United States Patent

Hubby

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[54] METHODS FOR CONTROLLING PUMPING WELLS

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Related U.S. Application Data

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[52] **U.S. Cl.**.....**73/155**, 166/314

[51] **Int. Cl.**.....**E21b 47/00**

[58] **Field of Search**.....73/155; 166/314; 346/33 W

[56] **References Cited**

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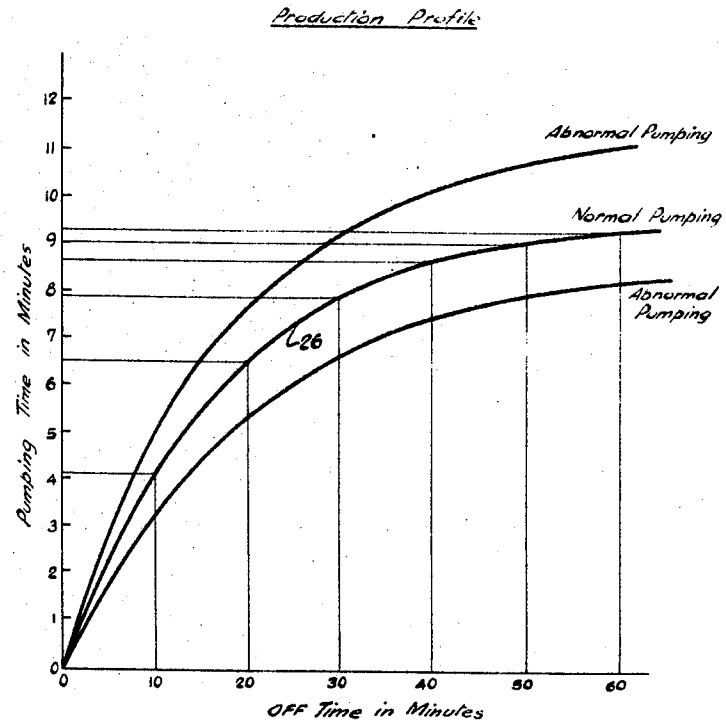
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[57] **ABSTRACT**

A method and system for pumping-well control including determination of a production profile for the well. The profile consists of a function that defines the normal producing conditions when the well fluid is pumped out of the well at a greater rate than it is produced therein. Optimum producing conditions may then be determined and set. In addition, the magnitude of the load on the pump motor is monitored and fed out for remote indication and/or control.

6 Claims, 7 Drawing Figures



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SHEET 1 OF 6

Fig. 1.

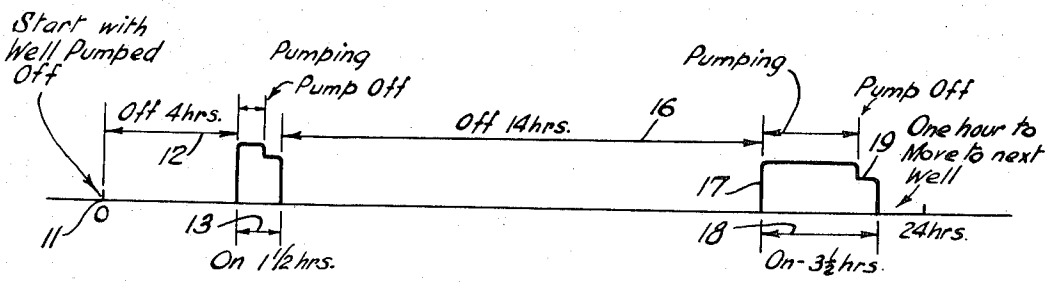


Fig. 2.

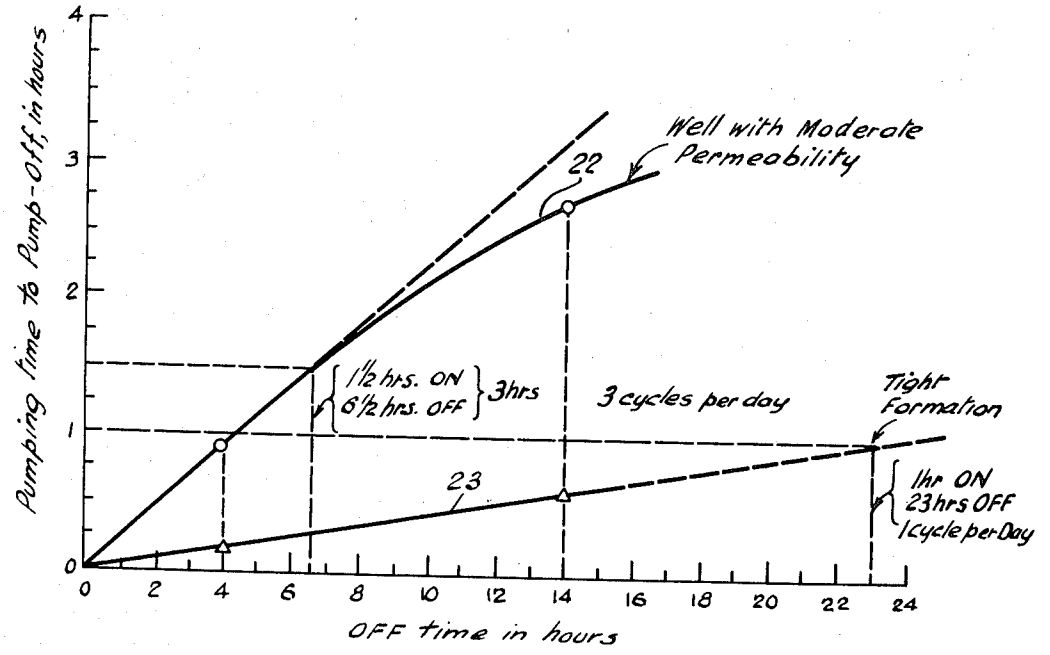


Fig. 3.

