HORIZONTAL-SPINNER, A NEW PRODUCTION LOGGING TECHNIQUE

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INTRODUCTION

The oilfield adage that "you cannot hurt a good gas well or help a bad gas well" is not necessarily true. The new Horizontal-Spinner coupled with vast interpretation experience of temperature logs has revealed a number of completion problems that can be overcome.

The gas source is not always where the perforations are placed and many perforations are not opened when treated. In deep gas wells the present formation logging tools do not properly identify the productive zones; and the present perforating and treating techniques do not create access to all the zones to be tested.

HORIZONTAL-SPINNER DESCRIPTION

The Horizontal-Spinner is designed to operate when struck by a horizontal force coming out of a perforation and will not operate in a vertical flow condition or in an openhole completion. A magnetic collar locator is run simultaneously with the Horizontal-Spinner for depth control.

The equipment is designed to operate up to 400°F at 15,000 psi. The present tools are 1-11/16 in. OD. The electronic components have no physical connection with the mechanical spinner and the bearing design is of a self-cleaning concept. Figure 1, Section "A", is a diagram of the mechanical section of the horizontal-spinner. Section "B" is the louvered area of the tool case that protects and diverts the thrust at the proper angle onto the "J" type impeller, Section "C".

HORIZONTAL-SPINNER/TEMPERATURE LOG EXAMPLES

The following field examples illustrate some of the problems seen in most gas wells, and the data acquired has enabled operators to improve the productivity of many gas wells through reperforating and/or re-treating.

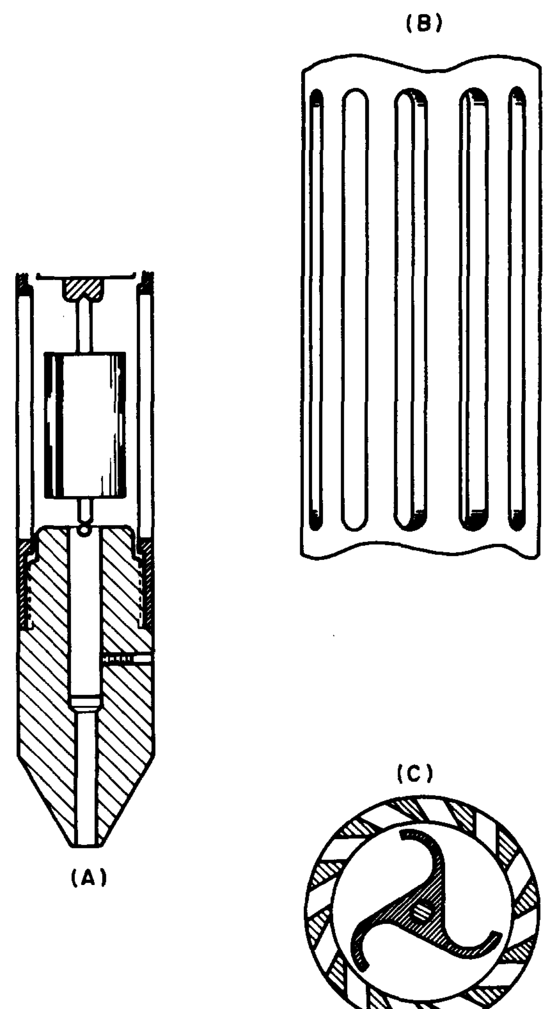

FIG. 1—HORIZONTAL-SPINNER

Example 1—Winkler Co., Tx (Fig. 2)

The well (Ellenburger, 9600 ft) was perforated with 4 shots per foot; shot from the bottom up. When the zone from 9316-9340 ft was perforated, the well pressured-up. The remaining perforations were shot under pressure. The well was not treated and was completed for a natural flow of 8 MMCF/D.

Interpretation: A major part of the production is from 9366-9380 ft, by-passing opposite perforations and entering the casing at 9322-9332 ft, as shown by the horizontal-spinner. The zone from 9240-9298 ft is either not open or nonproductive. The heating indicated by the temperature log, where gas is entering the perforations, is due to compression since the well has a higher producing capacity. It is not uncommon to see the gas source communicating up or down to open perforations.

