden '359 describes a drill string controller that operates nearly identically to that of the '142 Patent. See c. 4, l. 74 - c. 5, l. 50.

## APPENDIX B

### Comprehensive Claim Charts Showing Applicability of All References Relied Upon

#### Claim 1

'142 Patent Claims	Prior Art
<p><b>1.</b> An automatic drilling system for automatically regulating the release of the drill string of a drilling rig during the drilling of a borehole, comprising:</p> <p>a drilling fluid pressure sensor;</p>	<p><b>Bowden '359</b></p> <p>Bowden '359 describes regulating the rate of drill string release based on a pressure signal derived from bit weight. c. 2, l. 27 - c. 3, l. 53, and Fig. 1. The system could be trivially adapted to measure drilling fluid pressure, as the system of Bowden '359 already operates on a pressure signal. Both Dillon and Hobhouse teach controlling drill string release based on drilling fluid pressure. Dillon . p. 1, col. 1 line 54ff, Hobhouse c. 8, ll. 38-49.</p> <p><b>Dillon</b></p> <p>Dillon includes a drilling fluid pressure sensor. Fig. 1a, elements 106, 107, p. 4, col. 1, lines 14-32.</p> <p><b>Hobhouse</b></p> <p>Hobhouse indicates that an object of its invention is to "provide a control system for drilling rigs." c. 1, ll. 39-40. Hobhouse's system includes hydraulic cylinder "to regulate the sinkage of the drill string". c. 8, ll. 33-34. The system includes a drilling fluid pressure sensor. Fig. 8, elements 103-107, c. 8 ll. 15-29.</p> <p><b>LeCompte</b></p> <p>LeCompte indicates that one object of its invention "resides in the provision of brake actuation mechanism co-acting with the telescopic drill stem section and actuated by the back pressure of the mud laden fluid ... for automatically retarding the lowering of additional drill stem into the hole ... and, if</p>

'142 Patent Claims	Prior Art
	<p>necessary, stop further lowering of drill stem....” p. 1, ll. 49-58.</p> <p>Length compensator U; Mud pipe M; Slidable valve 84</p> <p>p. 4, c. 1, ll. 27-31, p. 3, c. 1, ll. 8-13  p. 5, c. 1, l. 14 - p. 6, c. 1, l. 15</p> <p><b>Brett/Warren</b></p> <p>Brett/Warren is related to “computer controlled drilling”. (Title). Control is accomplished by “vary[ing] the weight on bit so that the controlled parameter was held constant.” p. 201, c. 1, second full paragraph. The weight on bit is varied by a hydraulic actuator that applies more or less lifting force to the drill string. p. 199, c. 2, “Actuation” section. One of skill in the art will recognize that this inherently constitutes regulating the rate of release of the drill string.</p> <p>Brett/Warren discloses a drilling fluid pressure sensor: Pump pressure is designated as a “direct control” variable. p. 207, Table 1.</p>
<p>a drilling fluid pressure regulator coupled to said drilling fluid pressure sensor, said drilling fluid pressure regulator measuring changes in drilling fluid pressure and outputting a signal representing those changes;</p>	<p><b>Bowden ‘359</b></p> <p>Bowden ‘359 describes a “regulator” sensitive to a pressure signal, in the context of bit weight measurement. Fig. 11 elements 107-113 make a regulator nearly identical to that described in the ‘142 Patent. c. 7, l. 66 – c. 8, l. 16. Also, Fig. 1 elements 4-6a, 24a, and 66. c. 2, l. 43-67. The device of Bowden ‘359 could trivially be adapted to output a signal representing changes in drilling fluid pressure.</p> <p><b>Hobhouse</b></p> <p>Hobhouse discloses such a device in Figure 8, elements 108 and 109, which are coupled to the pressure sensor (103-107), and output a</p>



'142 Patent Claims	Prior Art
	<p>signal indicative of pressure changes. c. 8, ll. 22-27.</p> <p><b>LeCompte</b>  Slidable valve 84; Valve groove 86; spring 85; Steam boiler O; steam pipe P  p. 5, c. 1, l. 24 - p. 6, c. 1, l. 15.</p> <p><b>Brett/Warren</b>  See Nomenclature: p. 204, c. 1-2  Analog Control (Fig. 10/11) p. 200  Integral Control (Equations 1-4) p. 205</p>
<p>a relay coupled to said drilling fluid pressure regulator, said relay responsive to the output signal of said drilling fluid pressure regulator to supply a drill string control signal at an output thereof; and</p>	<p><b>Bowden '359</b>  Bowden '359 describes a pneumatic relay system nearly identical to that of the '142 Patent, in the context of bit weight measurement. Fig. 11 element 105. c. 7, ll. 71-74. The relay of Bowden '359 would be usable without change in a system that controls based on drilling fluid pressure.</p> <p><b>Hobhouse</b>  Figure 8 of Hobhouse shows "control console" 111 that receives the electric signal from the pressure sensor and controls cylinder 99. "The control console 111 ... may supply pressure fluid to the underside of the piston 98 in the cylinder 99, to regulate the sinkage of the drill string...." c. 8, ll. 30-34.</p> <p><b>LeCompte</b>  Slidable valve 84; Steam cylinder 67; piston 70; arm 73  p. 5, c. 1, l. 14 - p. 6, c. 1, l. 15</p> <p><b>Brett/Warren</b>  Analog Control (Fig. 10/11) p. 200  Integral Control (Equations 1-4) p. 205</p>
<p>a drill string controller coupled to said relay wherein a decrease in drilling fluid pressure results in said relay supplying a drill string control signal that operates said drill string</p>	<p><b>Bowden '359</b>  Bowden '359 describes a drill string controller that operates nearly identically to that of the '142 Patent, and inherently</p>

'142 Patent Claims	Prior Art
<p>controller to effect an increase in the rate of release of said drill string and an increase in drilling fluid pressure results in said relay supplying a drill string control signal that operates said drill string controller to effect a decrease in the rate of release of said drill string.</p>	<p>regulates the rate of drill string release. See c. 4, l. 74 - c. 5, l. 50.</p> <p><b>Ball</b> provides further evidence that the system of Bowden '359, which automates the actuation of a conventional drum brake, regulates the <u>rate</u> of drill string release. Ball states that its "drilling apparatus has a conventional brake operated by a brake handle which operates on the drum to control the <u>rate</u> of feed out of the drill line...." c. 3, ll. 2-5, emphasis added.</p> <p><b>Hobhouse</b></p> <p>Figure 8 of Hobhouse shows "control console" 111 that receives the electric signal from the sensors and controls cylinder 99. "The control console 111 ... may supply pressure fluid to the underside of the piston 98 in the cylinder 99, to regulate the sinkage of the drill string...." c. 8, ll. 30-34. Hobhouse describes stopping the sinkage of the drill stem in response to an increase in mud-flush pressure, and increasing the sinkage of the drill stem in response to a decrease in mud-flush fluid pressure. c. 8, ll. 38-49. Stopping and increasing the sinkage of the drill string are control of the rate of release of the drill string. The control is through "graduated reference contacts" 110. c. 8, l. 27 and Fig. 8.</p> <p><b>LeCompte</b></p> <p>Brake lever 60; cable drum D  p. 5, c. 2, l. 82 - p. 6, c. 2, l. 51</p> <p>LeCompte describes that when drilling fluid pressure increases, additional braking is applied to "slow up feeding of upper drill stem into the hole." p. 5, ll. 97-112. When pressure falls, the brake actuation is relaxed "to allow normal lowering of the upper drill stem section H." p. 6, ll. 16-30. LeCompte slows or speeds up the drill string release in</p>