Production Profile

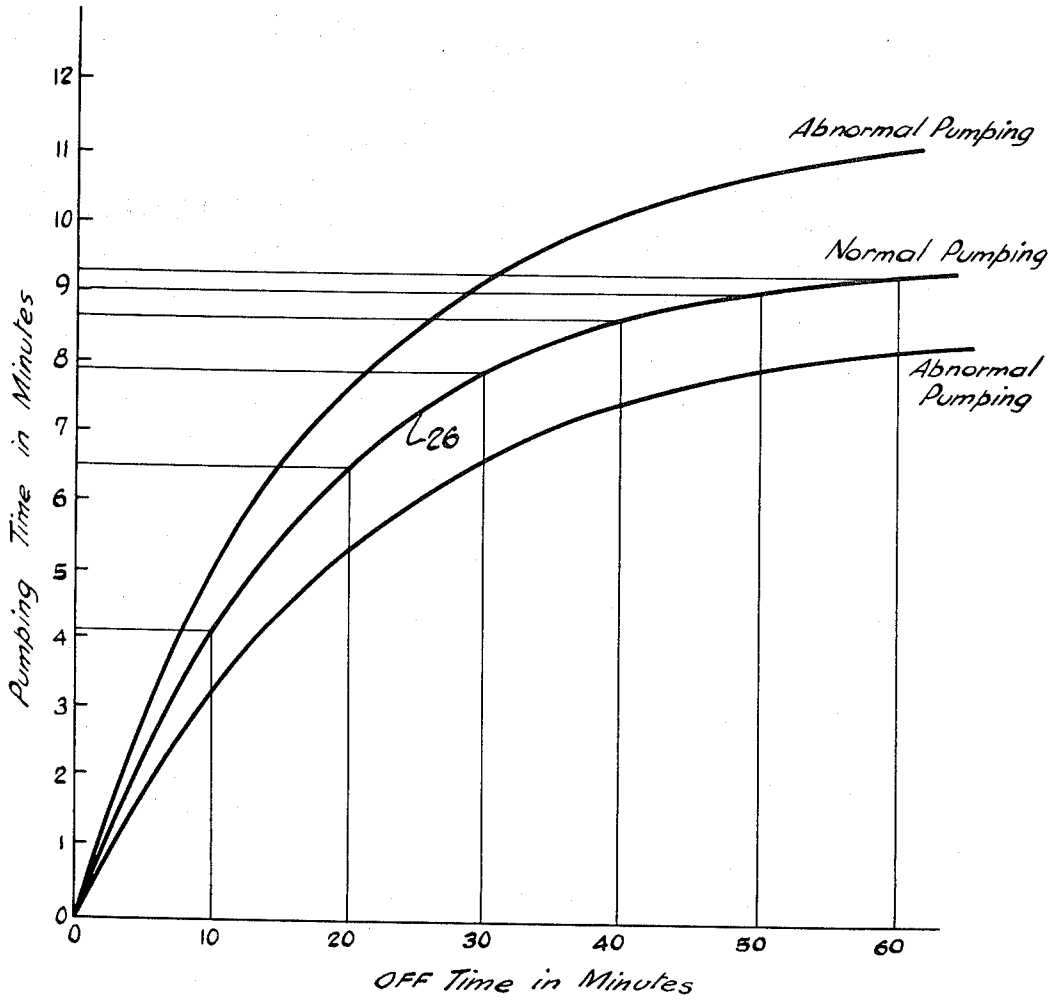
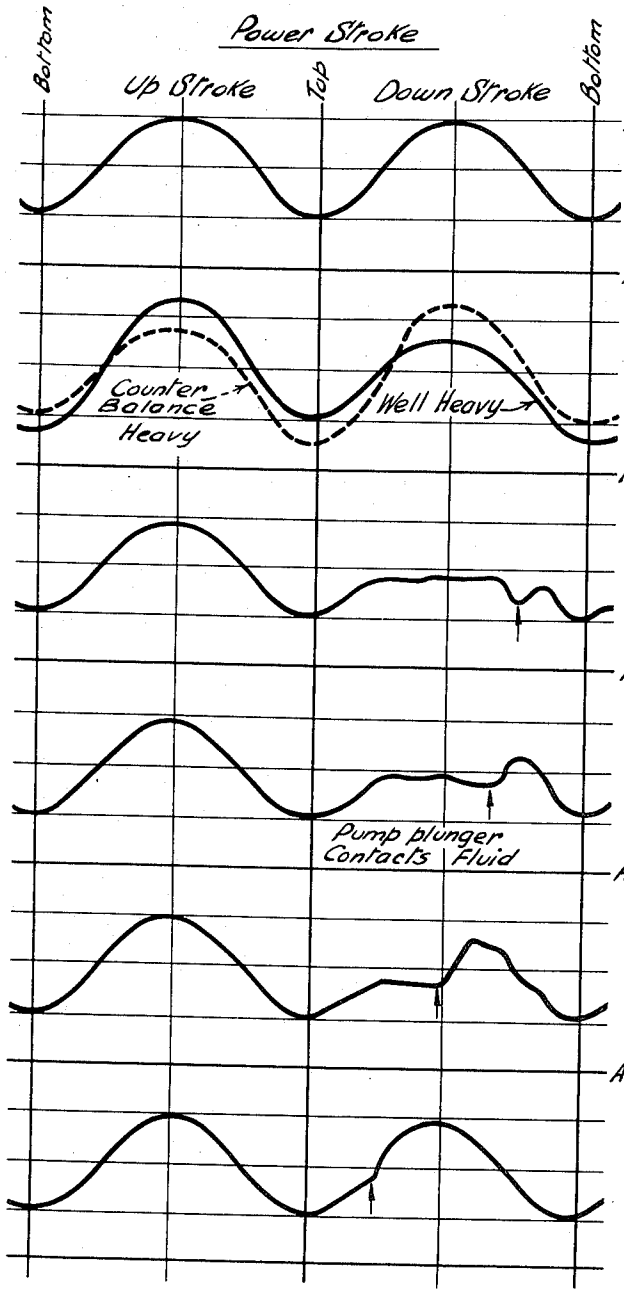


Fig. 4a.