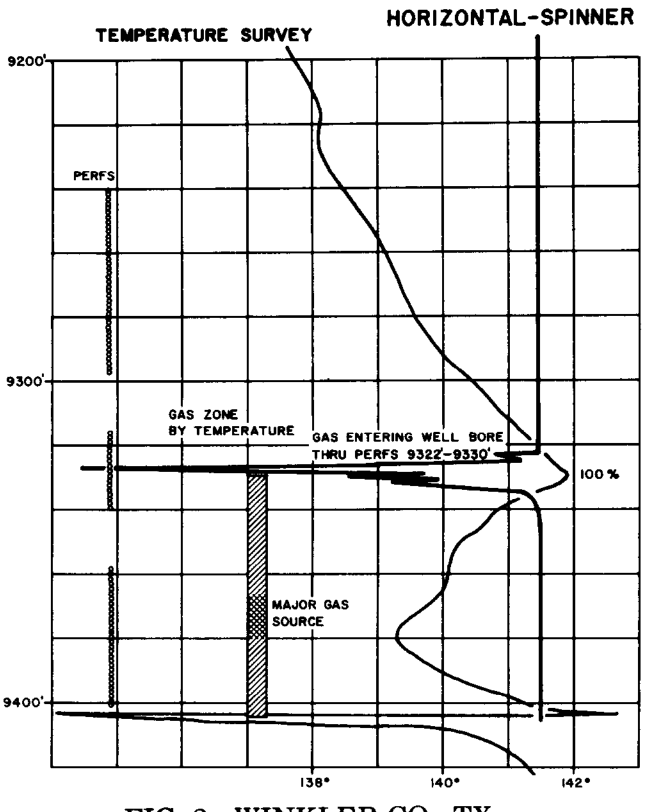

FIG. 2—WINKLER CO., TX.

Example 2—Ward Co., Tx. (Fig. 3)

The well (Fusselman, 13,600 ft) was perforated as shown on the log. The zone was acidized and the well was producing 1.7 MMCF/D and 30 BWPD at 1000 psi when surveyed.

Interpretation: The horizontal-spinner indicates two perforations producing: 13,371 ft - 58% of the gas, and 13,382 ft - 42% of the gas. The flowing temperature log indicates channelling from approximately 13,450 ft up to the two open perforations at 13,371 ft and 13,382 ft. The shut-in temperature log indicates the major gas zone is from 13,420-13, 454 ft. The major gas volume is by-passing several perforations and entering the casing 70-80 ft uphole. The temperature changes from 13,600 ft up to 13,452 ft indicate possible cross flow in a shut-in condition. The flowing temperature survey indicates a very minor gas entry through the perforations at 13,576 ft, 13,584 ft and 13,992 ft.

This well was reperforated and re-treated. The production increased from 1.7 MMCF/D to 5 MMCF/D and has been sustained for six months to date.

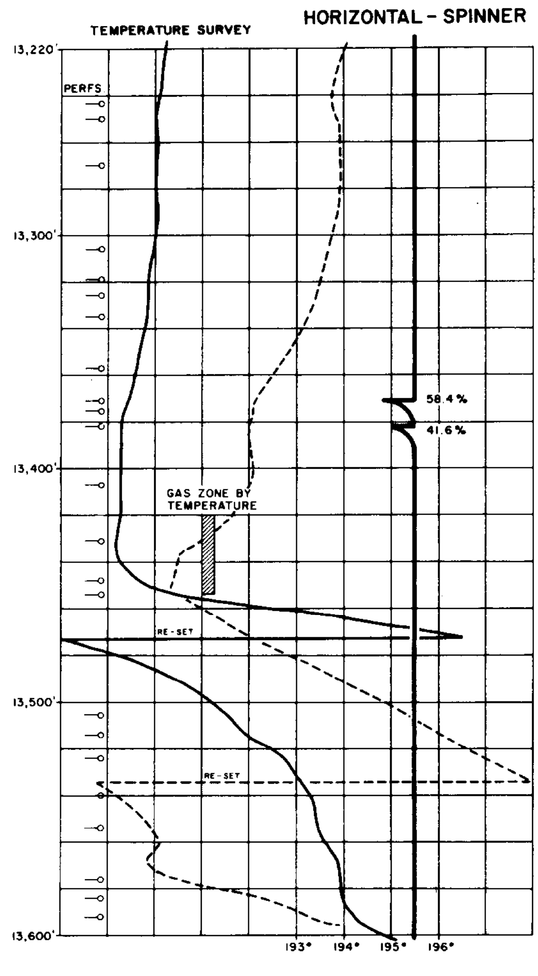

FIG. 3—WARD CO., TX.

Example 3—Reeves Co., Tx. (Fig. 4)

The well (Cherry Canyon, 6300 ft) was perforated as shown on the log. The well was acidized using ball sealers and was producing 2.81 MMCF/D, 5 BPD of condensate and 7 BWPD when surveyed.