'142 Patent Claims	Prior Art
	<p>response to drilling fluid pressure, thereby regulating the <u>rate</u> of release of the drill string.</p> <p><b>Brett/Warren</b>  100kip manual, servo, or computer controlled hydraulic hoist; hoist actuation system (Fig. 8) p. 199</p> <p>Analog Control (Fig. 10/11) p. 200  Integral Control (Equations 1-4) p. 205</p>

**Claim 2**

'142 Patent Claims	Prior Art
<p><b>2.</b> The automatic drilling system according to claim 1, further comprising:</p> <p>a bit weight sensor;</p>	<p><b>Bowden '359</b>  Bowden '359 describes a bit weight sensor producing a pressure signal. Fig. 1, element 16. c. 3, ll. 45-49. Also Figure 11, element D. c. 8, ll. 28-58.</p> <p><b>Dillon</b> provides explicit motivation for control of drill string release based on the combination of drilling fluid pressure and bit weight. p. 1, c. 1, ll. 54ff.</p> <p><b>Hobhouse</b>  Hobhouse uses cylinder pressure to sense bit weight. c. 5, ll. 30-36.</p>
<p>a bit weight regulator coupled to said bit weight sensor, said bit weight regulator measuring changes in bit weight and outputting a signal representing those changes;</p>	<p><b>Bowden '359</b>  Fig. 11 elements 107-113 make a regulator nearly identical to that described in the '142 Patent. c. 7, l. 66 – c. 8, l. 16. Also, Fig. 1 elements 4-6a, 24a, and 66. c. 2, ll. 43-67.</p> <p><b>Hobhouse</b>  Bit weight is indicated by a “signal from pressure transducer 63” in the cylinder. c. 7, ll. 42-43. See also c. 5, ll. 30-36.</p>

'142 Patent Claims	Prior Art
<p>a relay coupled to said bit weight regulator, said relay responsive to the output signal of said bit weight regulator to supply a drill string control signal at an output thereof; and</p>	<p><b>Bowden '359</b>  Fig. 11 element 105. c. 7, ll. 71-74. Also, Fig. 1 element 8. c. 2, ll. 62-67.</p> <p><b>Hobhouse</b>  Hobhouse must necessarily relay its bit weight signal to the drill string controller. See c. 7, ll. 40-47, relays 80, 81, and solenoid valve 71.</p>
<p>said drill string controller coupled to said relay wherein a decrease in bit weight results in said relay supplying a drill string control signal that operates said drill string controller to effect an increase in the rate of release of said drill string and an increase in bit weight results in said relay supplying a drill string control signal that operates said drill string controller to effect a decrease in the rate of release of said drill string.</p>	<p><b>Bowden '359</b>  See c. 4, l. 74 - c. 5, l. 50.</p> <p><b>Hobhouse</b>  The length of cylinder 4 is automatically adjusted to raise or lower the drill string, to keep weight-on-bit substantially constant. c. 5, ll.59-63. Raising and lowering the drill string is control of the rate of release of the drill string. The control is through "graduated reference contacts" 110. c. 8, l. 27 and Fig. 8.</p>

**Claim 3**

'142 Patent Claims	Prior Art
<p><b>3.</b> The automatic drilling system according to claim 1 further comprising:</p> <p>a drill string torque sensor;</p>	<p><b>Dillon</b>  One of the objects of Dillon's invention is "to provide for controlling the movement of the drill stem as a function of ... the load on the drilling motor ...." p. 1, c. 1, ll. 54 ff. Dillon provides a signal proportional to the current of the drilling motor. p. 3, c. 1, ll. 44-46. One of skill in the art will recognize that motor current is closely related to torque.</p> <p><b>Hobhouse</b>  Torque transducer 8 measures the torque on</p>

'142 Patent Claims	Prior Art
	<p>the drive shaft 9. c. 4, ll. 30-40, Fig. 5.</p> <p>Additionally, the '142 Patent itself discloses a commercially available torque sensor that produces a pressure signal indicating torque. c. 6, ll. 38-50, Fig. 10.</p> <p><b>Dillon</b> provides explicit motivation for control of drill string release based on the combination of drilling fluid pressure and drill string torque. p. 1, c. 1, ll. 54ff.</p>
<p>a drill string torque regulator coupled to said drill string torque sensor, said drill string torque regulator measuring changes in drill string torque and outputting a signal representing those changes;</p>	<p><b>Bowden '359</b></p> <p>Bowden '359 discloses a regulator easily adaptable to use in controlling based on any variable. Fig. 11 elements 107-113, c. 7, l. 66 – c. 8, l. 16. Also, Fig. 1 elements 4-6a, 24a, and 66. c. 2, ll. 43-67.</p> <p><b>Dillon</b></p> <p>A signal representing the motor current is output through conductor 63. p. 3, c. 1, ll. 29-46.</p> <p><b>Hobhouse</b></p> <p>"Torque transducer" 8 produces an "actual torque signal". c. 4, l. 31, c. 7, l. 30.</p>
<p>a relay coupled to said drill string torque regulator, said relay responsive to the output signal of said drill string torque regulator to supply a drill string control signal at an output thereof; and</p>	<p><b>Bowden '359</b></p> <p>Bowden '359 discloses a pneumatic relay easily adaptable to control based on any variable. Fig. 11 element 105. c. 7, ll. 71-74. Also, Fig. 1 element 8. c. 2, ll. 62-67.</p> <p><b>Dillon</b></p> <p>The current signal is relayed to reactor coil 64 at "control mechanism" 65, which outputs a signal to control the feed of the drill stem. p. 3, c. 1, ll. 29-46. Relays H and L further transmit the signal. p. 3, c. 2, l. 30 - p. 4, c. 1, l. 32.</p>

'142 Patent Claims	Prior Art
	<p><b>Hobhouse</b></p> <p>"The strain gauges [used to measure torque] are connected to the console...." c. 4, ll. 37-38. See also c. 7, ll. 28-39, relays 78, 80, 81, solenoid valve 71.</p>
<p>a drill strings controller coupled to said relay wherein a decrease in drill string torque results in said relay supplying a drill strings control signal that operates said drill strings controller to effect an increase in the rate of release of said drill string and an increase in drill string torque results in said relay supplying a drill strings control signal that operates said drill strings controller to effect a decrease in the rate of release of said drill string.</p>	<p><b>Bowden '359</b></p> <p>Bowden '359 describes a drill string controller that operates nearly identically to that of the '142 Patent, and inherently regulates the rate of drill string release. See c. 4, l. 74 - c. 5, l. 50. One of skill in the art would recognize that these are inherently the correct control relationships.</p> <p><b>Hobhouse</b></p> <p>Figure 8 of Hobhouse shows "control console" 111 that receives the electric signal from the sensors and controls cylinder 99. "The control console 111 ... may supply pressure fluid to the underside of the piston 98 in the cylinder 99, to regulate the sinkage of the drill string...." c. 8, ll. 30-34. One of skill in the art will recognize that the inherently preferred relationship is to slow the rate of drill string release when torque increases, and to accelerate the rate of drill string release when torque decreases.</p>