Analysis

A.1. Well balanced & pumping normally, full barrel of Fluid each stroke.

A.2. Full fluid. Improper balance. Slow change to "well heavy" — paraffin build-up on rods or increased water production Fast change to "CB Heavy," — Tubing Leak, Gas in Tubing.

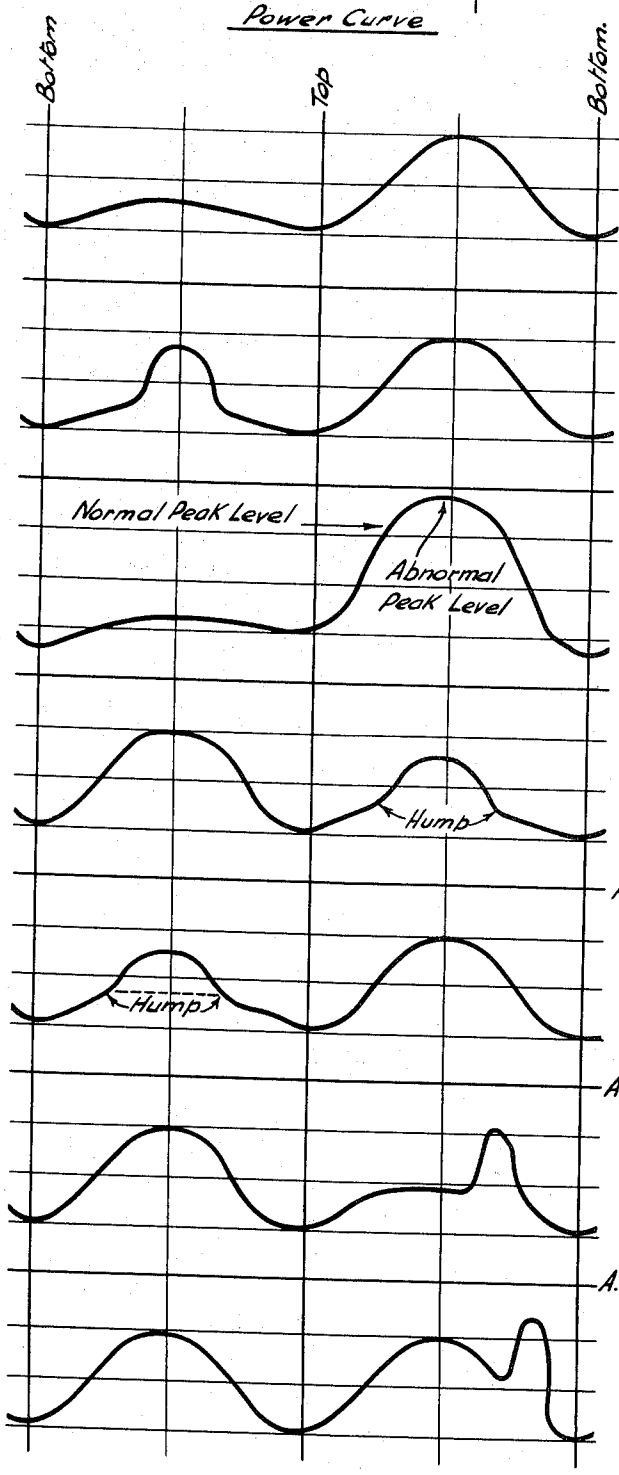
A.3. Balanced but not making any fluid. If pumped off, will return to normal after off time. If pump trouble, will not return to normal; indicates badly leaking standing valve, or Gas leak.

A.4. Balanced but pump barrel 1/4-full of fluid each stroke.

A.5. Balanced but making only 1/2 of pump volume each stroke.

A.6. Balanced but making only 3/4 of pump displacement each stroke.

Fig. 4b.



Analysis

A.7. Balanced. Well flowing. Flow rate exceeds pump displacement Gassy fluid in tubing. Balanced while pump off. If well does not have ability to flow, indicates badly leaking travelling valve or piston or rods broken near pump, tubing tubing leaking near pump.

A.8 Balanced. Well flowing. Flow rate less than pump displacement, Note similarity to A.11. If well does not have possibility of flowing, use A.11.

A.9. Broken rod string. Break near top.

A.10. Leaking standing valve. As leak gets worse, "hump will be reduced, disappear when leak is so bad that travelling valve does not open.

A.11 Leak travelling valve or piston. Note similarity to A.8. If well has possibility of flowing, stop pump and check for flow.

A.12 Rods hitting bottom after P.O.— Due to overtravel

A.13 Rods hitting bottom during pumping

FIG. 5.