Interpretation: The Horizontal-Spinner shows 55% of the total flow coming in the three perforations at 5930 ft, 5932 ft and 5934 ft; 14% through the perforation at 6027 ft and 31% through the perforations at 6070 ft and 6072 ft. The temperature survey confirms the gas source to be adjacent to the producing perforations.

The perforated interval from 5969-6001 ft is not producing. According to electric log data, this was supposed to be the most productive zone. The perforations below 6200 ft are not producing, although an off-set well is producing out of this zone. A selective treatment using blocking agents and acid evaluation temperature logging techniques could be very effective on this well.

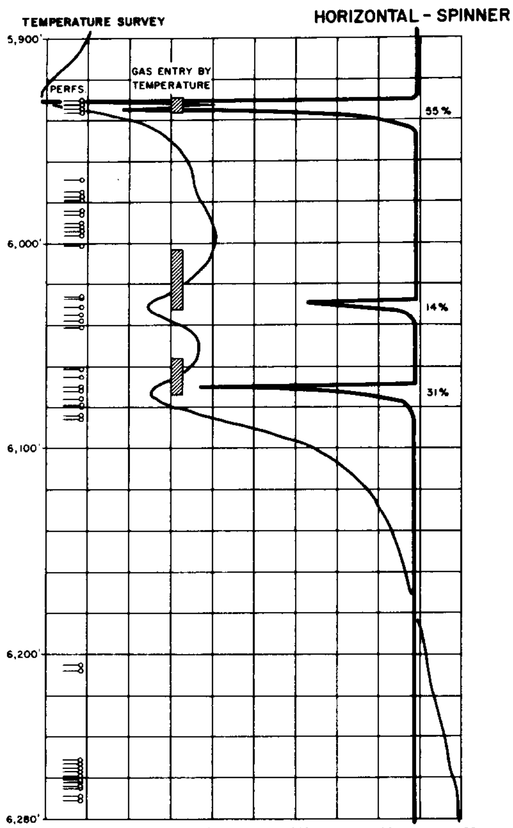

FIG. 4—REEVES CO., TX.

Example 4—Loving Co., Tx. (Fig. 5)

The well (Fusselman, 19,200 ft) was perforated as shown on the log. The zone was acidized with 5000 gal. acid at 2-3 BPM. The well was flowing 20 BWPH with an estimated 400 MCF/D when surveyed.

Interpretation: The surveys were made to determine which perforations were open and the origin of the gas and water. The four perforations at 19,161 ft, 19,170 ft, 19,179 ft and 19,181 ft were shown to be producing as indicated by the horizontal-spinner. There is no evidence of gas entry on the temperature log. Most of the thrust that actuates the horizontal-spinner is water entry.

The flowing temperature is abnormally hot (298°F) at the perforations and decreases below the perforations back to a normal geothermal gradient according to the temperature survey. This is an opposite reaction of that obtained when logging below a gas-producing zone. Prior temperature logging in this well in the Ellenburger below 20,000 ft confirmed that the normal geothermal gradient could not be in excess of 293°F at 19,180 ft. The conclusion is that the abnormal temperatures at the producing perforations are being caused by gas and/or fluid moving up a fracture system from some distance below 19,180 ft and entering the well bore at the perforations. The geothermal gradient and temperatures are normal from 19,180-19,420 ft, which tells us the vertical fracture system is some distance away from the well bore and not affecting the normal temperatures at this depth. This is not an unusual characteristic of the Fusselman formation in the Delaware Basin. The data gained here showed the operator that the zone was not commercial and it was abandoned. The well was completed in the Ellenburger.

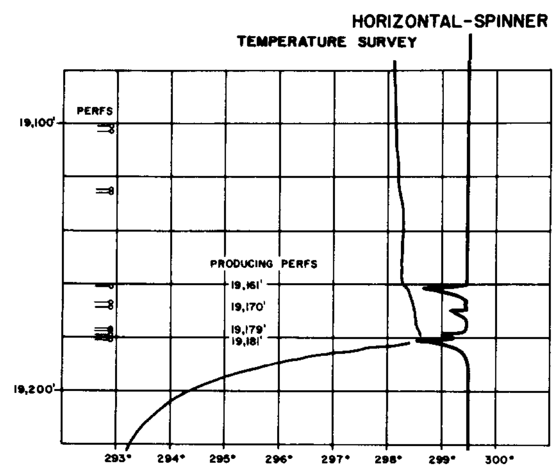

FIG. 5—LOVING CO., TX.