**Claim 4**

'142 Patent Claims	Prior Art
<p><b>4.</b> The automatic drilling system according to claim 1 further comprising:</p> <p>a drill string RPM sensor;</p>	<p><b>Dillon</b></p> <p>Dillon provides a signal related to drill string RPM. p. 3, c. 1, ll. 47-62.</p> <p><b>Hobhouse</b></p> <p>An "electromagnetic pickup is included to give an accurate measurement of the speed of</p>

'142 Patent Claims	Prior Art
	<p>the shaft 9.” c. 4, ll. 38-40.</p> <p><b>Dillon</b> provides explicit motivation for control of drill string release based on the combination of drilling fluid pressure and drill string RPM. p. 1, c. 1, ll. 54ff.</p>
<p>a drill string RPM regulator coupled to said drill string RPM sensor, said drill string RPM regulator measuring changes in drill string RPM and outputting a signal representing those changes;</p>	<p><b>Bowden ‘359</b></p> <p>Bowden ‘359 discloses a regulator easily adaptable to use in controlling based on any variable. Fig. 11 elements 107-113, c. 7, l. 66 – c. 8, l. 16. Also, Fig. 1 elements 4-6a, 24a, and 66. c. 2, ll. 43-67.</p> <p><b>Dillon</b></p> <p>Dillon provides a signal related to drill string RPM. p. 3, c. 1, ll. 47-62. Dillon’s signal is relayed to coil 79, shown in Figure 1a.</p> <p><b>Hobhouse</b></p> <p>The “accurate measurement of the speed of the shaft” is necessarily an output signal that reflects any changes in the speed of the shaft. c. 4, ll. 38-40.</p>
<p>a relay coupled to said drill string RPM regulator, said relay responsive to the output signal of said drill string RPM regulator to supply a drill strings control signal at an output thereof; and</p>	<p><b>Bowden ‘359</b></p> <p>Bowden ‘359 discloses a pneumatic relay easily adaptable to control based on any variable. Fig. 11 element 105. c. 7, ll. 71-74. Also, Fig. 1 element 8. c. 2, ll. 62-67.</p> <p><b>Dillon</b></p> <p>Relays H and L further transmit the signal.</p> <p><b>Hobhouse</b></p> <p>Hobhouse necessarily must relay its RPM signal to console 111, as Hobhouse currently controls drill string RPM. c. 4, ll. 52-54.</p>
<p>a drill strings controller coupled to said relay wherein an increase in drill string RPM results in said relay supplying a drill strings control signal that operates said drill strings controller to effect an increase in the rate of release of</p>	<p><b>Bowden ‘359</b></p> <p>Bowden ‘359 describes a drill string controller that operates nearly identically to that of the ‘142 Patent in relation to bit</p>

'142 Patent Claims	Prior Art
<p>said drill string and a decrease in drill string RPM results in said relay supplying a drill strings control signal that operates said drill strings controller to effect a decrease in the rate of release of said drill string.</p>	<p>weight, and inherently regulates the rate of drill string release. See c. 4, l. 74 - c. 5, l. 50. One of skill in the art would recognize that these are inherently the correct control relationships.</p> <p><b>Hobhouse</b></p> <p>Figure 8 of Hobhouse shows "control console" 111 that receives the electric signal from the sensors and controls cylinder 99. "The control console 111 ... may supply pressure fluid to the underside of the piston 98 in the cylinder 99, to regulate the sinkage of the drill string..." c. 8, ll. 30-34. One of skill in the art will recognize that the inherently preferred relationship is to slow the rate of drill string release when RPM decreases, and to accelerate the rate of drill string release when RPM increases.</p>

**Claim 5**

'142 Patent Claims	Prior Art
<p><b>5.</b> The automatic drilling system according to claim 1 wherein said drilling fluid pressure regulator, comprises:</p> <p>a Bourdon tube coupled to said drilling fluid pressure sensor to measure changes in drilling fluid pressure;</p>	<p><b>Bowden '359</b></p> <p>Bowden '359 discloses, in the context of bit weight measurement, a system nearly identical to the regulator of the '142 Patent. See Figure 11, elements 107-113. Element 113 is a Bourdon tube. c. 7, l. 66 - c. 8, l. 16. Also, Fig. 1 elements 4-6a, 24a, and 66. c. 2, ll. 43-67. The regulator of Bowden '359 could trivially be adapted for use in control based on drilling fluid pressure.</p>
<p>a flapper coupled at one end to said Bourdon tube wherein said flapper pivots about a pivot point in response to changes in drilling fluid pressure measured by said Bourdon tube; and</p>	<p><b>Bowden '359</b></p> <p>Figure 11, element 109 is a pivoted "flapper". c. 8, ll. 15-16. Also, Figure 1, element 6a. c. 5, ll. 6-16; c. 4, ll. 1-38 and c. 9, ll. 12-33.</p>
<p>means responsive to the pivoting of said</p>	<p><b>Bowden '359</b></p>



<b>'142 Patent Claims</b>	<b>Prior Art</b>
flapper for outputting to said relay a signal representative of changes in drilling fluid pressure.	Figure 11 and c. 7, l. 66 – c. 8, l. 20. Also Figure 1 and c. 2, ll. 36-68; c. 4, ll. 1-38 and c. 9, ll. 12-33.

**Claim 6**

<b>'142 Patent Claims</b>	<b>Prior Art</b>
<p><b>6.</b> The automatic drilling system according to claim 2 wherein said bit weight regulator, comprises:</p> <p>a Bourdon tube coupled to said bit weight sensor to measure changes in bit weight;</p>	<p><b>Bowden '359</b></p> <p>Bowden '359 discloses a system nearly identical to the "bit weight regulator" of the '142 Patent. See Figure 11, elements 107-113. Element 113 is a Bourdon tube. c. 7, l. 66 – c. 8, l. 16. Also Figure 1, element 24a. c. 4, ll. 4-5.</p>
<p>a flapper coupled at one end to said Bourdon tube wherein said flapper pivots about a pivot point in response to changes in bit weight measured by said Bourdon tube; and</p>	<p><b>Bowden '359</b></p> <p>Figure 11, element 109 is a pivoted "flapper". c. 8, ll. 15-16. Also Figure 1, element 6a. c. 2, l. 51; c. 4, ll. 1-38 and c. 9, ll. 12-33.</p>
<p>means responsive to the pivoting of said flapper for outputting a signal to said relay representative of changes in bit weight.</p>	<p><b>Bowden '359</b></p> <p>Figure 11 and c. 7, l. 66 - c. 8, l. 20. Also Figure 1 and c. 2, ll. 36-68; c. 4, ll. 1-38 and c. 9, ll. 12-33.</p>

**Claim 7**

<b>'142 Patent Claims</b>	<b>Prior Art</b>
<p><b>7.</b> The automatic drilling system according to claim 3 wherein said drill string torque regulator, comprises:</p> <p>a Bourdon tube coupled to said drill string torque sensor to measure changes in drill string torque;</p>	<p><b>Bowden '359</b></p> <p>Bowden '359 discloses, in the context of bit weight measurement, a system nearly identical to the regulator of the '142 Patent. See Figure 11, elements 107-113. Element 113 is a Bourdon tube. c. 7, l. 66 – c. 8, l. 16. Also Figure 1, element 24a. c. 4, ll. 4-5. The regulator of Bowden '359 could easily be adapted for use in control based on drill</p>

<b>'142 Patent Claims</b>	<b>Prior Art</b>
	string torque.
a flapper coupled at one end to said Bourdon tube wherein said flapper pivots about a pivot point in response to changes in drill string torque measured by said Bourdon tube; and	<b>Bowden '359</b> Figure 11, element 109 is a pivoted "flapper". c. 8, ll. 15-16. Also, Figure 1, element 6a. c. 5, ll. 6-16; c. 4, ll. 1-38 and c. 9, ll. 12-33.
means responsive to the pivoting of said flapper for outputting a signal to said relay representative of changes in drill string torque.	<b>Bowden '359</b> Figure 11 and c. 7, l. 66 - c. 8, l. 20. Also Figure 1 and c. 2, ll. 36-68; c. 4, ll. 1-38 and c. 9, ll. 12-33.