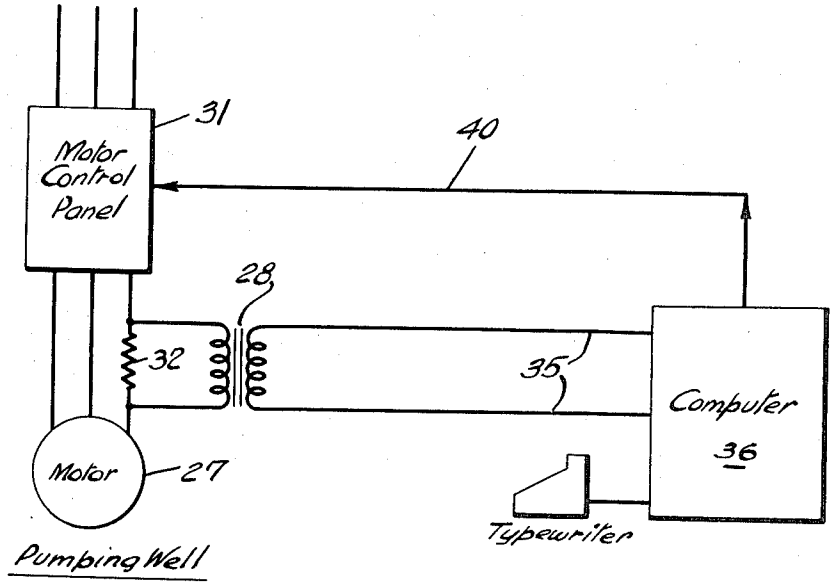
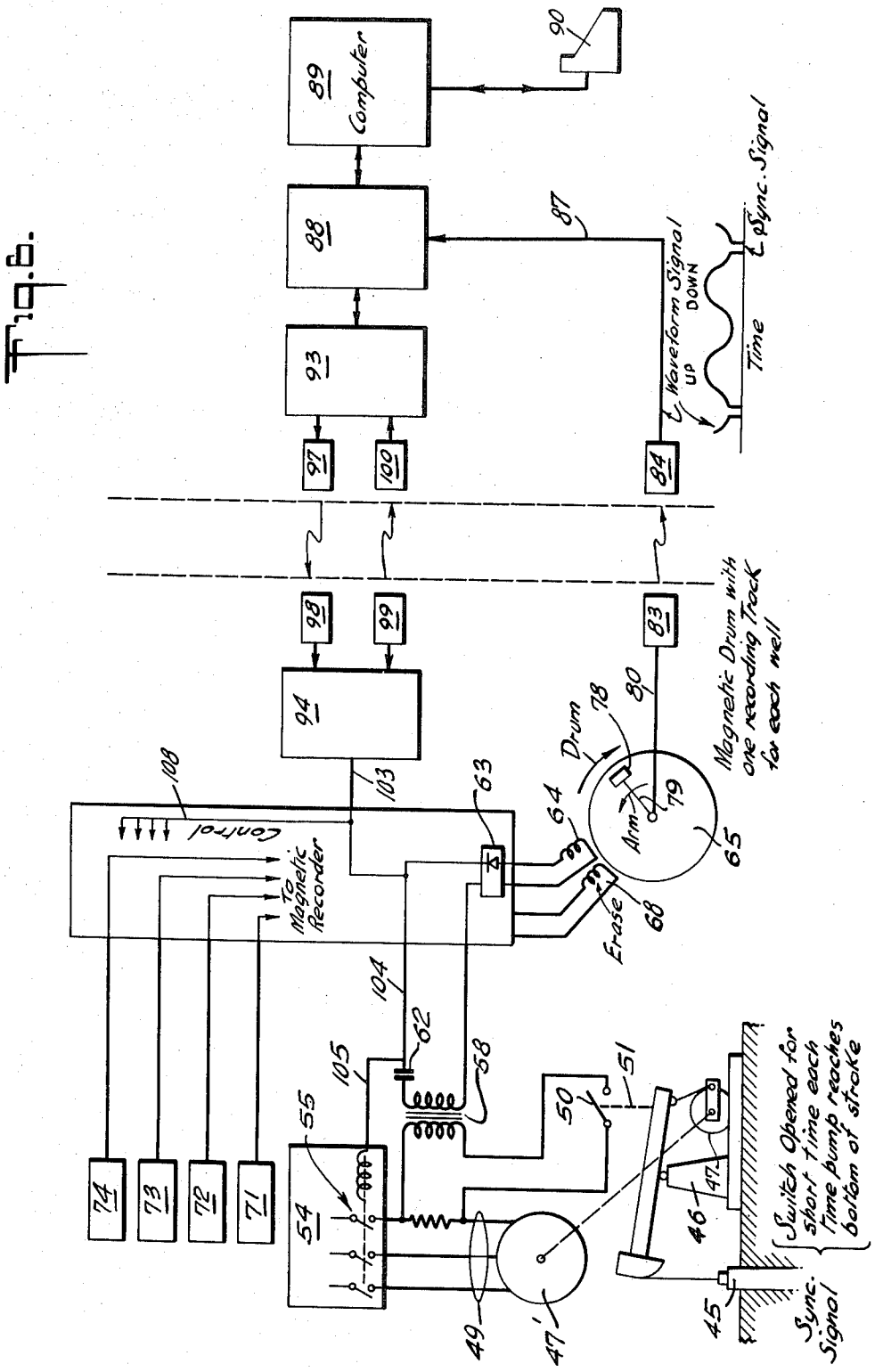

Motor Control Panel
31
40
28
32
35
Computer
36
Motor
27
Typewriter
Pumping Well

Fig. 6.


89 Computer
90
88
87
93
97
100
84
Waveform Signal
UP
DOWN
Time
Sync. Signal
98
99
83
94
Magnetic Drum with one recording Track for each well
Drum
78
80
108
103
63
64
Arm
79
65
Control
To Magnetic Recorder
Erase
68
104
62
58
105
55
51
50
74
73
72
71
54
46
47
49
47'
45
Sync. Signal
Switch Opened for short time each time pump reaches bottom of stroke

METHODS FOR CONTROLLING PUMPING WELLS

CROSS-REFERENCE TO RELATED APPLICATIONS

This is a division of application Ser. No. 692,877, filed Dec. 22, 1967 now U.S. Pat. No. 3,610,779.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention concerns oil well production control systems in general. More specifically, it relates to a method and system that is applicable to pumping wells wherein such wells are being pumped at a greater rate than the rate of fluid production therein.

2. Description of the Prior Art

Heretofore, in oil fields where conditions are such that the fluid must be pumped to recover it from the well or wells, the pumping has been carried out by a motor driven beam type of counter-weighted pump. The pump would be operated intermittently since the fluid production rate in the well would be less than the rate of pumping of the fluid from the well. This was very inefficient because it was difficult to determine when a given well had been pumped out. Thus, the pump was either stopped too soon, so that production was lost, or it continued to pump with substantially no production resulting therefrom, so that the cost of pumping action was wasted.