Example 5—Winkler Co., Tx. (Fig. 6)

The well (Fusselman, 16,700 ft) was perforated as shown on the log. The zone was acidized and the well was producing 1.5 MMCF/D when surveyed.

Interpretation: The temperature survey indicates the major gas entry from 16,580-16,626 ft, with a small gas entry through the perforation at 16,650 ft. The well is cross flowing while shut-in. The horizontal-spinner shows gas entries at 16,585 ft and 16,586 ft, two perforations that were shot out-of-zone. The major gas entry is through the perforation at 16,626 ft and a small percent of gas is coming through the perforation at 16,649 ft. Out of the total of 19 perforations, only four are producing and two of these are shot out-of-zone.

This well was reperforated and re-treated which resulted in an increase in production, from 1.5 MMCF/D to 3 MMCF/D. This 100% increase has been sustained for five months to date.

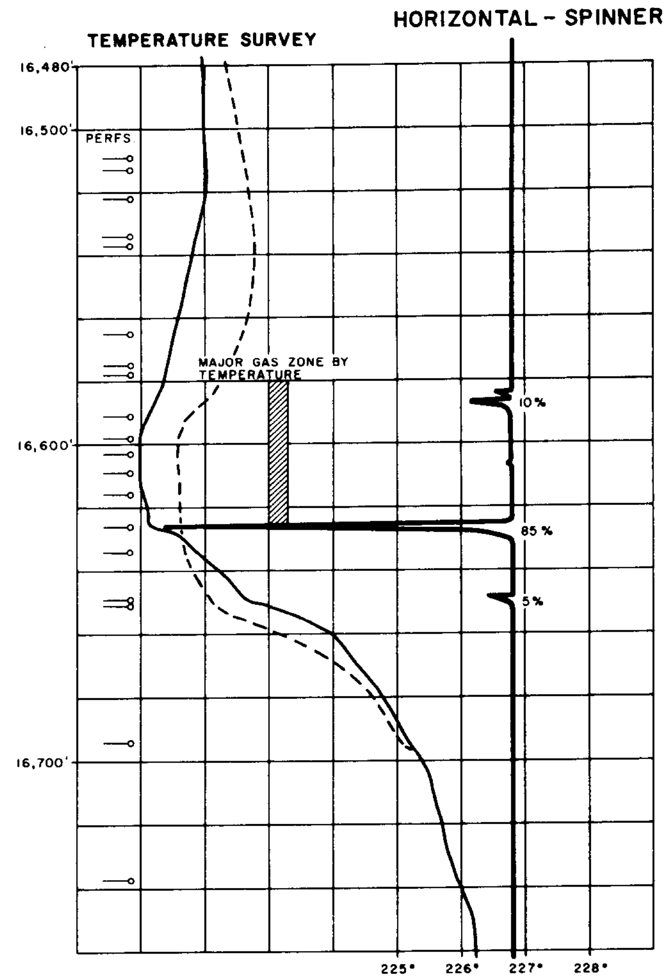

FIG. 6—WINKLER CO., TX.

Example 6—Wheeler Co., Tx. (Fig. 7)

A fold was encountered in the well (Hunton, 21,700 ft); the top zone was at 19,600 ft and the lower zone was at 20,600 ft. The well was to be produced from 20,600 ft until a dual completion could be made. The lower zone was partially perforated for test purposes and came in on natural flow. The well was producing 6.3 MMCF/D when surveyed.

Interpretation: The horizontal-spinner and flowing temperature surveys were run to locate the producing zones in the lower Hunton prior to running the production tubing that was to be set in a packer bore receptacle at 19,630 ft. The surveys showed that 90% of the gas flow was coming from an apparent hole or split in the casing opposite the major zone in the upper Hunton at 19,600 ft. The remaining zones in the lower Hunton were perforated, a packer with a plug was set in the liner below 19,630 ft, and the well is producing by natural flow from the upper Hunton until a dual completion is possible. All the perforating was performed in both pay zones prior to setting the packer.

The survey data enabled the operator to save considerable expense in the planned completion of this well.