**Claim 8**

<b>'142 Patent Claims</b>	<b>Prior Art</b>
<b>8.</b> The automatic drilling system according to claim 4 wherein said drill string RPM regulator, comprises:  a Bourdon tube coupled to said drill string RPM sensor to measure changes in drill string RPM;	<b>Bowden '359</b>  Bowden '359 discloses, in the context of bit weight measurement, a system nearly identical to the regulator of the '142 Patent. See Figure 11, elements 107-113. Element 113 is a Bourdon tube. c. 7, l. 66 – c. 8, l. 16. Also Figure 1, element 24a. c. 4, ll. 4-5. The regulator of Bowden '359 could easily be adapted for use in control based on drill string RPM.
a flapper coupled at one end to said Bourdon tube wherein said flapper pivots about a pivot point in response to changes in drill string RPM measured by said Bourdon tube; and	<b>Bowden '359</b> Figure 11, element 109 is a pivoted "flapper". c. 8, ll. 15-16. Also, Figure 1, element 6a. c. 5, ll. 6-16; c. 4, ll. 1-38 and c. 9, ll. 12-33.
means responsive to the pivoting of said flapper for outputting a signal to said relay representative of changes in drill string RPM.	<b>Bowden '359</b> Figure 11 and c. 7, l. 66 – c. 8, l. 20. Also Figure 1 and c. 2, ll. 36-68; c. 4, ll. 1-38 and c. 9, ll. 12-33.

**Claim 11**

'142 Patent Claims	Prior Art
<p><b>11.</b> A method for automatically regulating the release of the drill string of a drilling rig drill, comprising the steps of:</p> <p>measuring drilling fluid pressure;</p>	<p><b>Bowden '359</b></p> <p>Bowden '359 describes regulating drill string release based on a pressure signal. c. 2, l. 27 – c. 3, l.53, and Fig. 1. Bowden '359 uses a pressure signal derived from bit weight, but could be trivially adapted to use a drilling fluid pressure signal.</p> <p><b>Dillon</b></p> <p>Dillon includes a sensor that measures drilling fluid pressure. Fig. 1a, elements 106, 107, p. 4, c. 1, ll. 14-32.</p> <p><b>Hobhouse</b></p> <p>Hobhouse indicates that an object of its invention is to “provide a control system for drilling rigs.” c. 1, ll. 39-40. Hobhouse’s system includes hydraulic cylinder “to regulate the sinkage of the drill string”. c. 8, ll. 33-34. The system includes a drilling fluid pressure sensor. Fig. 8, elements 103-107, c. 8, ll. 15-29.</p> <p>In addition, the '142 Patent discloses a commercially available fluid pressure sensor. c. 5, ll. 29-38 and Fig. 5.</p> <p><b>LeCompte</b></p> <p>LeCompte indicates that one object of its invention “resides in the provision of brake actuation mechanism co-acting with the telescopic drill stem section and actuated by the back pressure of the mud laden fluid ... for automatically retarding the lowering of additional drill stem into the hole ... and, if necessary, stop further lowering of drill stem....” P. 1, ll. 49-58.</p> <p>Length compensator U; Mud pipe M;</p>

'142 Patent Claims	Prior Art
	<p>Slidable valve 84  p. 4, c. 1, ll. 27-31, p. 3, c. 1, ll. 8-13  p. 5, c. 1, l. 14 - p. 6, c. 1, l. 15</p> <p><b>Brett/Warren</b></p> <p>Brett/Warren is related to "computer controlled drilling". (Title). Control is accomplished by "vary[ing] the weight on bit so that the controlled parameter was held constant." p. 201, c. 1, second full paragraph. The weight on bit is varied by a hydraulic actuator that applies more or less lifting force to the drill string. p. 199, c. 2, "Actuation" section. One of skill in the art will recognize that this inherently constitutes regulating the rate of release of the drill string.</p> <p>Brett/Warren discloses a drilling fluid pressure sensor: Pump pressure is designated as a "direct control" variable. p. 207, Table 1.</p>
<p>producing a signal in response to changes in drilling fluid pressure, said signal representing the changes in drilling fluid pressure;</p>	<p><b>Bowden '359</b></p> <p>Bowden '359 describes a "regulator" sensitive to a pressure signal. Fig. 11 elements 107-113 make a regulator nearly identical to that described in the '142 Patent. c. 7, l. 66 – c. 8, l. 16. Fig. 1 elements 4-6a, 24a, and 66 also show the regulator. c. 2, ll. 43-67.</p> <p><b>Dillon</b></p> <p>Dillon's sensor and associated circuitry produce a signal representing changes in fluid pressure. "The pressure of the mud pump is transmitted from the housing 107 to the piston 106 which, in coaction with a spring moves the position of the iron core 105, thereby varying the reactance of the reactor coil 104." p. 4, c. 1, ll. 21-25.</p> <p><b>Hobhouse</b></p>

'142 Patent Claims	Prior Art
	<p>“Changes in mud-flush pressure beyond determined limits produce a change in pressure in the hydraulic fluid and generate an electrical signal from the strain gauges 107.” c. 8, ll. 22-25.</p> <p><b>LeCompte</b>  Slidable valve 84; Valve groove 86; spring 85; Steam boiler O; steam pipe P  p. 5, c. 1, l. 24 - p. 6, c. 1, l. 15</p> <p><b>Brett/Warren</b>  See Nomenclature: p. 204, c. 1-2  Analog Control (Fig. 10/11) p. 200  Integral Control (Equations 1-4) p. 205</p>
<p>relaying said signal to a drill string controller; and</p>	<p><b>Bowden '359</b>  Bowden '359 describes a pneumatic relay system nearly identical to that of the '142 Patent. Fig. 11 element 105. c. 7, ll. 71-74. Fig. 1 element 8. c. 2, ll. 62-67.</p> <p><b>Dillon</b>  Reactor coil 104 shown in Figure 1a relays the fluid pressure signal to reactor coil 198 at “control mechanism” 65, which outputs a signal to control the feed of the drill stem. Relays H and L further transmit the signal. p. 3, c. 2, l. 30 - p. 4, c. 1, l. 32.</p> <p><b>Hobhouse</b>  Figure 8 of Hobhouse shows “control console” 111 that receives the electric signal from the pressure sensor and controls cylinder 99. “The control console 111 ... may supply pressure fluid to the underside of the piston 98 in the cylinder 99, to regulate the sinkage of the drill string....” c. 8, ll. 30-34.</p> <p><b>LeCompte</b>  Slidable valve 84; Steam cylinder 67; piston 70, arm 73</p>