SUMMARY OF THE INVENTION

Briefly, the invention relates to a method that is applicable to an oil field that is being produced by pumping. It concerns the method of determining the production profile for a particular well. It comprises the steps of pumping said well at a rate that is greater than the rate of producing fluid therein, and of detecting when said well pumps-off a first time. It also comprises the steps of stopping said pumping for a first predetermined relatively short time period from said first pump-off, of again pumping said well at said pumping rate, and of detecting when said well pumps-off a second time. Further, it comprises the steps of stopping said pumping for a second predetermined relatively long time period after said second pump-off, and of again pumping said well at said pumping rate until pump-off occurs a third time. Finally, it comprises the steps of measuring the pumping time intervals that follow said predetermined short and long time periods, and of determining a production profile for said well.

The invention also relates to another method for controlling a well that is being produced by pumping at a rate that is greater than the rate of producing fluid therein. Furthermore, the pumping is automatically stopped whenever pump-off occurs and said pumping is re-commenced after a predetermined period of time beginning with said pump-off. The method comprises the steps of determining a normal production profile for said well, of detecting whether said well is pumping or off, and of measuring the periods of time when said well is pumping and when said well is off. It also comprises the steps of comparing the measured pumping-time off-time periods with said normal production profile, and of causing an alarm signal for said well whenever said measured pumping-time off-time periods differ from said normal production profile by more than a predetermined percentage thereof.

Again briefly, the invention relates to a system for controlling a pumping well having a reciprocating pump driven by a motor. The system comprises in combination means associated with said well for providing a wave-form signal proportional to the load on the motor driving said pump. And it comprises computer means for receiving said wave-form signal and for providing an output to control said motor.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects and benefits of the invention will be more fully set forth below in connection with the best mode or modes contemplated by the inventor for carrying out the invention, and in connection with which there are illustrations provided in the drawings, wherein:

FIG. **1** is a diagram indicating graphically the steps that are involved in one method according to this invention;

FIG. **2** is a graphic illustration in the form of curves showing two typical production profiles of different pumping wells;

FIG. **3** is another graphic illustration showing a normal production profile curve and also curves both above and below normal which would each be caused by different factors during the life of a pumping well;

FIG. **4** illustrates a family of power curves for a given well that indicate a normal and various abnormal pumping cycles, with captions explaining possible diagnoses;

FIG. **5** is a schematic diagram illustrating a system for controlling a pumping well according to the invention; and

FIG. **6** is a schematic diagram illustrating a system for controlling a plurality of pumping wells in accordance with the invention and including a special element for recording and obtaining time compression at the output.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In connection with pumping wells in general and particularly such wells that are being pumped at a rate which is greater than the rate of production of fluid in the well, it has been discovered that by carrying out a method according to this invention a production characteristic for a given well may be determined. That characteristic is termed herein a production profile. Such a method is illustrated in FIG. **1** of the drawings, and the pumping control arrangements used may be like those disclosed in my copending applications Ser. Nos. 516,949, filed Dec. 28, 1965 now U.S. Pat. No. 3,440,512 and 496,406 filed Oct. 15, 1965, now Pat. No. 3,413,535. As will be evident from the description that follows herein the method could be carried out manually if desired and the pump motor could be an internal combustion engine. The steps of the method are as follows:

Having pumped the well until pump off of the fluid has occurred, a time period is commenced. This is indicated by a zero index mark **11**, on FIG. **1**. Then, the pumping is stopped for a predetermined relatively short period of time, e.g., a period represented by a distance

12 along the horizontal axis of the FIG. 1 graph to the right of the zero index 11. This time is indicated by the caption of FIG. 1 as being four hours.

Next, the pump is started and the well is pumped for a given period (such as a time period 13 illustrated in FIG. 1) that is long enough to allow the well to pump-off following the measured off period 12. Then, the well is again shut off, i.e., the pumping is stopped. This time it is stopped for a period which is relatively long, e.g., 14 hours off (as indicated by an arrow 16 on the FIG. 1 graph). Then the well is once more pumped as indicated by a curve 17. The leading edge of 17 marks the beginning of an on period represented by the distance. Again, this time period will be long enough to allow the well to pump-off. The pumped-off condition is indicated by a step portion 19 on the curve 17.

It will be appreciated that the length of time during which the well is pumped following each off period, will vary for different wells. It will depend upon the producing conditions of a given well. Consequently, the information gained by carrying out the foregoing steps will give information that provides a basis for determining a so-called production profile for the well.

Such a production profile may be illustrated for a given well (see FIG. 2) by a curve 22 that has the "-pumping time to pump off" shown as the units measured parallel to the ordinate, and the "off time" shown as the units measured parallel to the abscissa, both as the coordinates the curve. Thus, the curve 22 illustrates the relationship between these two measured or predetermined times, and this illustrates the production profile of a given well.

It will be noted that the production profile curve 22 is for a well that has moderate permeability. There is another curve 23 illustrated that is a straight line. It illustrates the production profile for a different well that has a tight formation.

The information gained by making a determination of the production profile of any well (in accordance with the foregoing method or otherwise) may be advantageously employed in various ways. One way involves another method that may be employed, namely to set the time periods of a pumping cycle that are optimum for a given well, as related to a predetermined production period or schedule. The steps of such a method involve making use of a production profile for a given well and thereafter determining a desired pumping-time to off-time cycle for such well.

