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Cleanup/Stimulation of a Horizontal Wellbore Using Propellants

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Final Report

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EXECUTIVE SUMMARY

This report documents the stimulation/cleanup of a horizontal well bore (Wilson 25) using propellants. The Wilson 25 is a Bartlesville Sand well located in the Flatrock Field, Osage County, Oklahoma. The Wilson 25 was drilled under cost- sharing contract No. DE-FG22-89BC14458 (Results of that project are contained in DOE Report No. DOE/BC/14458-1, "The Drilling of a Horizontal Well in a Mature Oil Field. Final Report. Rougeot Oil and Gas Corporation. January 1991). The present report, covering the cleanup/stimulation of that well, includes the rationale, planning, results, and recommendations for using propellants as a means to cleanup/stimulate a horizontal well bore.

The Wilson 25 was drilled to determine if horizontal drilling could be used as a means to economically recover primary oil that had been left in place in a mostly abandoned oil field because of the adverse effects of water coning. Pump testing of the Wilson 25 horizontal well bore before cleanup or stimulation produced 6 barrels of oil and .84 barrels of water per day. The high percentage of daily oil production to total daily fluid production indicated that the horizontal well bore had accessed potentially economical oil reserves if the fluid production rate could be increased by performing a cleanup/stimulation treatment.

Propellants were selected as an inexpensive means to stimulate and cleanup the near well bore area in a uniform manner. The ignition of a propellant creates a large volume of gas which penetrates the formation, creating numerous short cracks through which hydrocarbons can travel into the well bore. More conventional stimulation/cleanup techniques were either significantly more expensive, less likely to treat uniformly, or could not be confined to the near well bore area.

Three different propellant torpedo designs were tested with a total of 304' of horizontal well bore being shot and producible. The initial test shot caused 400' of the horizontal well bore to become plugged off, and subsequently it could not be production tested. The second and third test shots were production tested, with the oil production being increased 458% and 349%, respectively, on a per foot basis.

The data from the Wilson 25 will allow independent producers to estimate the cost, and to plan and perform a propellant shot cleanup/stimulation of a horizontal well bore. The Wilson 25 results indicate that a propellant shot treatment is an economically viable means to cleanup/stimulate a horizontal well bore.

BACKGROUND

Objective of the U.S. Department of Energy.

In August, 1989, the Department of Energy awarded a grant to Rougeot Oil and Gas Corporation for $153,532 for cost-sharing the drilling of a 1,000-foot-long, medium-radius horizontal well. The well was drilled in June, 1990.

The resultant oil rates indicated that, with well bore cleanup/stimulation, future horizontal wells could be economically viable in a mature oil field.

In November, 1990, the Department of Energy awarded a grant of $29,880 to Rougeot Oil and Gas Corporation for cost-sharing the cleanup/stimulation of this horizontal well. The work was completed in February, 1992.

The production potential of a horizontal well in a mature oil field needed to be evaluated and the technology transferred to the oil industry in the near term. If economically successful, horizontal drilling in the Mid-Continent by the thousands of independent oil operators could increase the domestic oil supply as well as provide an economic spark to the depressed oil industry. If not economically successful, the project would provide detailed technical information to the independent oil operators so they could assess the applicability of "horizontal drilling" on their leases.

Objective of Rougeot Oil and Gas Corporation.

Rougeot's objective was to test the use of propellants to cleanup and stimulate the near well bore area in a horizontal well (Wilson 25). The Wilson 25 is a Bartlesville Sand oil well located in the North Flatrock Field, Osage County, Oklahoma. Rougeot obtained production data to determine how effective propellant shots are in the cleanup/stimulation of horizontal wells. This project is part of an overall objective of determining the profitability of horizontal wells in mature oil fields.

Rougeot had found that private funding for testing horizontal drilling in mature reservoirs was not available. The DOE had partially funded the original drilling of the Wilson 25. See the Report DOE/BC 14458-1 for Contract No. DE-FG-89BC14458 - The Drilling of a Horizontal Well in a Mature Oil Field. The testing of propellants in the well bore is a natural continuation of the work that had already been performed.

In November of 1990, the DOE awarded Rougeot a grant providing funds for testing the use of propellants to cleanup/stimulate the Wilson 25 horizontal well bore. The project budget was $41,500, of which the DOE would fund up to $29,880. Rougeot's comprehensive report on the testing of propellent shots in a horizontal well will be disseminated to the public as part of the DOE's technology transfer program.

PROJECT OVERVIEW

Project History.

In June of 1990, Rougeot Oil and Gas Corporation drilled the horizontal well (Wilson 25) under a cost-sharing agreement with the Department of Energy. The purpose of the horizontal well project was to test the use of horizontal well drilling technology as a means to redevelop a mature oil field. The mature oil field selected was the Bartlesville Sand reservoir in the North Flatrock Field, Osage County, Oklahoma. The underlying theory was that the adverse affects of water coning had left significant amounts of recoverable oil in place that could be accessed with horizontal drilling. The horizontal well was drilled on an oil lease that had been mainly plugged out in the 1920s because of depletion. A 1,050' horizontal well bore was placed in the uppermost ten feet of the Bartlesville Sand. (The true vertical depth of the horizontal well bore is 1420' to 1428' while the measured depth is 1816' to 2866'.) The well was drilled and equipped for $150,532, with a stabilized production rate of 5.82 BOPD and 2.49 BWPD. The drilling and completion of the Wilson 25 was performed on a low-cost basis to allow for the economical development of a limited amount of oil reserves (50,000 to 75,000 barrels per 1,000 feet of horizontal well bore).

The horizontal section of the Wilson 25 was air drilled, and with natural completion, producing rates of 36 to 65 barrels of oil per day were anticipated. The actual stabilized production rate of 5.82 BOPD suggested a lack of near well bore permeability. This low effective permeability could have been caused naturally by shale laminations or artificially by damage while drilling.

The cleanup/stimulation of the near well bore area of the Wilson 25 was complicated by the following factors:

1. Commonly used methods are either prohibitively expensive and/or could not guarantee uniform treatment of the entire well bore.
2. Within forty feet of the horizontal well bore was the underlying Bartlesville water sand, which would yield enormous quantities of saltwater if it were accessed with any treatment. There is no effective lithological barrier between the Bartlesville oil and water sands.
3. The Wilson 25 was drilled as a water coning application. The cleanup/ stimulation treatment had to be confined to the near well bore to help delay the adverse effects of water coning.

Detonating a liquid propellant (a propellant shot) was selected as the method most likely to provide a relatively low- cost, uniform, confined treatment of the near well bore area of the horizontal well bore.

Planning Considerations.

At the inception of the project, Rougeot searched the marketplace for a propellant shot service that could satisfy the project requirements. Rougeot's requirements proved to be not readily available at economic prices and it became apparent that Rougeot would need to fabricate a propellant shot delivery mechanism for the Wilson 25 project. Rougeot planned to detonate this delivery mechanism and its contents as a torpedo. A propellant torpedo involved many untested components. Less than expected performance in any component area would have a catastrophic result, with minimal progress toward an acceptable design being accomplished. Considering the preceding, Rougeot decided to perform three test shots. The disadvantage of this approach is that there is duplication of material and procedures which limits the amount that can be accomplished with a limited budget.

The torpedo design can be broken into the following components areas, which are interrelated but separate options:

a. Propellant
b. Propellant Carrier
c. Detonation device/system
d. Torpedo assembly and placement

An overriding concern in the planning process was the cost. Estimated recoverable reserves for 1,000 feet of horizontal well bore were 50,000 to 75,000 barrels. The overall objective was to develop horizontal drilling and completion techniques to economically exploit this limited amount of reserves. In order to accomplish this objective, Rougeot believed that the detonation of a propellant torpedo and related cleanout must be performed at a cost of less than $50,000 per 1,000' of horizontal well bore. This cost constraint significantly complicated the torpedo planning process.

1. **Propellant**.

The primary objective was to cleanup/stimulate the near well bore area without rubblizing the formation. Based on experience with cleaning out vertical well bores after nitroglycerin shots, it would be very expensive to clean out a horizontal well bore if significant formation rubblization occurred. Based on the preceding, Rougeot needed to identify a propellant/explosive that would crack, but not rubblize, the formation. Propellant products detonate at a slower speed than explosive products. This creates less shock energy (rubblizing) and more gas energy for formation cracking. Another factor requiring determination was the proper diameter of the propellant. Overshooting the well was a potential outcome which Rougeot could not afford. As a result, Rougeot attempted to determine the minimum shot size and proceed from that point. Too large a diameter could cause formation rubblization whereas too small a diameter would not be able to sustain detonation.

2. **Propellant Carrier.**

A propellant carrier must be fabricated out of a material that accounts for the following factors:

a. The propellant weighs approximately 11 pounds per gallon. If the torpedo was very long, the tensile strength of the carrier material becomes a factor, particularly while lowering the torpedo into the hole.

b. The external durability of the carrier material becomes a factor when sliding the torpedo through the abrasive open hole.

c. The carrier material must be readily cleaned out or retrieved from the well after detonation.

d. The carrier material should not damage (reduce permeability) the formation when it is blown apart or melted upon detonation.

e. The carrier material must have sufficient compressive strength to allow for sliding the torpedo into the pre-detonation position.

f. The carrier material must be readily sealed to prevent leakage of fluids both in or out during pre-detonation placement.

3. **Detonation Device/System.**

The method with which detonation would be initiated and sustained had to be determined. Methods of detonation considered were radio signal, electric wire line, and time bombs. The measures taken to sustain detonation vary greatly depending upon the propellant selected and is covered as part of discussion on the propellant selection decision.

The detonation system requires a high degree of reliability, as the torpedo cannot be retrieved once it is placed in the open hole.

4. Torpedo Assembly and Placement.

The torpedo was to be assembled in the wellhead for safety and logistical reasons. By assembling the torpedo in the wellhead it would be lowered into the well only when fully assembled. As a practical matter, a loaded torpedo longer than 70 feet could not be placed in the well with locally available equipment unless it is assembled in the wellhead.

A torpedo "pushing" tool was designed and fabricated. The tool insures that the tubing stays centered on the torpedo and doesn't slide to the side of the torpedo while it is being pushed into position in the horizontal well bore. Additionally, the torpedo "pushing" tool was designed to allow for the tubing to readily disengage from the torpedo when required.

Products Selected.