'142 Patent Claims	Prior Art
	<p>p. 5, c. 1, l. 14 - p. 6, c. 1, l. 15</p> <p><b>Brett/Warren</b></p> <p>See Nomenclature: p. 204, c. 1-2</p> <p>Analog Control (Fig. 10/11) p. 200</p> <p>Integral Control (Equations 1-4) p. 205</p>
<p>controlling said drill string controller to increase the rate of release of said drill string when said signal represents a decrease in drilling fluid pressure and to decrease the rate of release of said drill string when said signal represents an increase in drilling fluid pressure.</p>	<p><b>Bowden '359</b></p> <p>Bowden '359 describes a drill string controller that operates nearly identically to that of the '142 Patent, and inherently regulates the rate of drill string release. See c. 4, l. 74 - c. 5, l. 50.</p> <p><b>Hobhouse</b></p> <p>Hobhouse describes stopping the sinkage of the drill stem in response to an increase in mud-flush pressure, and increasing the sinkage of the drill stem in response to a decrease in mud-flush fluid pressure. c. 8, ll. 38-49. Figure 8 of Hobhouse shows "control console" 111 that receives the electric signal from the sensors and controls cylinder 99. "The control console 111 ... may supply pressure fluid to the underside of the piston 98 in the cylinder 99, to regulate the sinkage of the drill string...." c. 8, ll. 30-34. Stopping and increasing the sinkage of the drill string are control of the rate of release of the drill string. The control is through "graduated reference contacts" 110. c. 8, l. 27 and Fig. 8.</p> <p><b>LeCompte</b></p> <p>Brake lever 60; cable drum D</p> <p>p. 5, c. 2, l. 82 - p. 6, c. 2, l. 51</p> <p>LeCompte describes that when drilling fluid pressure increases, additional braking is applied to "slow up feeding of upper drill stem into the hole." P. 5 lines 97-112. When pressure falls, the brake actuation is relaxed "to allow normal lowering of the upper drill</p>

'142 Patent Claims	Prior Art
	<p>stem section H.” p. 6, ll. 16-30. LeCompte slows or speeds up the drill string release in response to drilling fluid pressure, thereby regulating the <u>rate</u> of release of the drill string.</p> <p><b>Brett/Warren</b>  100kip manual, servo, or computer controlled hydraulic hoist; hoist actuation system (Fig. 8) p. 199</p> <p>Analog Control (Fig. 10/11) p. 200  Integral Control (Equations 1-4) p. 205</p>

**Claim 12**

'142 Patent Claims	Prior Art
<p><b>12.</b> The method according to claim 11 further comprising the steps of:</p> <p>measuring drill string torque;</p>	<p><b>Dillon</b>  Dillon provides a signal proportional to the current of the drilling motor. p. 3, c. 1, ll. 44-46. One of skill in the art will recognize that motor current is closely related to torque.</p> <p><b>Hobhouse</b>  Torque transducer 8 measures the torque on the drive shaft 9. c. 4, ll. 30-40, Fig. 5.</p> <p><b>Dillon</b> provides explicit motivation for control of drill string release based on the combination of drilling fluid pressure and drill string torque. p. 1, c. 1, ll. 54ff.</p>
<p>producing a signal in response to changes in drill string torque, said signal representing the changes in drill string torque; and</p>	<p><b>Bowden '359</b>  Fig. 11 elements 107-113 make a regulator nearly identical to that described in the '142 Patent. c. 7, l. 66 – c. 8, l. 16. Fig. 1 elements 4-6a, 24a, and 66 also show the regulator. c. 2, ll. 43-67.</p> <p><b>Dillon</b>  A signal representing the motor current is</p>

'142 Patent Claims	Prior Art
	<p>output through conductor 63. p. 3, c. 1, ll. 29-46.</p> <p><b>Hobhouse</b></p> <p>"... an amplifier receives ... the actual torque signal from the transducer..." c. 7, ll. 28-29.</p>
<p>relaying said signal to a drill string controller;</p>	<p><b>Bowden '359</b></p> <p>Bowden '359 describes a pneumatic relay system nearly identical to that of the '142 Patent. Fig. 11 element 105. c. 7, ll. 71-74. Fig. 1 element 8. c. 2, ll. 62-67.</p> <p><b>Dillon</b></p> <p>The current signal is relayed to reactor coil 64 at "control mechanism" 65, which outputs a signal to control the feed of the drill stem. p. 3, c. 1, ll. 29-46. Relays H and L further transmit the signal. p. 3, c. 2, l. 30 - p. 4, c. 1, l. 32.</p> <p><b>Hobhouse</b></p> <p>"The strain gauges [used to measure torque] are connected to the console...." c. 4, ll. 37-38. See also c. 7, ll. 28-39, relays 78, 80, 81, solenoid valve 71.</p>
<p>controlling said drill string controller to increase the rate of release of said drill string when said signal represents a decrease in drill string torque and to decrease the rate of release of said drill string when said signal represents an increase in drill string torque.</p>	<p><b>Bowden '359</b></p> <p>Bowden '359 describes a drill string controller that operates nearly identically to that of the '142 Patent, and inherently regulates the rate of drill string release. See c. 4, l. 74 - c. 5, l. 50. One of skill in the art would recognize that these are inherently the correct control relationships. Additionally, at least Dillon teaches this relationship between drill string release and torque. p. 4, c. 1, ll. 50-59.</p> <p><b>Dillon</b></p> <p>Dillon's "control mechanism" 65 regulates power to "hoisting motor" 26, which raises and lowers the drill string. Excess torque</p>



'142 Patent Claims	Prior Art
	<p>results in a reduction of feed or even retraction of the drill stem. p. 4, c. 1, ll. 50-59.</p> <p><b>Hobhouse</b></p> <p>Figure 8 of Hobhouse shows "control console" 111 that receives the electric signal from the sensors and controls cylinder 99. "The control console 111 ... may supply pressure fluid to the underside of the piston 98 in the cylinder 99, to regulate the sinkage of the drill string...." c. 8, ll. 30-34. One of skill in the art will recognize that the inherently preferred relationship is to slow the rate of drill string release when torque increases, and to accelerate the rate of drill string release when torque decreases.</p>

**Claim 13**

'142 Patent Claims	Prior Art
<p><b>13.</b> The method according to claim 11 further comprising the steps of:</p> <p>measuring drill string RPM;</p>	<p><b>Dillon</b></p> <p>Dillon provides a signal related to drill string RPM. p. 3, c. 1, ll. 47-62.</p> <p><b>Hobhouse</b></p> <p>An "electromagnetic pickup is included to give an accurate measurement of the speed of the shaft 9." c. 4, ll. 38-40.</p> <p><b>Dillon</b> provides explicit motivation for control of drill string release based on the combination of drilling fluid pressure and drill string RPM. p. 1, c. 1, ll. 54ff.</p>
<p>producing a signal in response to changes in drill string RPM, said signal representing the changes in drill string RPM;</p>	<p><b>Bowden '359</b></p> <p>Fig. 11 elements 107-113 make a regulator nearly identical to that described in the '142 Patent. c. 7, l. 66 – c. 8, l. 16. Fig. 1 elements 4-6a, 24a, and 66 also show the</p>