In order to accomplish the foregoing optimum pumping cycle (pumping-time to off-time), the curve of the production profile for a given well should be drawn, e.g., the curve 22 of FIG. 2. This would be done from information obtained on the characteristics of the well, such as by carrying out the method described above. Then a pumping time would be selected that falls on the linear part of the curve, while the off-time that corresponds to that pumping time would then be noted on the other coordinate axis. Next, a point (not shown) on the production profile curve would be chosen (along the linear portion of the curve) so as to provide a sum of the pumping-time and off-time periods that equals a sub-multiple of some predetermined production time, such as 24 hours. Finally, a timer for controlling the starting of the pumping motor for the well would be set so that the time periods allowed for pumping would be slightly more than the pumping times as determined from the production profile curve. Consequently, the well would pump off before the end of each pumping period. Once the equipment has been set for such pumping-time off-time periods, the pumping of that well should insure maximum production in the absence of any pump trouble. Similarly, it should increase efficiency by reducing electric power costs and pump maintenance costs. It may also be found that production is increased in some cases.

It will be appreciated that the methods and system, or systems, according to this invention relate to a pumping oil well, or a plurality of such wells, where the well has limited production and where the pumping is at a rate greater than the rate of production. Under such conditions, the pump regularly pumps out all of the oil from the well. If a pump-off controller is employed, the pump will be stopped automatically. Then the oil will continue to flow from the formation into the well bore where it will accumulate. The rate of accumulation of the oil is dependent upon a number of factors which are fairly constant and these include the characteristics of the formation, the pressure in the well bore and the height of the column of fluid in the well bore above the level of the producing zone. The rate of withdrawal from the well bore depends on the size and mechanical efficiency of the pump used and it speed of operation. These latter factors are also relatively constant. Therefore, by measuring the time periods for pumping-time and off-time in accordance with the first method described above, the production profile for a given well may be determined.

Such a production profile curve 26 is illustrated in FIG. 3. As already explained, this provides a showing from which may be made a determination of the length of time that should be required to pump out all of the accumulated fluid for any given length of off-time for the well. However, if it should be found that the actual time required for thus pumping out the oil is different from the time to be expected (as determined from the normal production profile curve 26) there is an indication that some change has taken place in the production pattern of the well and consequently the matter may be investigated in order to determine what the change has been.

Thus, another method according to this invention relates to controlling a well that is being produced by pumping at a rate that is greater than the rate of producing fluid therein. Furthermore, the pumping is automatically stopped whenever pump-off occurs and is re-commenced after a predetermined period of time beginning with the said pump off.

A first step of such latter method is that of determining a normal production profile for the well. This may be accomplished by carrying out steps according to the foregoing description for the first method. It will result in information which may be plotted to illustrate the production profile, e.g., the normal production profile curve 26 of FIG. 3.

After the normal production profile has been determined, another step of this method is that of detecting whether the well is pumping or not. With reference to FIG. 5, it will be appreciated that this step may be easily accomplished by merely determining whether there is power being drawn by a motor 27 or not. A

somewhat more detailed showing of control circuit with electrical elements to do this is disclosed in each of the copending applications mentioned above. One element would be a transformer **28** that transmits an electrical signal when the motor **27** is energized.

It will be appreciated that the pumping or pump-off conditions, i.e., whether or not the well is pumping, may also be determined manually. For example, there could be visual observation of the pump. Or, it could be accomplished in various other ways, such as by having a mechanical signal indicator associated with the motor driving the pump. The latter is particularly applicable to a situation where the motor is a gasoline or other non-electrical type engine.

A next step in this method is the measuring of the periods of time when the well is pumping. This can be easily accomplished in connection with the foregoing determination of the presence or absence of an electrical signal from transformer **28** in FIG. **5**. The time duration of the presence of the signal will determine the pumping time for the well. Clearly, such time could also be determined by manual means such as observing and timing the pumping period each time.

Another step in this method is the comparing of the measured pumping-time and off-time periods with a normal production profile. This means that the measured time periods would be compared with those that would be had from the normal times as determined from the production profile for the well. For example, with reference to FIG. **3**, after a given off-time of 30 minutes, the pumping-time should be almost eight minutes, as determined from the curve **26** of the profile illustrated. If the measured pumping-time were more or less than that, it would indicate abnormal pumping conditions. The same comparison might also be accomplished by having a normal profile stored in a computer and then, of course, feeding in the measured times (as indicated in FIG. **5**) for making the comparison with the normal profile data in accordance with known techniques of computer operation.

Finally, the method includes a step of creating or causing an alarm signal for the well whenever the measured pumping-time off-time relationship is different from that expected (as determined from the normal production profile) by more than a predetermined percentage of the normal. After an alarm signal has been provided, some steps may be taken (as desired) to investigate and determine the cause of abnormal operation of the well. Thus corrective steps may then be taken promptly where needed.

It is pointed out that one manner or analyzing the cause of abnormal operations is to have a record made of the electric power that is being used by the pumping motor. Such a record would show conditions throughout each pumping cycle and such conditions are a direct indication of different situations which may occur with respect to the pumping operation. A pumping cycle of the type being now considered is that for a beam type reciprocating pump where the cycle includes a complete up stroke and down stroke of the pump. Thus, the power curve has a rise from minimum to maximum and back, for each of these strokes and if the apparatus is properly balanced these two parts of the whole cycle are substantially similar and equal. Such pumping cycle is fully described in my U.S. Pat. No. 3,413,535 **mentioned above.**

In FIG. **4** there is illustrated a plurality of such electric power curves each showing one typical pumping cycle for a pumping well. It will be observed that these curves are designated A—**1** through A–**1** and opposite each curve there is a caption indicating the conditions which may cause the shape of the curve that is there illustrated. The curves A–**2** through A–**6** show commonly encountered conditions of unbalance and pump-off. These figures illustrate an important point which is not always recognized, i.e., a well that is in the pumped off condition cannot be balanced by adjusting the weights so that the peaks are of equal amplitude. The first prerequisite for balancing is that the well be making enough fluid so that the pump suction is flooded and the pump takes in a full barrel of fluid each stroke. This fact can be readily determined from the shape of the power curve and the balancing procedure is thereby simplified.