Three test shots were performed and are fully described and evaluated later herein. For the initial test shot, certain options were selected that proved to be the most attractive for all three test shots. These options, used in all three test shots with only minor modification, are as follows:

1. Propellant selection
2. Detonation device/system selection
3. Torpedo assembly and placement selection

1. **Propellant Selection.**

There are several products available which claim to crack oil- and gas-producing formations without rubblizing the formation. As previously stated, these products are technically classified as propellants. Rougeot selected a product marketed by the Atlas Powder Company called Atlafrak (see Appendix "C" for Atlafrak characteristics). Atlafrak was selected because of its relatively low shock energy and high gas-volume production capability. Furthermore, while other companies have products similar to Atlafrak in terms of low shock energy and high gas volume, Atlafrak is the easiest to initially detonate. While ease of detonation can be a safety problem, it is difficult for propellants to sustain detonation over distances greater than fifty feet. The contingency that a portion of the torpedo would not detonate is a possible project failure that was considered critical to avoid. As the diameter of the torpedo increases it becomes more likely that the propellant will be able to sustain detonation. Atlafrak in a diameter of less than 2.5 inches will not sustain detonation. However, the advantage of an increased diameter in terms of sustaining detonation can be offset by the propellant's increased likelihood to rubblize the formation as its diameter increases. Consequently, a certain amount of trial and error was required to determine the optimum diameter of torpedo for a given formation. The diameter of each torpedo detonated in the Wilson 25 was varied to develop an understanding of the optimum diameter for the Bartlesville Sand.

2. **Detonation Device/System.**

Electronic and radio detonation systems were excluded because of a lack of experience by Rougeot with systems of this nature. Rougeot also had safety concerns with products that are not widely used in oil field applications.

Electric wire line detonation systems were excluded because of potential problems with severing or damaging the wire line while placing the torpedo in the hole. Additionally there was concern about post detonation bridging of the wire line in the open hole as well as well as the cased segment of the well.

Rougeot selected a time bomb device to initiate detonation of the primary boosters. Zero Instrument Co. manufactures an inexpensive 12-hour time bomb that is fairly simple to use. This time bomb has been used in oil field applications for over sixty years with an extremely high degree of reliability. There was concern that this time bomb was too fragile to be run in a horizontal well. This concern was to be addressed in a "trial run". An additional concern was that this time bomb would fail for unexplained reasons. An unexploded torpedo should never be recovered. If a bomb fails to detonate a second time bomb must be run. To reduce the likelihood of a time bomb failure causing non-detonation of the torpedo, two time bombs were run in each torpedo. Because of the dissimilar propellant carriers employed in each test shot, the method of configuring and arming the time bombs differed for each test shot (see Figure 3 - Torpedo #1, Figure 9 - Torpedo #2, and Figure #12 - Torpedo #3).

Consideration was given to whether multiple boosters would be needed to sustain the detonation of the propellant. Atlas Powder Company recommended that multiple boosters would not be required for torpedoes with diameters of 2.5 inches and greater. There was further concern that multiple boosters may "speed up" the rate of detonation and cause rubblization. Torpedoes #1 and #2 were each one contiguous torpedo each with one primary booster detonated by time bomb. Torpedo #3 was a segmented torpedo in which only one segment was armed by time bomb and accompanying primary booster, and each segment contained two secondary boosters connected by 50-grain primer cord.

3. <u>Torpedo Assembly and Placement Selection.</u>

For all three torpedoes, the well head was specially configured to allow for the bomb assembly. Figure 4 illustrates the wellhead configuration for Torpedo #1. For torpedoes #2 and #3, only minor alterations to the wellhead configuration were made to allow for varying torpedo diameters. There were no other wellhead configuration design changes for Torpedoes #2 and #3.

All three torpedoes were lowered into the fluid in the curved portion of the well with the completion rig's sand line attached to the "torpedo hook" and detached. The "torpedo hook" on torpedo #3 was dissimilar from that on torpedoes #1 and #2, and was a significant torpedo design enhancement (see Torpedo #3 bomb design planning discussion). After detachment, all three torpedoes were pushed into place with tubing and specifically designed "torpedo pushing" tools. The "torpedo pushing" tool for torpedoes #1 and #2 (see Figure 5) varies considerably in design from the tool used for Torpedo #3 (see Figure 13).

CLEANOUT/ STIMULATION - TORPEDO #1

Planning and Design.

The torpedo design tested in the first shot is outlined below:

1. The torpedo carrier was a 3" polyethylene line pipe (O.D. 3.5" - I.D. 2.864"). This size pipe will accommodate .36 gallons of propellant per foot. A continuous segment of 136' was utilized. The advantages of the polyethylene were considered to be:
   a. The 3" polyethylene has the rigidity and outside "wear resistance" to be readily pushed into position in the open hole.
   b. The 3" polyethylene has the tensile strength to hold the weight of the propellant while the bomb is being assembled and lowered into the well.
   c. The 3" polyethylene is readily sealed and can be readily adapted to the metal hook needed to lower the bomb into the hole.
   d. After torpedo detonation, the 3" polyethylene will remain in large pieces that can be readily cleaned out of the hole.
   e. The 3" polyethylene costs $1.18/foot. This cost is significantly lower than many of the alternative carrier materials.
2. The detonation device was two 12-hour time bombs (see Figure 3).
3. The plan for the Torpedo #1 test shot is summarized below:

a. Lay down rods. Check T.D. with the tubing and verify that no obstructions are present in the open hole.

b. Place 3" polyethylene pipe with plugged end in the top of the well and load with water for "trial run". Attach the torpedo to the tubing to allow for ready retrieval.

c. Assuming no problems occur in the trial run, fill the 3" polyethylene with Atlafrak and the time bomb assemblies.

d. Lower the torpedo into the curved portion of the well by sand line and detached. Run the torpedo "pushing tool" (see Figure 5) in the well on tubing. Push the torpedo to the interval 2666'-2802' M.D. Pull the tubing from the well.

e. Load the well with lease brine to 900' V.D.

f. Torpedo detonation initiation occurs per the time bomb clock setting.

g. Following detonation, run production tubing in the well to T.D. (if possible) to check the extent and nature of the torpedo debris.

h. Run the bottom hole pump and rods and attempt to production test well prior to beginning clean out operations.

i. Clean out well if necessary.

j. Place well into production and evaluate the production test results.

Initially, there was uncertainty as to what extent the uncased well bore surface would damage the polyethylene pipe and whether the time bomb clocks would handle any concussion associated with pushing the torpedo into place. A trial run with the time bomb clock running but unarmed and the torpedo loaded with water was conducted to allow Rougeot to evaluate polyethylene pipe wear and time bomb clock performance.

A continuous 136' segment of polyethylene line pipe was cut, staked out in a rigid position, steamed, to allow it to be straightened. A machine-fabricated 3.5" O.D. polyethylene plug with drain assembly was butt fused to the bottom of the torpedo. A 3.5" O.D. transition was butt fused to the top of the torpedo. To load the torpedo, the 136' of polyethylene pipe was lowered into the top of the well, landed in the wellhead and secured in the wellhead spider with conventional 3.5" tubing slips (see Figures 4 and 6 for detailed drawings of the wellhead and surface configurations). The torpedo was filled with water for the dual purpose of the "trial run" and to allow the torpedo to be safely loaded with Atlafrak. Atlas Powder Co. indicated that Atlafrak could not be poured in a free-fall altitude for over 20' to 30' without risking detonation. Consequently, once the torpedo was filled with water and after the "trial run", 20' of 1" plastic pipe was inserted into the top of the water filled torpedo. The Atlafrak was poured down the 1" plastic pipe. At 11 pounds per gallon, the weight differential allowed the Atlafrak to gently settle to the bottom of the 136' torpedo while displacing water out the annular space at the top of the torpedo. The torpedo was considered to be full of propellant when water ceased to be displaced out of the top of the torpedo during the filling procedure. Two armed time bomb assemblies, each with dynamite boosters, was inserted into the top of the torpedo and suspended by nylon cord (see Figure 3).

A steel plug with attached hook (torpedo hook) was then inserted in the top of the torpedo, sealing the entire torpedo contents.

The possibility was considered that it would not be necessary to clean out the well after shooting and prior to the commencement of pumping operations. The torpedo debris might remain on the bottom side of the horizontal well bore and possibly not adversely affect pumping the well. Unlike a vertical well, the torpedo debris in a horizontal well bore may not bridge and plug off the producing formation. After the torpedo detonation, the production tubing can be used to tag T.D. to provide some information as to the nature and extent of the torpedo debris, providing useful information for planning any clean out operation.

Placement and Detonation.

On May 16, 1991, the trial run was begun. The torpedo with plug fused on bottom and transition fused on top was placed in the well and loaded with water and the two unarmed time clocks. The tubing was attached directly to the top of the torpedo for the trial torpedo run. The tubing was run in the hole, pushing the torpedo to the end of the open hole (2869' M.D.). The tubing was not rotated. The tubing and attached torpedo were pulled back out of the hole. The clocks in the time bomb assemblies were retrieved and found to be in perfect running condition. The outside of the torpedo carrier was inspected and only minor abrasions were observed. The torpedo filled with water was left landed in the wellhead. The trial torpedo run was completed in 9 hours.

On May 18, 1991 the torpedo was filled with Atlafrak per the plans previously outlined. It required 2.5 hours to fill the torpedo with Atlafrak, displace all water out of the torpedo, and install the armed time bomb assemblies with boosters. The time bomb clocks were set for detonation in 8 hours. Unlike the trial run, a steel plug with hook was installed in the top of the torpedo. The torpedo was then lowered by sand line into the curved portion of the well and detached. The "torpedo pushing" tool described in Figure 5 was then run on tubing into the well, pushing the torpedo to the interval 2666' to 2802'. The tubing was then loaded with water and pressured to 1,000 psig.

This procedure engaged the tool's safety mechanism, insuring the tool was decoupled from the torpedo before withdrawing the tool and tubing from the well, thus leaving the torpedo at the exact desired interval. Lease brine was pumped into the well until the fluid level in the well was 900' from the surface. The torpedo detonated as planned.

On May 22, 1991 the production tubing was run into the open hole to determine the location of the torpedo debris. The tubing ran into an obstruction at 2249' M.D. and could not be pushed past 2279'. The tubing was brought back to 1836' M.D. and the rods and bottomhole pump run. The well was pump tested during the period May 22, 1991 through June 1, 1991. See Exhibit 1 for daily oil and water production. Prior to shooting the well, the well was averaging 5.82 BOPD and 2.50 BWPD. During the last three days of the well-test period, production averaged 7.28 BOPD and 24.66 BWPD. This represented an increase of 1.53 BOPD and 24.66 BWPD from the shot.

The percentage of oil to total fluid (oil cut) prior to the shot was approximately 69% whereas the oil cut of the incremental fluid after the shot was approximately 6 %. Rougeot believed that this dramatic difference in oil cut before and after shooting could have been the result of one of the following conditions:

1. The torpedo blast had caused cracks in the formation to extend from the well bore into the underlying water sand causing a high percentage of the produced fluid to be water.
2. The obstruction in the well bore at 2279' was restricting fluid flow. The restriction was causing excessive back pressure to be placed on the well bore upstream of the obstruction. Rougeot's experience in the Bartlesville Sand had been that back pressure on the reservoir would adversely effect oil cut as well as total fluid volume. It was decided to clean out the well to determine if produced fluid flow was being restricted.