'142 Patent Claims	Prior Art
	<p>regulator. c. 2, ll. 43-67.</p> <p><b>Dillon</b></p> <p>Dillon provides a signal related to drill string RPM. p. 3, c. 1, ll. 47-62.</p> <p><b>Hobhouse</b></p> <p>An "electromagnetic pickup is included to give an accurate measurement of the speed of the shaft 9." c. 4, ll. 38-40.</p>
<p>relaying said signal to a drill string controller;</p>	<p><b>Dillon</b></p> <p>Accelerating resistors 76/77; drilling table 4; coil 79; 2 leads of the secondary winding of drilling motor 7; conductor 78, reactor coil 75; conductor 80; balancing mechanism 65; contact members 115 and 118; contact members 114 and 115  p. 3, c. 1, ll. 48-62; Fig. 1a  p. 3, c. 2., l. 34 – p. 4, c. 1, l. 3.</p> <p><b>Hobhouse</b></p> <p>Fig. 3, console 1, rotary table speed meter 37, c. 5, ll. 40-43.</p>
<p>controlling said drill string controller to increase the rate of release of said drill string when said signal represents a increase in drill string RPM and to decrease the rate of release of said drill string when said signal represents an decrease in drill string RPM.</p>	<p><b>Bowden '359</b></p> <p>Bowden '359 describes a drill string controller that operates nearly identically to that of the '142 Patent in relation to bit weight, and inherently regulates the rate of drill string release. See c. 4, l. 74 - c. 5, l. 50. One of skill in the art would recognize that these are inherently the correct control relationships.</p> <p><b>Dillon</b></p> <p>Dillon's "control mechanism" 65 regulates power to "hoisting motor" 26, which raises and lowers the drill string, responding in part to RPM. Dillon is not explicit as to the relationship between speed and drill string advance, but one of skill in the art will recognize that this is inherently the correct</p>

'142 Patent Claims	Prior Art
	<p>relationship.</p> <p><b>Hobhouse</b></p> <p>Figure 8 of Hobhouse shows "control console" 111 that receives the electric signal from the sensors and controls cylinder 99. "The control console 111 ... may supply pressure fluid to the underside of the piston 98 in the cylinder 99, to regulate the sinkage of the drill string...." c. 8, ll. 30-34. One of skill in the art will recognize that the inherently preferred relationship is to slow the rate of drill string release when RPM decreases, and to accelerate the rate of drill string release when torque increases.</p>

**Claim 14**

'142 Patent Claims	Prior Art
<p><b>14.</b> A method for automatically regulating the release of the drill string of a drilling rig drill, comprising the steps of:</p> <p>measuring drilling fluid pressure and bit weight;</p>	<p><b>Bowden '359</b></p> <p>Bowden '359 describes regulating the rate of drill string release based on a pressure signal derived from bit weight. c. 2, l. 27 - c. 3, l. 53, and Fig. 1.</p> <p><b>Dillon</b></p> <p>Dillon indicates that an object of its invention is to control the movement of the drill stem as a function of various parameters, including drilling fluid pressure and bit weight. p. 1, col. 1 line 54ff. Dillon includes a sensor that measures drilling fluid pressure. Fig. 1a, elements 106, 107, p. 4, c. 1, ll. 14-32.</p> <p>Springs 109, levers 110, iron core 111, and reactor coil 97 shown in Figure 1a cooperate to measure bit weight. p. 3, c. 1, ll. 68-74.</p> <p><b>Hobhouse</b></p> <p>Hobhouse indicates that an object of its invention is to "provide a control system for</p>

'142 Patent Claims	Prior Art
	<p>drilling rigs.” c. 1, ll. 39-40. Hobhouse’s system includes hydraulic cylinder “to regulate the sinkage of the drill string”. c. 8, ll. 33-34. The system includes a drilling fluid pressure sensor. Fig. 8, elements 103-107, c. 8, ll. 15-29. Hobhouse uses cylinder pressure to sense bit weight. c. 5, ll. 30-36.</p> <p>In addition, the ‘142 Patent discloses a commercially available fluid pressure sensor. c. 5, ll. 29-38 and Fig. 5.</p> <p><b>Dillon</b> provides explicit motivation for control of drill string release based on the combination of drilling fluid pressure and bit weight. p. 1, c. 1, ll. 54ff.</p>
<p>producing a first signal in response to changes in drilling fluid pressure, said first signal representing the changes in drilling fluid pressure;</p>	<p><b>Bowden ‘359</b></p> <p>Bowden ‘359 describes a “regulator” sensitive to a pressure signal, in the context of bit weight measurement. Fig. 11 elements 107-113 make a regulator nearly identical to that described in the ‘142 Patent. c. 7, l. 66 – c. 8, l. 16. Also, Fig. 1 elements 4-6a, 24a, and 66 also show the regulator. c. 2, ll. 43-67. The regulator of Bowden ‘359 could be trivially adapted to operate on a drilling fluid pressure signal.</p> <p><b>Dillon</b></p> <p>Dillon’s sensor and associated circuitry produce a signal representing changes in fluid pressure. “The pressure of the mud pump is transmitted from the housing 107 to the piston 106 which, in coaction with a spring moves the position of the iron core 105, thereby varying the reactance of the reactor coil 104.” p. 4, c. 1, ll. 21-25.</p> <p><b>Hobhouse</b></p> <p>“Changes in mud-flush pressure beyond determined limits produce a change in pressure in the hydraulic fluid and generate</p>

'142 Patent Claims	Prior Art
<p>producing a second signal in response to changes in bit weight, said second signal representing the changes in bit weight;</p>	<p>an electrical signal from the strain gauges 107.” c. 8, ll. 22-25.</p> <p><b>Bowden ‘359</b></p> <p>Fig. 1 elements 4-6a, 24a, and 66 make a regulator nearly identical to that described in the ‘142 Patent, that produces a signal representing changes in bit weight. c. 2, ll. 43-67. Fig. 11 elements 107-113 also show the regulator. c. 7, l. 66 – c. 8, l. 16.</p> <p><b>Dillon</b></p> <p>Reactor coil 97 outputs a signal representing changes in bit weight. “Any change in the weight on the bottom of the well will change the reactance of the reactor coil 97....” p. 2, c. 2, ll. 6-8.</p> <p><b>Hobhouse</b></p> <p>Hobhouse uses cylinder pressure to sense bit weight. c. 5, ll. 30-36. A signal is produced. c. 7, ll. 41-47, relays 80, 81, and solenoid valve 71.</p>
<p>selecting any one of said first signal, said second signal, and both said first and said second signals to control the release of said drill string; and</p>	<p><b>Dillon – Manual Selection</b></p> <p>“Knife switch” 98 can disable the influence of fluid pressure on drill string release. p. 4, c. 1, ll. 33-36. Coils 64 and 79, carrying signals relating to torque and speed, also can be disconnected. p. 4, c. 1, ll. 37-40. Dillon can control based on any one, all, or any combination of four inputs that include drilling fluid pressure, bit weight, motor load, and motor speed. p. 1, c. 1, ll. 54ff.</p> <p><b>Hobhouse – Manual Selection</b></p> <p>Control selector 42, shown in Figs. 3 and 7, selects either or both of two control signals to control release of the drill string. c. 5, ll. 49-76, c. 7, ll. 23-74.</p> <p><b>Dillon – Automatic Selection</b></p> <p>Upon an indication that the load (torque, as</p>