It will be appreciated that power curves of the type illustrated in FIG. **4** may be entered in a computer for purposes of comparison with curves as taken from a pumping well. Thus, an analysis and determination might be made when (within predetermined limits) correspondence with a particular typical curve is found. In this manner, rapid and automatic determination of the analysis of troubles encountered may be accomplished upon proper manipulation of the data as it is determined from a pumping well and fed to a computer for analysis and/or control.

With reference to FIG. **5**, it is to be noted that it is a schematic circuit and block diagram showing a system according to the invention. The motor **27** is driving a pumping well under conditions previously described in connection with the foregoing methods. It is under control of a panel **31** that may include equipment such as that illustrated in either of my patents mentioned above. Consequently the motor **27** may be shutdown upon desired conditions being met.

The transformer **28** is connected with an input thereof across a resistor **32**, and the output signal (via transformer **28**) will be generally in the form of a power curve, e.g., in accordance with the power curves illustrated in FIG. **4**. Such power curve signal is transmitted over the circuit including a pair of wires **35** to a computer **36** which may have associated therewith a typewriter **37** for reading out from, or having input data inserted into, the computer.

The computer has an output connection that is schematically indicated by a line **40** that leads to the motor control panel **31**. This carries the necessary control signals for energizing and/or shutting down the motor **27** by means of its control panel **31**.

It will be clear to anyone skilled in the art that the foregoing system (illustrated in FIG. **5**) provides a means whereby the pumping motor **27**, and, of course, the well being pumped thereby, may be monitored continuously and automatically. Therefore, the well may be subject to a continuous determination as to data concerning the status of the well and also, as desired, it may have control actions based thereon, e.g. for shutting down the motor or for starting same once more.

Furthermore, it will be appreciated that the signal being transmitted via the transformer **28** to the computer **36** provides information in that the wave form plus the existence or non-existence of the signal itself

may both be used in the computer. The latter information, along with the time periods during which the existence or non-existence of the power wave form was determined, provides the necessary data for determining a production profile for the well in question. At the same time, the data may be used in the computer for comparing such profile with a normal profile for the same well, by having a normal profile programmed into the computer beforehand. In this manner, deviations from a normal well profile will provide a signal that can be used as desired, for a mere alarm or for both an alarm signal and a control signal to shut down the well.

Referring now to FIG. 6, it is pointed out that a system according to this invention may be applied to a plurality of pumping wells. A group of wells may thus be controlled continuously and automatically. Furthermore, they may have the production profiles recorded and surveyed, and also the pumping conditions monitored. The latter is done so that any mechanical or other difficulties may be determined at once and corrective actions taken.

One feature of a plural well system of this sort is the provision of a recording means, with a high speed scanning feature. This acts so that the power curves for the individual wells may be recorded continuously in real time and then scanned at high speed. This accomplished in effect a compression of the time element, whereby a substantial number of wells may be continuously monitored and controlled with the ability to carry out a number of different functions. This is done without in any way interrupting or causing delays in the continuous monitoring and controlling of all of the wells in a field.

FIG. 6 illustrates schematically a well **45** that is being pumped by a beam-type pump **46** which in turn is driven by an electrical motor **47**. In order to provide a synchronizing signal for the beginning of each pumping power cycle there is a switch **50** that is mechanically actuated. It is linked to the pump mechanism, as schematically indicated by a dashed line **51**.

The electrical circuit for controlling the motor **47** is shown by a diagram wherein the motor **47'** is connected via a three-wire circuit **49**, as illustrated, which leads from a control panel **54**. Controls in the panel include a solenoid actuated switch **55** which acts to connect or disconnect the source of electrical power to the motor **47'**.

The signal (that represents the power curve for the motor) is transmitted via the circuit that connects the input of a transformer **58** across a resistor **59**, which resistor is located in one of the leads **49** to the motor **47'**.

The power curve signal is an AC signal modulated by the power that the motor **47** draws. Consequently, the envelope which is the power curve is transmitted via the transformer **58**. It then proceeds over a circuit that includes a capacitor **62** for blocking DC signals and via a rectifier **63** to a coil **64**. The rectifier **63** acts to demodulate the AC signal in order to provide pulsating DC to the coil **64** that is mounted on a recording head (not shown). The recording head and coil are associated with a magnetic recording drum **65**. It will be observed that there is an erase coil **68** that is associated with an erase head (not shown) which is located adjacent to but behind, or in front of (depending upon which way you wish to consider it) the coil **64**. The erase coil **68** acts so that the record which has been laid down by signals in the coil **64**, will be erased after one substantially complete revolution of the drum **65**.

It is to be noted that there will be provided a duplication of substantially all of the just described elements, which relate to the well **45**. Such duplication is applied to each of the other of a plurality of wells which are indicated by the blocks **71–74**. These additional wells are merely schematically indicated. Each one of the blocks indicates a separate pumping well with equipment to feed its power curve to an individual coil (not shown) like the coil **64** for well **45**. It will be readily understood by anyone skilled in the art that the foregoing duplication of elements for the additional wells is a matter of mere routine. The individual coils and recording heads are located spaced axially along the surface of the drum **65** is order that each well will have a recording track of its own.

With respect to the magnetic drum **65** and as to its operation (relative to a given one of the pumping wells), it will be noted that the drum is rotated in the direction indicated by the arrow marked "Drum" on the outside thereof. This rotation is at a relatively slow speed, e.g., 1 revolution per minute. Consequently, for typical pumping wells there will be about 10 or 15 pump strokes recorded during a revolution of the drum **65**. A pick-up head **78** is rotated on the end of an arm **79** in the direction indicated by the arrow marked "Arm." It will be observed that this is opposite to that for the drum **65**. The arm **79** is rotated at a high speed, e.g., 3,600 revolutions per minute. The result is that the power curve wave forms that have been recorded on the drum **65** during a revolution that had ended at the beginning of a given revolution of the arm **79**, will be fed out in "compressed time" form since the revolution of the arm only takes a little less than 0.02 seconds.