Cleanout.

To cleanout the well, Rougeot built an overshot tool out of 5 1/2" casing (see Figure 7) which was intended to wash over the metal hook plug and large pieces of polyethylene. The hole would be reverse circulated with lease brine at a rate of 3-5 BPM and the tubing rotated.

On June 11, 1991 the cleanout operation was commenced. The 5 1/2" cleanout tool became quickly plugged while circulating and had to be tripped out. A very limited amount of bomb debris was found in the tool. The metal pieces (torpedo hook and plug, time bomb parts) were large enough to plug the tool. The overshot was used until all significant metal torpedo components were recovered. The tool was abandoned when it was determined that the temperature and force of the blast had caused the polyethylene to be blown up the hole sideways and had bridged, effectively creating a rather solid polyethylene plug in the hole. The 5 1/2" cleanout tool was having to cut the polyethylene plug in order to wash over the polyethylene fragments. The polyethylene was rigid, and it took only a few feet of polyethylene lodged in the 5 1/2 cleanout tool before the tool was totally plugged. The decision was made to abandon the overshot tool and use a 6 1/4" tri-cone medium tooth drill bit to drill up the polyethylene.

Rougeot began drilling up polyethylene debris at approximately 2375 M.D. Lease brine was circulated at 3-5 BPM and the pipe was rotated at 50 RPM. Initially good poly cutting returns were observed at the surface. At 2392' M.D. a marked change in drilling returns occurred. Prior to 2392' M.D. the drilling returns were mostly small pieces of polyethylene whereas after 2392' M.D. the drilling returns were mostly sand. Rougeot spent 8 hours drilling from 2392' M.D. to 2443' M.D. with the drilling returns being mostly sand. Taking into consideration the slow drill rate and the nature of the returns, it was determined that the drill bit had probably sidetracked. It was decided that the clean out operations would be abandoned, as it would be too costly to determine if the drill bit had sidetracked and/or correct the problem. See Figure 1 - Diagram of Torpedo Placement and Cleanout Results.

Results and Conclusions.

The Wilson 25 was placed back on production on June 16, 1991. Prior to the poly torpedo shot the well was producing 5.82 BOPD and 2.50 BWPD. Initially after the Torpedo #1 shot the well was producing 7.5 BOPD and 25 BWPD. On July 12, 1991 the well production fell to 2.4 BOPD and 12 BWPD. This decline occurred in less than 24 hours. The total cost of the Torpedo #1 shot and cleanout was $22,284.34.

Rougeot's conclusion related to Torpedo #1 are as follows:

1. The time bomb detonation system was successful. The bomb detonated as intended.
2. The Atlafrak propellant performed as intended. The fluid increase of 1.53 BOPD and 24.66 BWPD that existed prior to the hole plugging indicated that the propellant caused cleanup/stimulation of the near well bore area.
3. The 20-foot-long 1" tube used to fill the carrier with propellant was not long enough, as the Atlafrak and water took too long to separate.
4. The polyethylene performed in all areas as expected except for the problems encountered in cleaning it out. The polyethylene was too malleable to be readily removed from the hole. This high degree of malleability caused the polyethylene to bend versus breakup.
5. The cleanout drilling assembly must be more rigid to reduce the likelihood of sidetracking.
6. The cost of the work was as follows:
    a. The cost of the torpedo shot was $15,539.62 ($114.26/foot) and the cost of the cleanout was $7,169.52 ($52.72/foot) for a total cost of $22,284.34 ($163.85/foot) to shoot and cleanout 130' of the horizontal well bore.

b. The cleanout cost of $49.59/foot should be reduced in the future, as this cost includes the cost of attempting to remove the polyethylene plug and the possible sidetracking problem. It was hoped that this sequence of events could be avoided in the future.

c. The total torpedo cost of $61.54/foot included $30.79/foot for materials and $30.75/foot for services. The torpedo cost per foot for materials was within an acceptable range for the project to be economically successful. The portion of the torpedo cost associated with services declines on a per foot basis when longer torpedoes are used, whereas the material cost per foot will be the same on a per foot basis unless significant design changes are made.

7. The overnight dramatic decline in the well's produced fluid occurring on July 12, 1992, was probably caused by migration of poly debris within the poly plug, resulting in additional plugging.

CLEANOUT/STIMULATION - TORPEDO #2

Planning and Design.

Based on the results of the Torpedo #1, Rougeot made the following torpedo design changes for the second test shot:

1. The carrier material was changed to 2 1/2-inch fiberglass line pipe (O.D. 2.73 - I.D. 2.43). This size pipe accommodates .24 gallons of propellant per foot. Smith Fiberglass Products, Inc. designed specialized connections and collars to limit the weight of the fiberglass while providing a carrier that can be readily sealed and has the desired strength. The fiberglass is less malleable than the polyethylene and breaks up more readily upon detonation and during cleanout operations (see Figure 8-Torpedo #2).
2. The torpedo was detonated using two twelve hour time bombs. However, a specialized fiberglass carrier was fabricated to house the time bombs. The Torpedo #1 time bomb assemblies were housed in aluminum tubes (see Figure 9 - Torpedo #2 - Time Bomb Assembly).
3. The I.D. of the fiberglass carrier was 2.43". This represents a downsizing of the torpedo from Torpedo #1 (.36 gallons per foot of Atlafrak for Torpedo #1, and .24 gallons per foot of Atlafrak for Torpedo #2). This downsizing was an attempt to reduce the length of formation cracking and resulting incremental water production.
4. Immediately preceding bomb detonation the hole was filled to the surface with lease brine. The intent was to increase the fluid overburden above the torpedo, thus reducing the speed at which the torpedo debris

would be hurled up the hole and possibly decreasing the likelihood of bridging by torpedo debris.

5. The 5 1/2 " overshot tool was utilized for one-trip to recover the metal hook and fiberglass plug. After pulling this tool, the remaining fiberglass was "drilled up." A prime factor in selecting fiberglass as a carrier material is that it can readily be "drilled up." In drilling, the tubing was stiffened with the use of stabilizers and a drill collar to avert the possibility of side tracking.

6. Ninety foot of 1" plastic pipe was used to fill the carrier with Atlafrak to assist in the speed of separation.

The plan for the torpedo #2 test shot is summarized in the following:

1. Lay down rods. Run tubing to T.D. to check hole for obstructions. Lay down tubing.

2. Assemble and fill the carrier with Atlafrak in the wellhead (see Figure 8 - Torpedo #2 Design). Torpedo #2 consisted of the time bomb carrier, which was 10' long, and seven 31-foot joints of 2.5" fiberglass tubing. Total length of Torpedo #2 was 217'. Lower the torpedo into the curved portion of the well by sand line and detach.

3. Run the torpedo pushing tool and tubing in the hole. Push the torpedo to the planned shot interval of 2150' to 2367' M.D. and pull the tubing from the well.

4. Load hole with lease brine to the surface.

5. Torpedo detonation initiation occurs per the time bomb clock setting.

6. Run 5 1/2" cleanout tool one trip to recover metal hook and fiberglass plug (see Figure 7 - shot debris cleanout tool). Circulate lease brine at a rate of 3-5 BPM while running the cleanout tool.

7. Run drill bit with stabilizers and drill collar to drill up fiberglass debris (see Figure 10 - Cleanout Drilling Assembly). During drilling operations, circulate lease brine at a rate of 3-5 BPM and rotate the drilling assembly at a rate of 50 RPM.

8. Run tubing, rods and bottom hole pump and place well into production.

Placement and Detonation.

On November 23, 1991 the fiberglass torpedo was assembled in the wellhead. Total length of the torpedo was 217.79' (see Exhibit 8 - Torpedo #2 Design). It required 5 1/2 hours to assemble and fill the torpedo in a manner similar to loading Torpedo #1 described in detail previously in this report. Armed time bomb clocks with boosters were installed in the torpedo and set for 8 hours. A fiberglass plug with steel hook was installed in the top of the torpedo. The torpedo was then placed in the well by sand line and tubing in a similar manner as the placement of Torpedo #1 was described previously in this report. The torpedo was pushed to the shot interval of 2150' to 2367' M.D. The bomb detonated as planned (see Figure 1 - Diagram of Torpedo Placement and Cleanout Results). The cost of the torpedo was $6020.63 ($27.64/foot). The cost of the torpedo does not include the cost of the fiberglass carrier, as Smith Fiberglass contributed the fiberglass at no cost. The 207' of 2 1/2" fiberglass normally retails for $ 828 ($4.00/foot). (See Figure 1 - Diagram of Torpedo Placement and Cleanout Results.

Cleanout.

Cleanout operations were begun on November 25, 1991. The 5 1/2" O.D. cleanout tool was run in the hole on tubing and encountered a bridge at approximately 1903' M.D. The hole was reversed circulated with lease brine at a rate of 3-5 BPM and the tubing was rotated at 50 RPM for 5.5 hours while the cleanout tool moved into the hole only 2' to 1905' M.D. The 5 1/2" cleanout tool was pulled out of the hole. The top 3" fiberglass coupling, 3" fiberglass plug and metal hook were recovered from the cleanout tool. It was important that the metal hook was retrieved as the fiberglass bridge could not be drilled up by a tri-cone bit with any significant metal still in the hole.

On November 26, 1991 a drill bit with stabilizers and a drill collar (see Figure 10 - Cleanout Drilling Assembly) were run in the hole on tubing to 1905 M.D. Lease brine was circulated at a rate of 3-5 BPM and the tubing was rotated at 50 RPM. Good fiberglass returns were observed at the surface. After approximately five hours of drilling the drilling assembly became stuck at 1919' M.D.

On November 30, 1991, Rougeot pumped down a back-off tool to the top stabilizer and was able to successfully back-off the drilling assembly at the bottom of the top stabilizer. Upon retrieving the stabilizer it was observed that the tungsten carbide buttons had come out of the top stabilizer causing the drilling assembly to hang up.

On December 3, 1991, Rougeot went into the hole with a stabilizer (no wear buttons) and hydraulic jars. Rougeot successfully screwed the new stabilizer back into the drilling assembly and was able to jar loose and commence drilling ahead. The hole was cleaned to 2410' when the jars which were in intermittent use began to fail and the cleanout was abandoned. Problems were encountered with the drilling assembly hanging up on the way out of the hole. The drilling assembly was out of the hole at 1:30 p.m. on 12-6-92. The average rate of cleanout had been 30' per hour.

On December 9, 1991, Rougeot went in hole with tubing, seating nipple, and mud anchor to 2423' M.D. to circulate the hole. Approximately 280 barrels of lease brine (total on-site storage) was circulated at a rate of 3-5 BPM. The circulated water did not clean up nor did it appear to be carrying solids adequately.