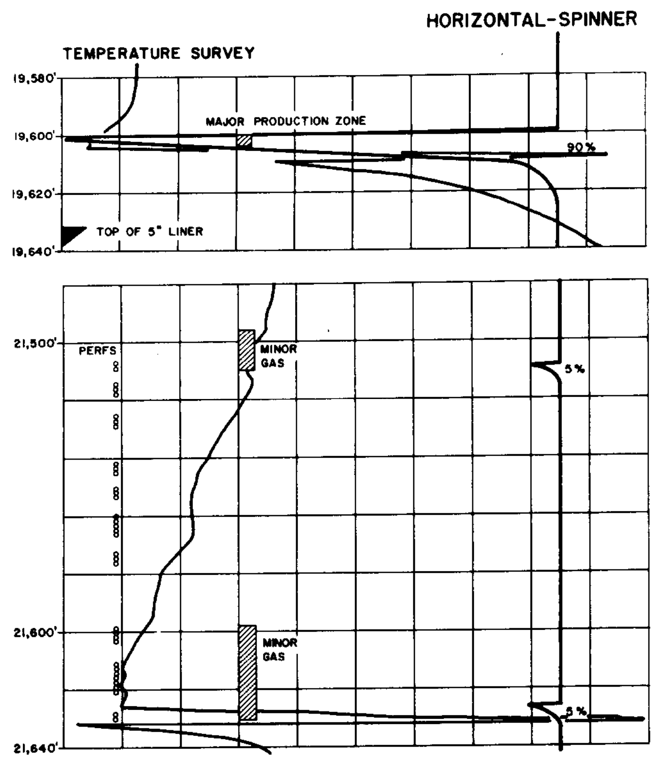

FIG. 7—WHEELER CO., TX.

Example 7—Pecos Co., Tx. (Fig. 8)

An earlier completion was attempted in the Montoya between 13,200 ft and 13,300 ft. The Montoya produced 400 MCF/D. The Fusselman (13,100 ft) completion was then attempted using a retrievable packer. A plug was set at 13,140 ft and the packer was set above the Fusselman. An acid evaluation log after treatment indicated the major portion of the treatment went down hole with a minor amount going into the perforations at 13,000 ft. The plug had slipped down hole 17 ft during the Fusselman treatment which indicated the communication was by the plug rather than through the perforations and down the outside of the casing.

Interpretation: The well was flowed back and was producing 1 MMCF/D when the horizontal-spinner and temperature surveys were run. The temperature surveys indicated all the gas was being produced from the Montoya (13,300 ft). No temperature drop was seen across the Fusselman and a 100°F temperature drop occurred at the bridge plug at 13,157 ft. The horizontal-spinner determined no flow from the Fusselman perforations and a "turbulence spin" was detected while the spinner was setting on the plug at 13,157 ft. All production was coming from the Montoya. The Fusselman and Montoya zones were temporarily abandoned and a completion was made in another zone up-hole.

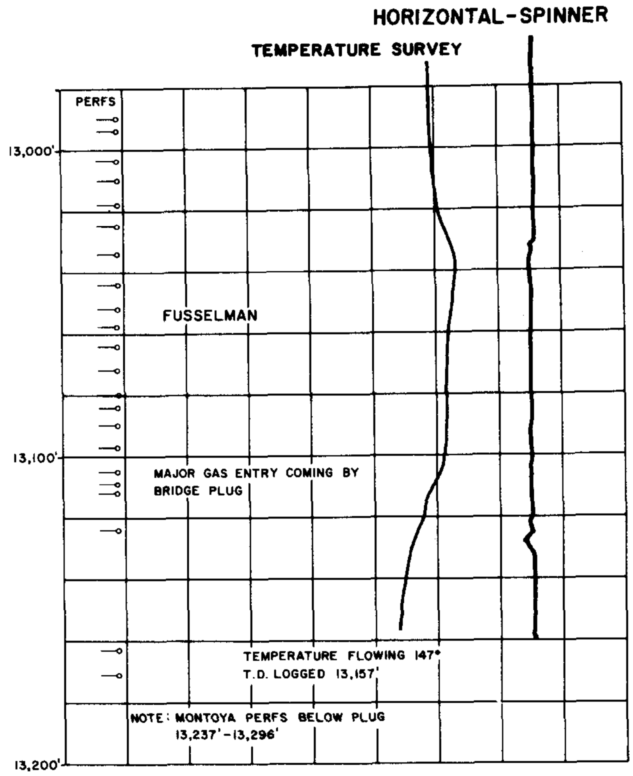

FIG. 8—PECOS CO., TX.

CONCLUSION

The Horizontal-Spinner can determine which perforation is producing and what percent of flow is entering each perforation. The temperature survey will confirm the producing source. As a general rule, very few perforations are effectively opened to the gas source and, in many cases, the major gas source is not perforated or not open to the well bore and is channelled or communicated to an open perforation.

Productivity can be increased by reperforating and/or re-treating in many wells. The cost of production logging, treating and perforating is minimized by not having to perform a full workover operation and by not having to lose but one or two days of production. Results are immediate and pay-out can be very fast.