'142 Patent Claims	Prior Art
	<p>indicated by current) on the drilling motor is “excessive”, Dillon’s system automatically overrides control based on other variables and hoists the drill stem. p. 4, c. 1, ll. 41-59.</p> <p><b>Hobhouse – Automatic Selection</b></p> <p>Even when one control parameter is “dominant”, limits are set for other parameters, and drill string release is stopped when any limit is exceeded. c. 6, ll. 1-9.</p> <p>Thus both Dillon and Hobhouse provide for the manual selection from among several signals of combinations of signals on which to control drill string release, and also teach automatic selection between primary and secondary control variables during operation of their respective systems.</p>
<p>relaying said selected signal or signals to a drill string controller which regulates the release said drill string in response to said selected signal or signals.</p>	<p><b>Bowden ‘359</b></p> <p>Bowden ‘359 describes a drill string controller that operates nearly identically to that of the ‘142 Patent, and inherently regulates the rate of drill string release, in the context of bit weight control. See c. 4, l. 74 - c. 5, l. 50.</p> <p><b>Dillon</b></p> <p>Signals from Dillon’s drilling fluid pressure and bit weight sensors are relayed to “control mechanism” 65, regulates power to “hoisting motor” 26. “The stem will thus be hoisted or lowered, as the case may be, to reestablish a balanced condition....” p. 2, c. 2, ll. 13-16.</p> <p><b>Hobhouse</b></p> <p>Figure 8 of Hobhouse shows “control console” 111 that receives the electric signal from the sensors and controls cylinder 99. “The control console 111 ... may supply pressure fluid to the underside of the piston 98 in the cylinder 99, to regulate the sinkage of the drill string....” c. 8, ll. 30-34.</p>

**Claim 15**

<b>'142 Patent Claims</b>	<b>Prior Art</b>
<p><b>15.</b> The method according to claim 14, further comprising the steps of:</p> <p>measuring drill string torque and drill string RPM;</p>	<p><b>Dillon</b></p> <p>One of the objects of Dillon's invention is "to provide for controlling the movement of the drill stem as a function of ... the load on the drilling motor, the speed of the drilling motor...." p. 1, c. 1, ll. 54 ff. Dillon provides a signal proportional to the current of the drilling motor. p. 3, c. 1, ll. 44-46. One of skill in the art will recognize that motor current is closely related to torque.</p> <p>Dillon provides a signal related to drill string RPM. p. 3, c. 1, ll. 47-62.</p> <p><b>Hobhouse</b></p> <p>Torque transducer 8 measures the torque on the drive shaft 9. c. 4, ll. 30-40, Fig. 5.</p> <p>An "electromagnetic pickup is included to give an accurate measurement of the speed of the shaft 9." c. 4, ll. 38-40.</p> <p><b>Dillon</b> provides explicit motivation for control of drill string release based on the combination of drilling fluid pressure, bit weight, drill string torque, and drill string RPM. p. 1, c. 1, ll. 54ff.</p>
<p>producing a third signal in response to changes in drill string torque, wherein said third signal represents the changes in drill string torque;</p>	<p><b>Dillon</b></p> <p>A signal representing the motor current is output through conductor 63. p. 3, c. 1, ll. 29-46. One of skill in the art will recognize that motor current is closely related to torque.</p> <p><b>Hobhouse</b></p> <p>"Torque transducer" 8 produces an "actual torque signal". c. 4, l. 31, c. 7, l. 30. See also c. 7, ll. 28-39, relays 78, 80, 81, solenoid valve 71.</p>

'142 Patent Claims	Prior Art
<p>producing a fourth signal in response to changes in drill string RPM, wherein said fourth signal represents the changes in drill string RPM;</p>	<p><b>Dillon</b></p> <p>Dillon provides a signal related to drill string RPM. p. 3, c. 1, ll. 47-62.</p> <p><b>Hobhouse</b></p> <p>An "electromagnetic pickup is included to give an accurate measurement of the speed of the shaft 9." c. 4, ll. 38-40.</p>
<p>selecting any one of said first, second, third, and fourth signals, a combination of said first, second, third, and fourth signals, and all of said first, second, third, and fourth signals to regulate the release of said drill string; and</p>	<p><b>Dillon – Manual Selection</b></p> <p>"Knife switch" 98 can disable the influence of fluid pressure on drill string release. p. 4, c. 1, ll. 33-36. Coils 64 and 79, carrying signals relating to torque and speed, also can be disconnected. p. 4, c. 1, ll. 37-40. Dillon can control based on any one, all, or any combination of four inputs that include drilling fluid pressure, bit weight, motor load, and motor speed. p. 1, c. 1, ll. 54ff.</p> <p><b>Hobhouse – Manual Selection</b></p> <p>Control selector 42, shown in Figs. 3 and 7, selects either or both of two control signals to control release of the drill string. c. 5, ll. 49-76, c. 7, ll. 23-74.</p> <p><b>Dillon – Automatic Selection</b></p> <p>Upon an indication that the load (torque, as indicated by current) on the drilling motor is "excessive", Dillon's system automatically overrides control based on other variables and hoists the drill stem. p. 4, c. 1, ll. 41-59.</p> <p><b>Hobhouse – Automatic Selection</b></p> <p>Even when one control parameter is "dominant", limits are set for other parameters, and drill string release is stopped when any limit is exceeded. c. 6, ll. 1-9.</p> <p>Thus both Dillon and Hobhouse provide for the manual selection from among several signals of combinations of signals on which</p>



'142 Patent Claims	Prior Art
	to control drill string release, and also teach automatic selection between primary and secondary control variables during operation of their respective systems.
relaying said selected signal or signals to a drill string controller which regulates the release said drill string in response to said selected signal or signals.	<b>Bowden '359</b>  Bowden '359 describes a drill string controller that operates nearly identically to that of the '142 Patent. See c. 4, l. 74 - c. 5, l. 50.  <b>Hobhouse</b>  Figure 8 of Hobhouse shows "control console" 111 that receives the electric signal from the sensors and controls cylinder 99. "The control console 111 ... may supply pressure fluid to the underside of the piston 98 in the cylinder 99, to regulate the sinkage of the drill string...." c. 8, ll. 30-34.

## APPENDIX C

### Historical Development of Automatic Drilling Control

The starting point for the analysis is the 1932 LeCompte Patent and the 1935 Dillon Patent, attached respectively as Exhibits F and D. As is discussed above, LeCompte teaches and claims a device for controlling the release of the drill string using fluid pressure measured at a telescoping joint that expands and compresses as more force is applied to the bit. Dillon teaches and claims a system that senses changes in bit weight, fluid pressure, RPM and torque, alone or in combination, and regulates the advancement of the string accordingly. Dillon was the first of several inventions to teach and claim controlling the advancement of the drill string using multiple parameters, expressly including all of those listed in the '142 Patent.

#### *i. Early Intermittent Control*

As early as 1932, LeCompte and Dillon taught the use of drilling fluid pressure to control the advancement of the drill string. LeCompte provided for a "brake actuating mechanism... actuated by the back pressure of mud laden fluid... for automatically retarding the lowering of additional drill stem into the hole..." LeCompte, at p. 1, c.1, l. 47 – p.1, c. 2, l. 60. This allowed the device to "maintain a predetermined pressure, by weight of a lower section of drill stem on the bit, and no more..." *Id.* at p.2, c.2, ll. 92-106. Thus, LeCompte taught a means to actuate the brake in response to changes in drilling fluid pressure, so that he could maintain optimal weight on the bit for efficient drilling operations.