On December 10, 1991, Rougeot circulated 280 additional barrels of lease brine at 3-5 BPM with two 14-barrel gum gel pills (25#/14 oh.). The circulated water at the tail end of the circulating period still contained an unexpected volume of debris, so it was decided to repeat the procedure on December 11, 1991. On December 11, 1991, Rougeot circulated an additional 280 barrels of lease brine at 3-5 BPM with four 14-barrel gum gel pills. The water at the end of the circulating period became extremely clean. The tubing was pulled up to 1831' and rods and bottom hole pump were run in the well.

During the course of circulating the well, small amounts of Atlafrak were observed in the pits. The Atlafrak would sink into the mud on the bottom of the earthen pits, so it was impossible to determine how much Atlafrak was circulated out of the hole.

Results and Conclusions.

The well was placed back on production on December 21, 1991 and the stabilized production rate after 45 days was 7.9 BOPD and 21.6 BWPD. This represented an increase in fluid production from Torpedo #2 of 5.5 BOPD and 9.6 BWPD over production from Torpedo #1.

Rougeot's conclusions related to Torpedo #2 are summarized in the following:

1. The time bombs functioned as planned. Based on the fact that some Atlafrak was circulated out of the hole, it is apparent that an indeterminate amount of the 217.79' torpedo did not detonate. The fiberglass carrier I.D. was probably of insufficient diameter to allow detonation to be sustained over 217'.
2. The incremental production of 5.5 BOPD and 9.6 BWPD for the 217' shot can be extrapolated to an increase of 25.3 BOPD and 44.16 BWPD if 1,000' of horizontal well bore had been shot.
3. Fiberglass torpedo debris can readily be cleaned out of the hole. The cleanout operation would have been efficient had the top stabilizer not lost its buttons.
4. The cost of work is as follows:

a. The combined cost of the torpedo and cleanout was $21,464.08 ($98.91/foot).

b. The cost of the cleanout was $15,443.08 ($70.76/foot) cannot be evaluated. This cost escalated appreciably when the wear buttons fell out of the stabilizer, causing a fishing job as well as a slowed rate of cleanout.

c. The cost of the torpedo shot was $6020.63 ($27.74/foot). Of the $27.74/foot, $20.84 was related to materials and $6.90/foot was related to services. The cost of the Torpedo #2 shot would have increased by approximately $4.00/foot to $31.74/foot had the fiberglass been purchased. The $31.74 compares favorable with the Torpedo #1 cost of $61.54/foot. Rougeot considers a total torpedo cost of approximately $32.00/foot acceptable.

5. A rigid drilling assembly and hydraulic jars should be utilized anytime an operator attempts to drill up any shot debris.

CLEANOUT/STIMULATION - TORPEDO #3

Planning and Design

To plan Torpedo #3, Rougeot consulted with Rick Tallini of Otto Cupler Torpedo Co., who had developed and successfully employed a horizontal well shooting system. This torpedo design (See Figure 11 and Figure 12) is summarized below:

1. A lightweight plain end fiberglass (3.5" O.D. - 3.35 I.D.- .45 gallons/foot) tube was used as an outside shell. The tubes were in 29' lengths. Three tubes or segments were used making an 87' torpedo.
2. A tin nose cone and funnel shaped tail piece were fabricated and riveted to each end of the (3) fiberglass segments. The tin nose cone on the bottom of each torpedo segment mated with the funnel shaped tail piece on the top of the adjacent torpedo segment when lowered into the well. The tail pieces were fitted with a bale (handle) similar to the bale/handle on a five- gallon bucket, which functions as the torpedo "hook" for lowering the torpedo in the hole. The segmented torpedoes, when lowered into the hole individually, can then be pushed into position as a "train". It was hoped that disintegration of the lightweight tin nose cone and tail pieces by the C-4 (see below at 3.) would simplify the cleanout by minimizing metal debris.
3. Approximately 1 pound of C-4 plastic explosive was placed in the tin nose cone or bottom of each torpedo segment with a 50 grain primer cord attached running throughout the length of the torpedo. The primer cord was tied to the bail at bail end and run into the C-4 in the nose cone end to ensure that detonation was initiated/sustained in each segment.
4. An 8 mm poly seamless bag 33' long with a sealed bottom end was placed throughout each torpedo segment. Each fiberglass shell and bag

was placed in the wellhead and held by conventional 3.5" tubing slips. The propellant was poured in the top open end of the plastic bag in the top of each torpedo segment until full. Once the bag was full, it was sealed with a special polyethylene bag sealing machine.

5. Each segment was lowered into the curved portion of the well bore and detached. In the last segment (segment #3), two time bombs assemblies with boosters were placed in the propellant.

6. A minimal amount of fluid tamp was placed over the torpedo. It was hoped that torpedo debris would be either blown out of the hole or spread over a long distance within the well bore reducing the chances of bridging.

7. A torpedo pushing tool (see Figure 12 - Torpedo #3 Pushing Tool) was fabricated to be run on tubing and fit in the last (top) torpedo segment's funnel-shaped tin tail piece.

The plan for test shot #3 is summarized in the following:

1. Lay down rods. Run tubing to the T.D. to check hole for any obstructions. Lay down tubing.

2. Assemble each of the (3) - 29' long torpedo segments individually in the wellhead. Lower each segment individually into curved portion of the well by sand line and detach. Push all (3) torpedoes with pushing tool to the shot interval of 1866' to 1953' M.D. Pull the tubing out of the well.

3. Load the hole with lease brine to 900' V.D.

4. Torpedo detonation initiation occurs per the time bomb clock setting.

5. Check the open hole with tubing for bridging.

6. Attempt to pump well without any cleanout.

7. Cleanout well if necessary, based on open hole conditions observed.

Placement and Detonation.

On February 10, 1992, the Torpedo segments were individually filled with Atlafrak and lowered into the well. The segments were pushed to 1866' M.D. The time bomb was set to detonate in 8 hours. The shot interval was 1866' to 1953' M.D. Torpedo #3 detonated as planned. After detonation, the production tubing was run 200' past the bottom of the shot interval and bridged debris was found. The tubing was pulled to 1750' M.D. The well was placed into production but the bottom hole pump failed within 48 hours because of excessive amounts of fiberglass and sand being pumped. The torpedo cost was $3,655.08 ($42.01/foot). The 3.5 inch O.D. fiberglass, which was contributed at no cost by Smith Fiberglass Products, Inc., normally retails for $1.90/foot.

Cleanout.

Cleanout operations were commenced on February 17, 1992, after the bottom hole pump failed. The tubing was run to approximately 2153' M.D. The open hole was circulated with 280 barrels of lease brine and two 14-barrel gum gel pills at a rate of 5-7 barrels per minute while rotating the tubing.

While the circulated water was not as clean as desired, it was decided to run the bottom hole pump and attempt to pump test the well. The pump failed because of excessive sand within 7 days. On March 2, 1992 the well was circulated again to approximately 2153' M.D., using approximately 800 barrels of lease brine and four 14-barrel gum gel pills (25#/14 oh.) at a rate of 3-5 barrels per minute. Rougeot was able to circulate 800 barrels of water fairly inexpensively by filtering and recycling the circulated water. The circulated water became extremely clean by the end of the circulating process and the well was placed back on production.

Results and Conclusions.

The final cleanout proved to be successful. The stabilized production rate is 9.58 BOPD and 26.40 BWPD. The increase in production resulting from the shot is 1.68 BOPD and 4.50 BWPD. The cost of the cleanout was $3145.52 ($36.15/foot).

Rougeot's conclusions related to Torpedo #3 are as follows:

1. The bomb detonated as planned and the torpedo debris was readily cleaned out of the hole. The torpedo design functioned as intended.
2. The incremental production of 1.68 BOPD and 4.50 BWPD can be extrapolated to a production increase of 19.3 BOPD and 51.7 BWPD per 1,000 feet of horizontal well bore.
3. The cost of work is as follows:
    a. The cost of the torpedo and cleanout was a combined $6,800.08 ($78.16/foot). This cost was significantly less than the prior test shots.
    b. The cleanout operations cost $3145.52 ($36.15/foot). This cost could have been reduced to approximately $2,500 had Rougeot prepared to perform the two well circulating operations as one job. The cost per foot should decrease as the amount of footage shot increases. The Torpedo #3 cleanout was simpler and cost less than the cleanouts of Torpedoes #1 and #2.
    c. The cost of Torpedo #3 was $3,655.08 ($42.01/foot). Of the $42.01/foot, $31.26/foot was for materials and $10.75/foot was for services. The material cost would have been $43.91/foot had the fiberglass been purchased. Assuming quantity discounts, the lowest material cost that

can be expected with Torpedo #3 is $25.00/foot if the total footage shot is increased. The cost of services could be reduced to below $5.00 per foot if the footage shot is increased. Torpedo #3 design will cost $30.00 to $45.00/foot depending upon the amount of footage shot.

4. Torpedo #3 was not as effective as Torpedo #2 despite the fact that Torpedo #3 contained significantly more Atlafrak per foot (0.24 gallons/foot versus .45 gallons/foot). Possible factors causing this disparity are as follows:

   a. The Torpedo #2 shot a longer and wider cross section (see Figure 1) of the horizontal hole than Torpedo #3. As a result it was more likely that Torpedo #2 contacted thin layers of sand with high permeability.

   b. 50 grain primer cord was run throughout Torpedo #3 to insure that detonation was sustained. The primer cord will cause the Atlafrak to detonate at a greater speed. As the speed of detonation increases, the Atlafrak will become less effective.

   c. In addition to the preceding, Torpedo #2 covered the upper two thirds of the "pay" whereas Torpedo #3 covered only the upper one third. A non-productive sand was in close proximity above the majority of Torpedo #3. At least 80% of Torpedo #3 was in the top 2' of the pay. When the sand above the horizontal well bore is non-productive, as much as 50% of the potential benefit from a shot could be lost.

CONCLUSIONS

The following conclusions can be made from the propellants shot in the Wilson 25 horizontal well:

1. The final propellant shot (Torpedo #3) represents a viable economical means to cleanup/stimulate a horizontal well bore. The procedures and methods utilized can be readily duplicated utilizing materials and services that are commonly available. Based on the cost data from the test shots, it is estimated that a 1,000' well bore could be shot in a manner similar to Torpedo #3 for $35,000 to $50,000.
2. Torpedo's #2 and #3 increased stabilized production 458% and 349% respectively. Extrapolating these results to a per 1,000' of well bore indicates that the Wilson 25 could be expected to produce 21 to 28 barrels of oil per day had the entire 1,000' of horizontal well bore had been shot. The total cost of the Wilson 25 to date, including drilling, equipping, and test shots, is $195,000. The Wilson 25 operation can be readily duplicated with the entire horizontal well bore shot for less than $195,000. Based on the extrapolated production results, a well of this nature will pay out in 15-21 months (assuming $20.00/bbl., 1/6 royalty and 7% severance tax). Each incremental 1,000' of horizontal hole will cost an incremental $50,000 to $75,000 to drill, equip, and shoot. Increasing the length of the horizontal well bore will significantly improve the economics of the horizontal well.
3. These "test shots" are part of the overall objective of testing the economic feasibility of using horizontal drilling to redevelop a mature oil

field. The Wilson 25 was drilled on an oil lease where most of the wells were plugged in the 1920's because they had reached their economic limit. The Wilson 25 results are not absolutely conclusive, because the results are extrapolated production amounts and not actual production amounts. However, the Wilson 25 results do support the conclusion that horizontal drilling combined with a propellant shot cleanup/stimulation treatment may be a viable means to redevelop a mature oil field.