The foregoing compressed time signals are, of course, picked up by the pick-up head **78**. They are fed over the circuit indicated by a line **80** to any transmission arrangement as appropriate for given circumstances, e.g., that indicated by blocks **83** and **84**. Such transmission might include radio or telephone lines or the like, as schematically indicated by the crooked arrow.

Considering now, for the purposes of this explanation, a group or series of compressed time wave form signals as picked up during revolution of the pick-up head **78** and arm **79**, there will be about 10 or 15 pumping cycle wave forms like that illustrated (with captions — under a circuit line **87**), all within the fraction of a second indicated above. These wave form signals will be carried over the circuit indicated by line **87** to some "interface" equipment. Such equipment is schematically indicated by a block **88**. It is here that the necessary equipment and circuits will be provided so that the signals will be handled to and from a computer **89**. The computer **89** will of course have usual provisions for indication and control such as an input-output typewriter **90** that is schematically indicated.

It will be understood by anyone skilled in the art that an equivalent arrangement might be employed to accomplish the time compression of the pumping wave form signals for the wells involved. However, in any case a major benefit of the compression is the ability to scan the whole group of wells continuously within a

very short time for each scan so that instantaneous corrective or control action can be taken for any one of the wells at any time.

It will be appreciated from the foregoing description that the compressed time arrangement employed in this embodiment involves having the data from all of the wells simultaneously recorded in real time on the drum **65**. These are on separate tracks on the drum and consequently there are separate pick-up heads carried by the arm **79**. The individual well wave form signals are taken off in sequence so that all of the tracks on the drum will be scanned one after another from one end of the drum to the other in a continuous manner. Depending upon the number of wells being connected to a given drum, it would be expected that each well could be monitored a number of times for every pumping cycle thereof. Therefore, the effective monitoring of the pumping conditions for each well is substantially continuous, and deviations may be rapidly determined with corrective action taken substantially at once.

It will be appreciated that the control signals feeding out from the computer **89** will return via the interface equipment (block **88**) to some central supervisory equipment that is represented by a block **93**. Such supervisory equipment has two-way communication with local supervisory equipment that is represented by a block **94**. Communication between these supervisory blocks **93** and **94** is carried out via the indicated blocks **97, 98, 99,** and **100** that correspond to previously mentioned blocks **83** and **84**. Thus, there are circuits for acting to transmit the signals involved over the distance that separates the computer installation from the local area equipment associated with the wells that are involved.

The output signals from the local supervisory element **94** are DC in nature. These are fed over a circuit to control the solenoid switch **55**, and that circuit is indicated in the diagram by lines **103, 104** and **105**. That circuit supplies the energization for the solenoid switch **55**. Of course, there will be a similar circuit for each of the additional wells, as is indicated by a line **108** that is connected to the line **103**.

It will be appreciated by anyone skilled in the art that the arrangement of equipment for carrying out the details of the signal handling will be in accordance with standard practice. This may involve various different particular types of equipment, as feasible and in accordance with good practice. Thus, various arrangements could be provided and no specific showing is made for the above described arrangement, e.g. that for switching sequentially after each revolution of the magnetic pick-up arm **79** from one track to the next on the drum. And of course, after the last track is scanned, in switching back to the first track for continuous repetition.

It will be appreciated also that the computer will be programmed and controlled so that the desired information and control relative to each well may be carried out. This will include a determination of the production profile, since the time periods for pumping or not pumping will be directly determined from the presence or absence of wave from power signals. In addition, during the presence of wave form signals, the continuous review and scanning will permit a comparison of each wave form signal with a library thereof such as those illustrated in FIG. **4**. Then when a determination of some difficulty has been made some action may be taken. As indicated previously, the first indication of abnormality will be that which stems from the variation of a production profile by more than a predetermined percentage relative to a normal profile for that well.

It will be appreciated that the recording and time compression could be employed with a single well if desired. The monitoring and control thus possible would leave a lot of time for other functions if desired.

While preferred embodiments of the invention have been described above in considerable detail in accordance with the applicable statutes, this is not to be taken as in any way limiting the invention but merely as being descriptive thereof.

I claim:

1. In an oil field being produced by pumping, a method of determining the production profile for each well comprising the steps of

pumping said well at a rate that is greater than the rate of producing fluid therein,

detecting when said well pumps-off a first time,

stopping said pumping for a first predetermined relatively short time period from said first pump-off,

again pumping said well at said pumping rate,

detecting when said well pumps-off a second time,

stopping said pumping for a second predetermined relatively long time period after said second pump-off,

again pumping said well at said pumping rate until pump-off occurs a third time,

measuring the pumping time intervals that followed said predetermined short and long time periods, and

determining a production profile for said well.

2. In an oil field being produced by pumping, a method of maintaining optimum production for one of the wells in said field, comprising the steps of determining a production profile for said well in accordance with the steps of claim **1**, and

employing said profile to determine a desired pumping-time off-time cycle.

3. A method according to claim **2** wherein said pumping-time off-time cycle is chosen from said production profile so as to equal a sub-multiple of a predetermined total time period.

4. A method according to claim **3** wherein said total time period is 24 hours.

5. A method for controlling a well that is being produced by pumping at a rate that is greater than the rate of producing fluid therein, wherein said pumping is automatically stopped whenever pump-off occurs and wherein said pumping is recommenced after a predetermined period of time beginning with said pump-off, comprising the steps of

determining a normal production profile for said well in accordance with the steps of claim **1**,

detecting whether said well is pumping or off,

measuring the periods of time when said well is pumping and when said well is off, and

comparing the measured pumping-time off-time periods with said normal production profile.

6. A method according to claim **5** further comprising a step of

causing an alarm signal for said well whenever said measured pumping-time off-time periods differ from said normal production profile by more than a predetermined percentage thereof.

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