Dillon similarly controlled the movement of the drill string in response to changes in drilling fluid pressure, but actually went further, and taught a means "to provide for controlling the movement of the drill stem as a function of tension in the drill-stem-supporting hook [bit weight], the load on the drilling motor [torque], the speed of the drilling motor [RPM], and the pressure of the fluid pumped by the mud pump [drilling fluid pressure], or any one, or any combination of these factors." Dillon at p.1, c. 1, l. 54 – c. 2, l. 5 (emphasis added). Dillon then claimed: "An automatic well drilling apparatus... means for suspending a portion of the weight of the drill stem to decrease or increase the feeding pressure upon the bit... control means sensitive to the torque in the drill stem, which means controls the operation of the suspending

means to regulate the feeding pressure upon the bit... pressure responsive means responsive to the pressure in the pump and weight responsive means both operable with said control means..." *Id.*, Claim 18 (emphasis added). Dillon therefore taught a means to measure and control the movement of the drill string using drilling fluid pressure, bit weight, torque and RPM or any combination of these drilling parameters.

Varney also discloses a way to measure and monitor pressure and regulate the release of the drill string in response to changes in drilling fluid pressure beyond certain limits.

The further developments that predicted the '142 Patent came in the next wave of inventions, following three different tracks: immediate and proportionate control using pneumatic regulators and relays (Bowden '359), electronics, and ultimately computers.

ii. *Continuous and Multivariate Control*

By 1962, Mr. J.E. Bowden, the father of Bobbie Bowden, had developed a pneumatic control system that was more precise, immediate and proportionate than the 1930's era technologies. This system was commercialized under the name "Satellite", and patented in the Bowden '359 Patent. The Satellite system used a pneumatic "regulator" and relay arrangement to ultimately control the rate of release of the drill string in response to changes in bit weight. As is described in detail above, the '142 Patent copies and replicates the sensing and control scheme of the Satellite system described in the Bowden '359 Patent.

Bowden '359 provides control of a single output variable based on a single input variable. Drill string tension is measured to evaluate bit weight, converted to a pressure signal, and the feed of the drill string is controlled in relation to the pressure signal representing bit weight.

Others in the field continued to develop systems that controlled drill string release based on drilling fluid pressure and other input variables, and based on combinations of input variables. Besides LeCompte and Dillon, already discussed, Varney patented in 1965 a system that regulated drill string release based on drilling fluid pressure. *See* LeCompte at p. 4, c. 2, l. 123 – p. 6, c. 1, l. 65 (illustrating brake actuating mechanism controlled in response to changes in drilling fluid pressure); Dillon at p. 4, c. 1, ll. 14-32 (illustrating multiple control parameter

automatic drilling system utilizing pressure); Varney at c. 9, l. 39 – c. 10, l. 35 (illustrating automatic drilling control based on drilling fluid pressure).

In 1967, Hobhouse patented a system that controlled drill string release based on drilling fluid pressure. Moreover, Hobhouse, like Dillon, measured and controlled based on multiple input parameters: weight on bit (W.O.B.), fluid pressure, and torque. Hobhouse taught a more sophisticated and advanced means than Dillon, and utilized a mud motor and system "to regulate the sinkage of the drill stem and thus the weight applied to the bit..." Hobhouse, at c. 8, ll. 34-35.

By 1969, computerized control of the drilling process was under development. F.S. Young, Jr. published *Computerized Drilling Control* where he explained his computerized automatic drilling system and draw works brake actuator system which continuously and proportionately increased or decreased the rate of release of the drill string in order to maintain a set weight on bit while drilling or a constant amount of rotary torque. Although Young controlled using only weight on bit and/or torque, he included the following *express suggestion*: "The goal of Humble's computerized rig control project is the automation of drilling operations to the fullest extent economically possible. Experience has shown the benefit of improved supervisory control. Logical extensions of the program, then, are to hydraulics, drilling fluid, and pressure sensing and control. Efforts in these areas are under way." Young, at p. 493 (emphasis added).

In 1984, Ball patented a "drill string control system which gives a substantially instantaneous and positive control of bit weight by a positive control of the brake controlling the feed out of drill line from the drum on the draw works [*sic*]." Ball, c. 2, ll. 21-27. Ball taught an electronic system where an increase in bit weight increased the braking force, thereby decreasing the rate of release of the drill string; correspondingly, a decrease in bit weight decreased the braking force, thereby increasing the rate of release of the drill string. *Id.*, at c. 10, ll. 49-60.

In 1989, Tommy Warren and Warren Winters patented a computerized system for directional drilling. The system measured several parameters during drilling, and values for the parameters were transmitted to the computer. Limits for those parameters were input into the computer's memory. If the transmitted values fell outside the desired limits, "necessary

adjustments" were "calculated and then made to weight-on-bit (WOB), RPM, and/or drillstring azimuthal orientation to bring the transmitted values within the desired limits." Abstract. One of skill in the art will recognize that making adjustments to weight-on-bit is inherently regulating the rate of drill string release. The measured parameters could include drill bit torque and downhole pressure, which were both indications of drilling fluid pressure. Thus, Warren and Winters regulated drill string release based on drilling fluid pressure, as well as other parameters and combinations of parameters.

Finally, in 1990, J. Ford Brett and Tommy Warren published *Field Experiences with Computer-Controlled Drilling* which detailed the development of a computer-controlled, continuous and proportionate automatic drilling system that used weight on bit, pressure, torque, and RPM to control the advancement of the drill string in order to maintain an optimum rate of penetration of the strata being drilled and optimum bit RPM. The Brett/Warren publication taught an automatic drilling system that employed combination of drilling parameters as limits. Although it generally only employed one feedback parameter at a time for continuous and proportionate control, the article disclosed algorithms that suggested simultaneous multiple variable control.

The technology Brett and Warren developed and described contained a drilling fluid pressure sensor, which measured drilling fluid pressure and fed that measurement to a feedback control unit, which calculated the difference (change) between the pressure measurement and the desired pressure set by the operator, and generated a signal corresponding to that change. That signal would then be sent (relayed) to a servocontroller that caused a hydraulic motor to either push down the drill string faster (increase the rate of release) or slower (decrease the rate of release) depending on whether the drilling fluid pressure decreased or increased. The device did so continuously and proportionately. Although the term "rate of release" is not used in the Brett/Warren disclosure, the concept of accelerating or decelerating the string's advancement down the hole is clearly expressed.

This line of references also expressly taught or suggested control based on the variables discussed in the '142 Patent. Besides LeCompte, Varney, Dillon, and Hobhouse, Young and Brett/Warren also taught or suggested control based on drilling fluid pressure. See

Young at p. 493 (suggesting "Logical extensions of the program, then, are to hydraulics, drilling fluid, and pressure sensing and control."); and Brett/Warren at p. 201, 207 (listing "PUMP PRESSURE" as a direct control parameter).

Using torque as a control parameter was also well known in the prior art. *See* Dillon at p. 2, c. 2, l. 76 – p. 3, c. 1, l. 46 (explaining torque monitoring and control); Young at pp. 485-490 (explaining torque control) and Fig. 2 (illustrating ROTARY TORQUE as a control input); Hobhouse at c. 2, ll. 37-41; c. 5, ll. 52-57 (disclosing "Torque Control"); and Brett/Warren at p. 201, 207 (listing "ROTARY TORQUE" as a direct control parameter).

Finally, using RPM as a control parameter also was well known in the prior art. *See* Dillon '889 at p. 3, c. 1, ll. 47-67 (explaining RPM monitoring and control); Young at pp. 485-490 (explaining rotary speed control) and Fig. 2 (illustrating ROTARY SPEED as a control input); Brett/Warren at p. 201, 207 (listing "TURBINE TACH." as a direct control parameter).