RECOMMENDATIONS

The following recommendations are made, based on the information contained in this report for the cleanup/stimulation of a horizontal well bore using propellants:

1. The shooting and cleanout should be performed immediately after the completion of the well while the drilling rig is still over the hole. The drilling rig could economically cleanout any torpedo debris.
2. Shooting every foot of the well is inefficient, as the torpedo materials are expensive, whereas the production benefit of shooting every foot of the well bore is minimal. The operator should investigate the possibility of shooting only evenly spaced intermittent intervals (i.e. every thirty feet). There is a possibility of significant savings if the total amount of materials used is reduced by 25%.
3. The cost of each incremental foot is relatively inexpensive for both the initial drilling and the propellant shooting of a horizontal well. The operator should try to drill and shoot as much footage as possible to maximize the economics of horizontal drilling.
4. The Bartlesville Sand in the Flatrock Field has many non-continuous shale laminations. The effective vertical permeability of these shale laminations was less than anticipated. The effect of the shale laminations causes consideration to be given to placing the horizontal well bore deeper/lower in the formation than otherwise would be contemplated and including a propellant shot cleanup/stimulation treatment in the well drilling plan.

NOMENCLATURE

Abbreviations Used

'	=	Feet
"	=	Inches
M.D.	=	Measured Depth
BPD	=	Barrels Per Day
BOPD	=	Barrels Oil Per Day
BWPD	=	Barrels Water Per Day
BFPD	=	Barrels Fluid Per Day
O.D.	=	Outside Diameter
I.D.	=	Inside Diameter
T.D.	=	Total Depth
V.D.	=	Vertical Dept
psi	=	Pounds Per Square Inch, Gage
RMP	=	Revolutions Per Minute
FPS	=	Feet Per Second

ACKNOWLEDGEMENTS

To write this report, Rougeot has only referenced proprietary data.

Rougeot would like to acknowledge the several professionals and their companies that provided services that were critical to the project. The following is an alphabetical listing to these professionals:

Philip G. Ellsworth	Manager Marketing Services Smith Fiberglass Products, Inc. Wichita, Kansas Provided fiberglass and fiberglass design assistance related to Torpedoes #2 and #3.
Thomas W. Fortson	Senior Scientist Atlas Powder Company Joplin, Missouri Provided technical consulting regarding Atlafrak and related detonation initiation.
Rick Tallini	Manager Otto Cupler Torpedo Company East Titusville, Pennsylvania Provided technical consulting and on-site services related to the Design and detonation of Torpedo #3.
Harvey E. Svetlik	Senior Technical Representative Phillips Driscopipe, Inc. Richardson, Texas Provided polyethylene and polyethylene design assistance related to Torpedo #1.
William Sneed	William Sneed Cleveland, Oklahoma Provided technical consultation regarding torpedo design, specialized tool fabrication, and on-site services related to detonation of Torpedoes #1, #2 and #3.
John F. Schatz	John F. Schatz Consulting Del Mar, California Provided informal consulting regarding propellant applications and experiences.
S. C. Watson	S. C. Watson and Associates McArthur, Ohio Provided informal consulting regarding propellant applications and experiences.

TABLE 1

Cost-Sharing of the Cleanup/Stimulation of Wilson 25
Department of Energy - Rougeot Oil and Gas Corporation

	Total Cost	Contribution DOE	Contribution Rougeot
Cleanup/Stimulation - Torpedo #1			
Material	$ 8,795	$ 6,332	$ 2,463
Clean-Out	6,745	4,856	1,889
Cleanup/Stimulation - Torpedo #2			
Material	$ 6,021	$ 4,335	$ 1,686
Clean-Out	15,443	11,119	4,324
Cleanup/Stimulation - Torpedo #3			
Material	$ 3,655	$ 2,632	$ 1,023
Clean-Out	3,146	606	2,540
	$43,805	$29,880	$13,925

TABLE 2

Production History of Wilson 25
5-21-91 - 2-22-92

DATE	PRODUCTION, BPD Oil	Water
Prestimulation		
5-07-91	5.55	2.39
5-08-91	5.05	2.56
5-09-91	6.62	2.56
5-10-92	5.79	2.48
Shut Down Well for Torpedo #1 - Stimulation/Cleanout Treatment		
5-21-91	10.21	26.19
5-22-91	9.32	29.52
5-24-91	6.14	28.00
5-25-91	7.96	25.24
5-28-91	9.77	26.43
5-29-91	8.47	26.51
6-01-92	7.82	26.31
Unsuccessfully attempted to Cleanout Well. Placed well back into production on 6-14-92		
6-17-92	0	46.23
6-18-92	1.31	42.21
6-20-92	1.28	35.34
6-21-91	1.94	33.95
6-24-91	1.65	30.49
6-27-91	7.61	33.79
7-03-91	9.82	33.02
7-22-91	2.08	12.32
11-22-91	2.43	11.87
Shut Down Well for Torpedo #2 - Stimulation/Cleanout Treatment. Placed well back into production on 12-13-92		
12-14-91	0	102.85
12-15-91	0	62.33
12-16-91	0	52.74
12-17-91	0	47.84
12-18-91	0	43.76
12-21-91	0	36.09
12-26-91	10.00	30.00
12-31-91	8.37	22.63
1-07-92	5.76	19.61
1-10-92	6.54	20.73
1-17-92	10.50	17.88
1-22-92	7.41	20.71
1-27-92	7.18	14.93
1-31-92	6.92	16.72

TABLE 2 (Cont'd)

Production History of Wilson 25
5-21-91 - 2-22-92

DATE	PRODUCTION, BPD Oil	Water
Shut Down Well for Torpedo's-Stimulation/Cleanout Treatment Placed well back into production on 2-10-92		
2-10-92	7.5	34.22
2-11-92	20.10	34.22
2-12-92	8.55	26.50
2-13-92	12.75	25.80
2-14-92	23.25	26.50
2-15-92	19.05	26.50
2-16-92 - Pulled Pump - Floating Sand		
2-20-92	11.70	25.40
2-21-92	23.25	26.50
2-22-92	15.90	26.50

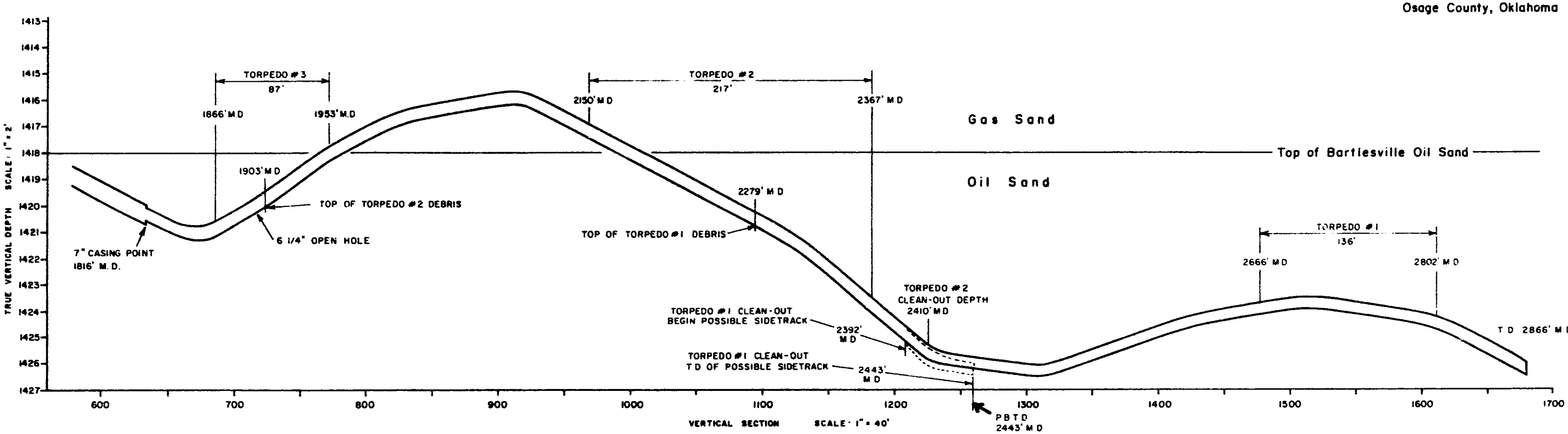
In April, 1992, the Wilson 25 rate of production stabilized at 9.45 BOPD and 26.10 BWPD (See Appendix B)

In November, 1992, the production ratio was 6.5 BOPD and 25.20 BWPD.

Figure 1
HORIZONTAL WELL PROFILE
TORPEDO PLACEMENT & CLEAN-OUT HISTORY

ROUGEOT OIL & GAS CORP.
Tulsa, Oklahoma

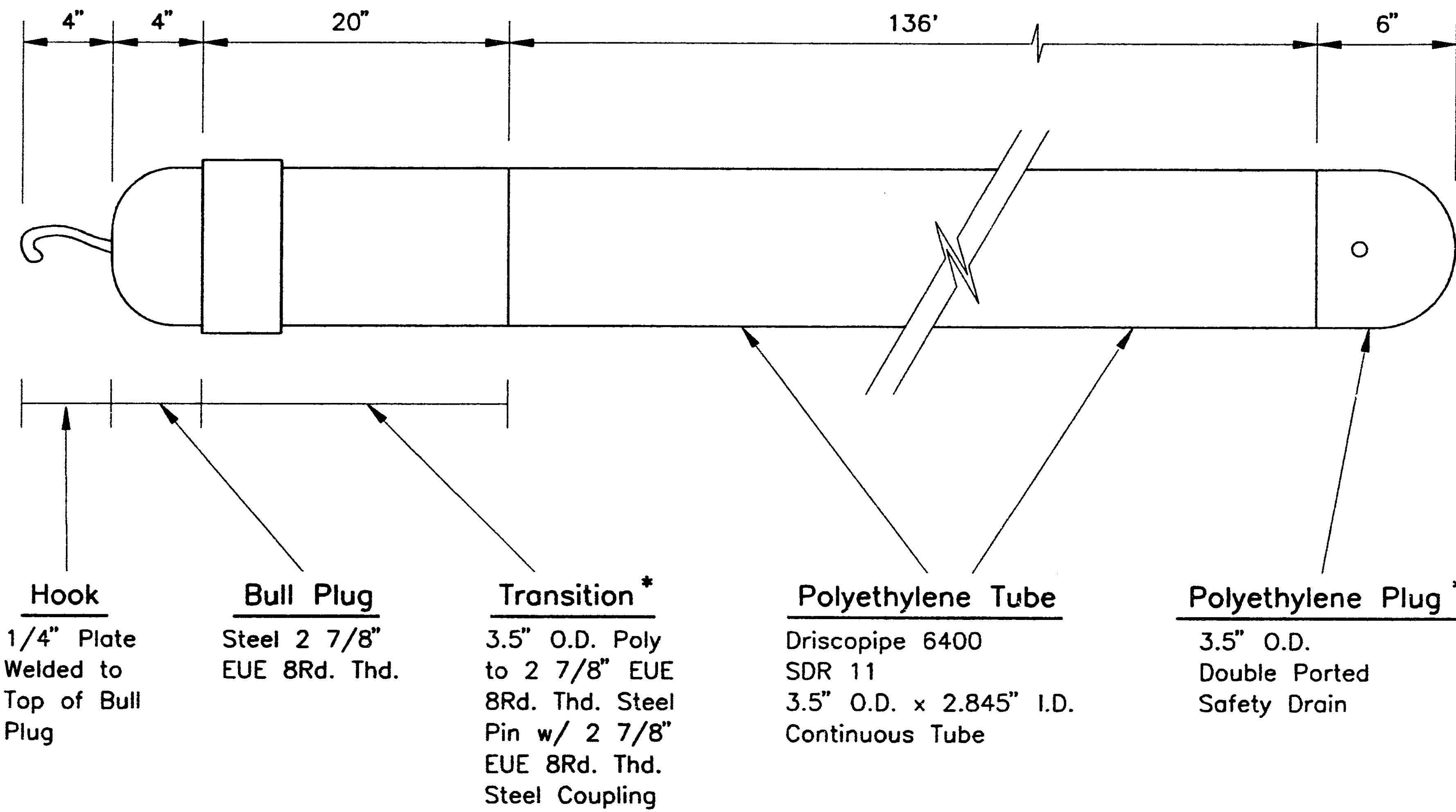
Wilson #25
Osage County, Oklahoma



ROUGEOT OIL & GAS CORP.

Fiqure 2

TORPEDO #1



* Attached by Butt Fushion

Fiqure 3

TORPEDO #1

TIME BOMB ASSEMBLY

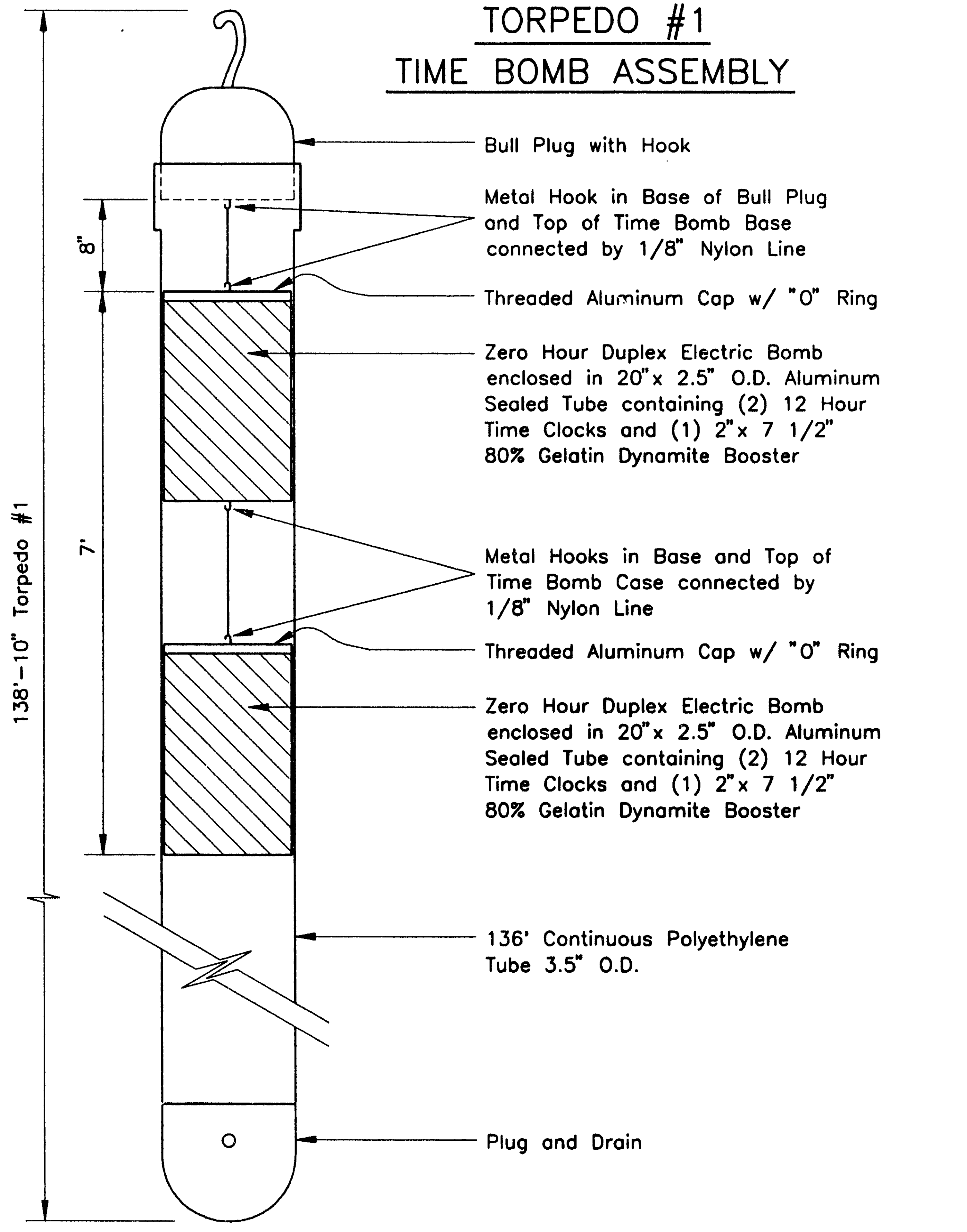
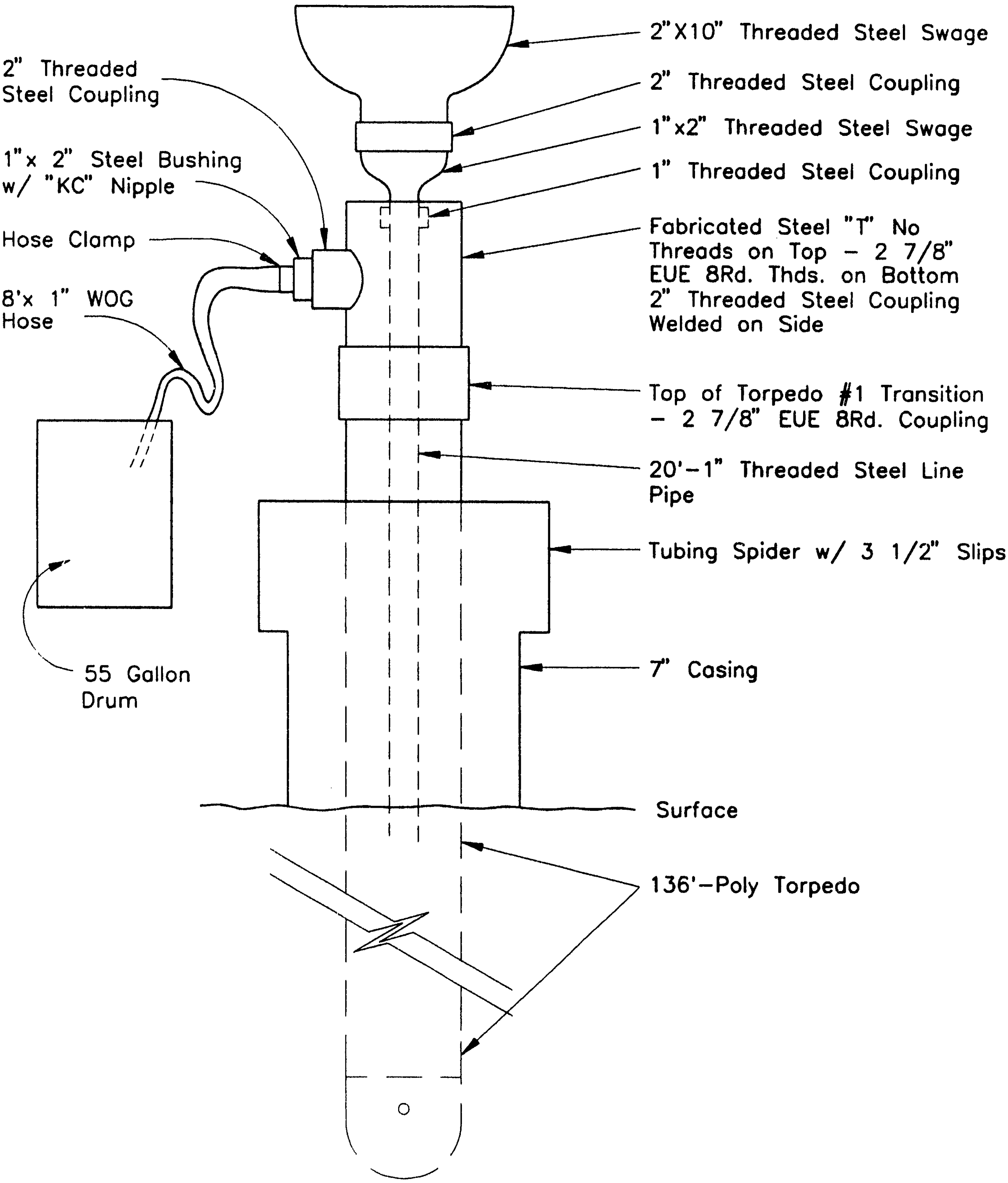


Figure 4

TORPEDO #1 FILLING ASSEMBLY



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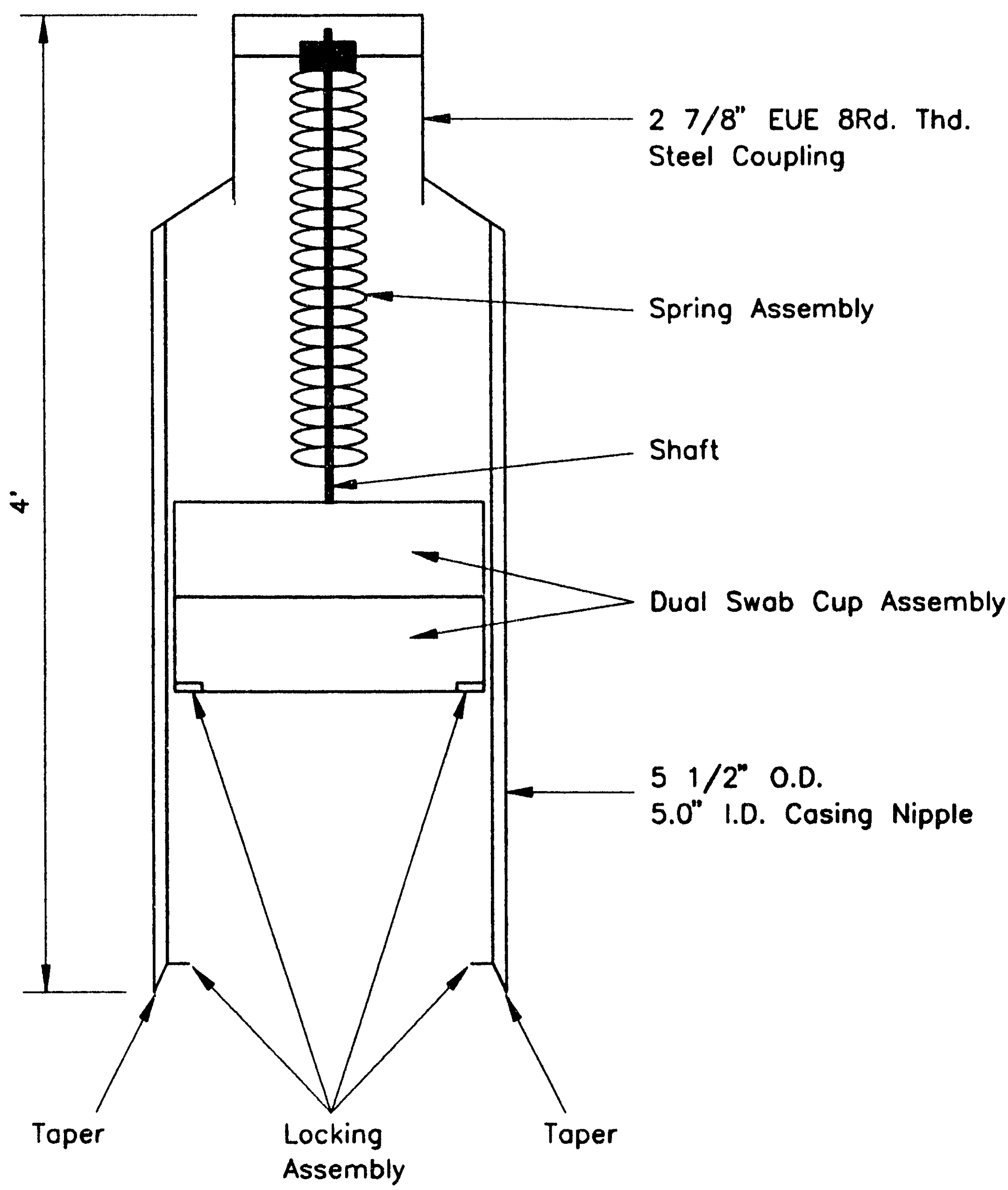
Fiqure 5

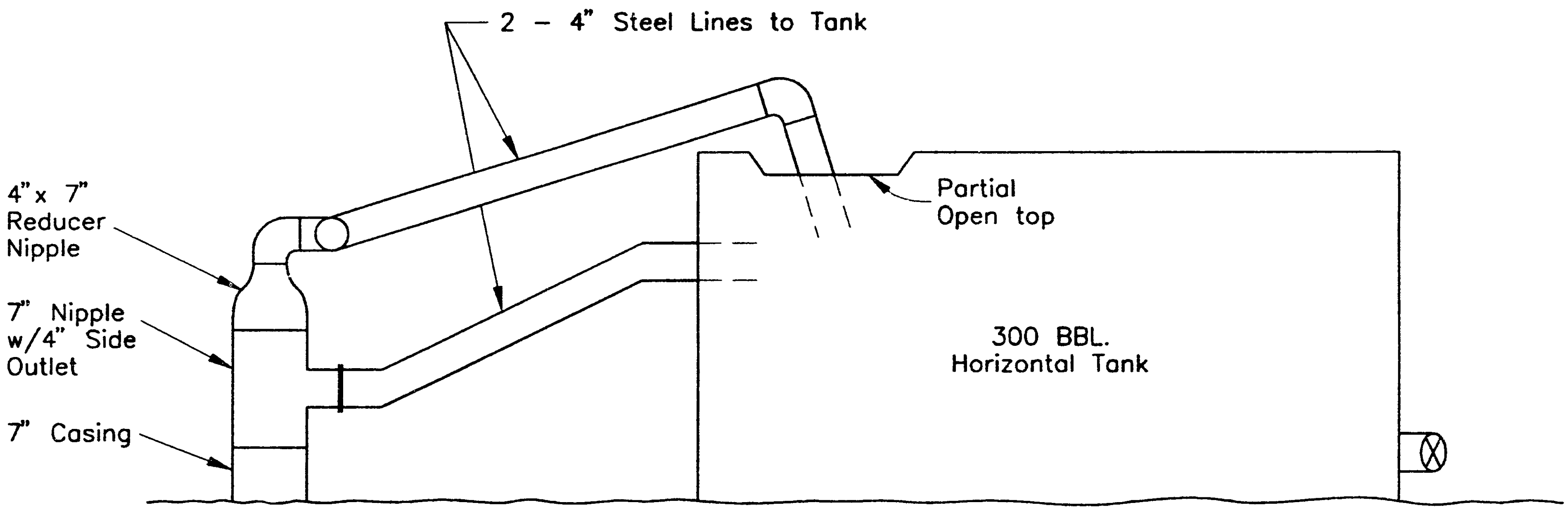
TORPEDO #1 & #2 PUSHING TOOL



ROUGEOT OIL & GAS CORP.

Figure 6

WELL HEAD ASSEMBLY – BLOW-BACK DIVERTER



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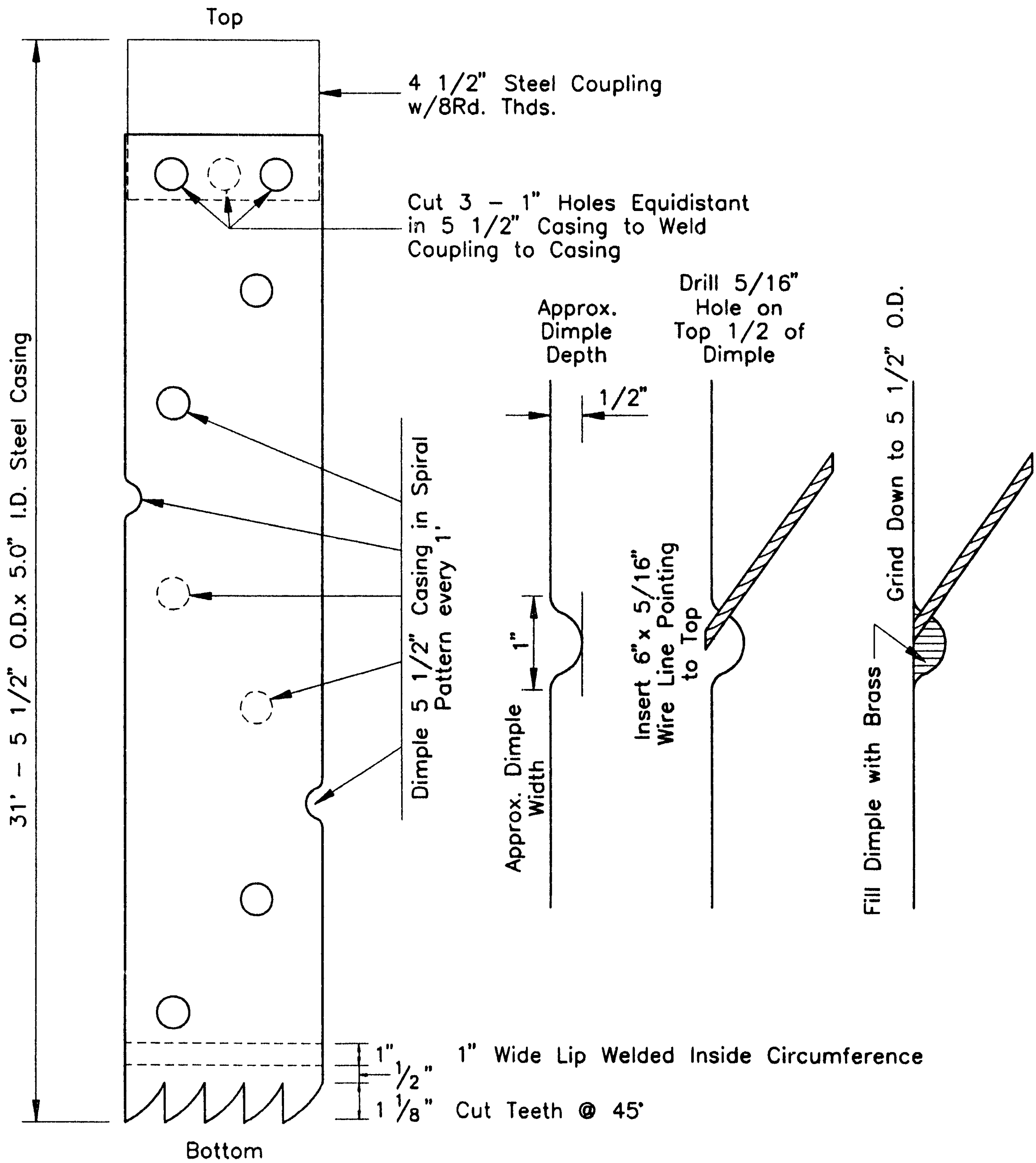
Fiqure 7

TORPEDO #1 & #2
SHOT DEBRIS OVERSHOT TOOL



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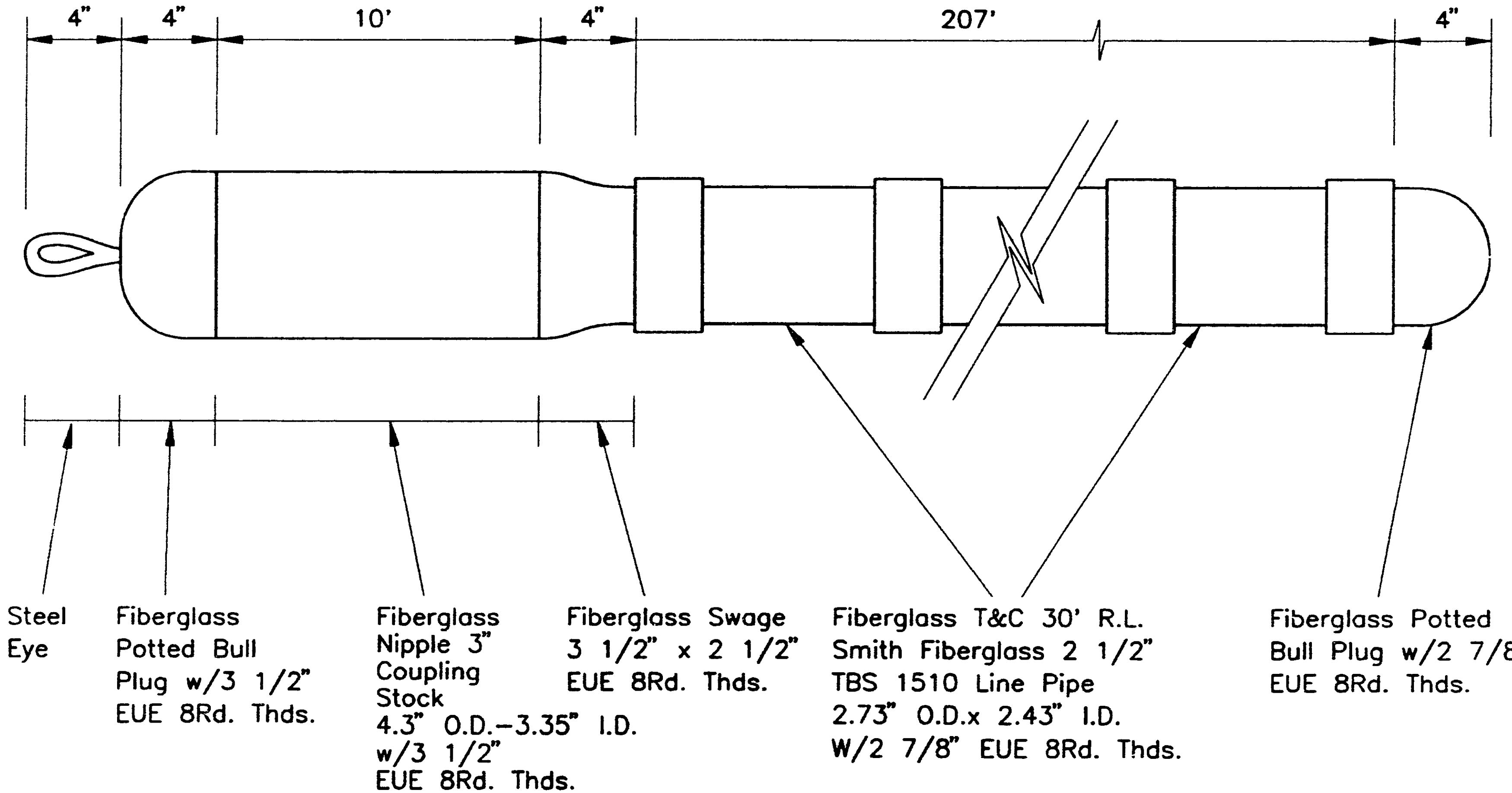
Fiqure 8

TORPEDO #2



ROUGEOT OIL & GAS CORP.

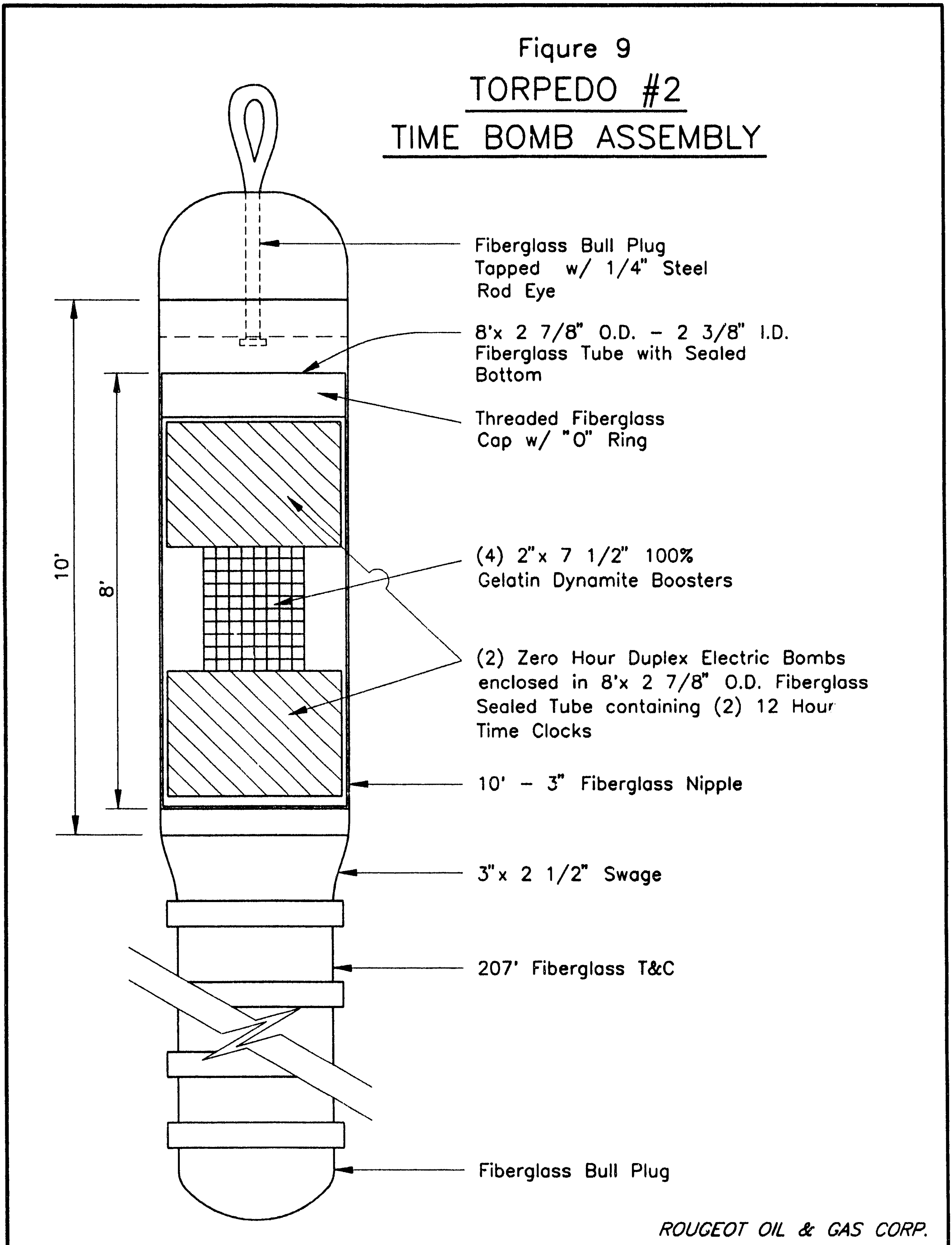
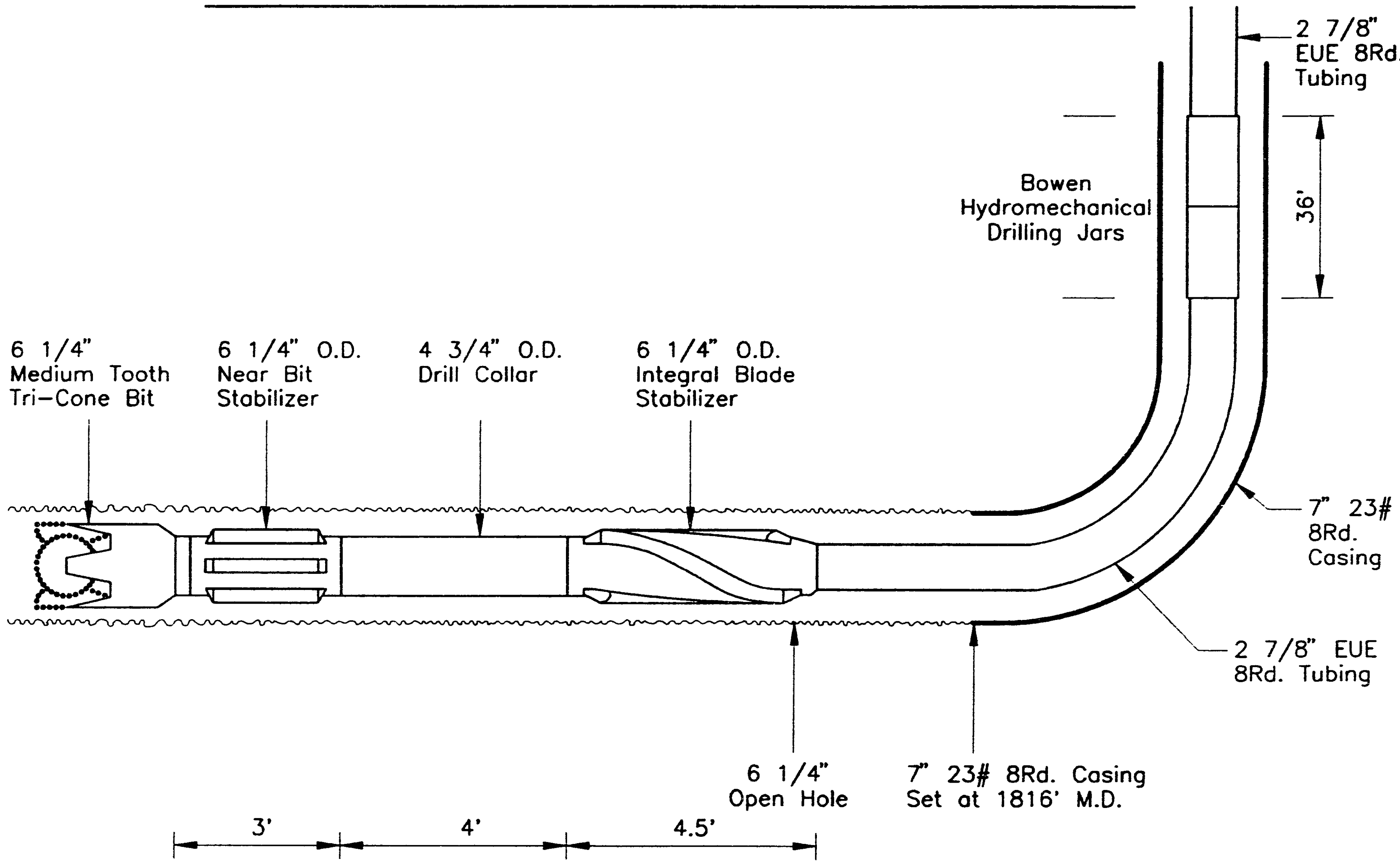


Figure 9
TORPEDO #2
TIME BOMB ASSEMBLY
Fiberglass Bull Plug Tapped w/ 1/4" Steel Rod Eye
8'x 2 7/8" O.D. - 2 3/8" I.D. Fiberglass Tube with Sealed Bottom
Threaded Fiberglass Cap w/ "O" Ring
(4) 2"x 7 1/2" 100% Gelatin Dynamite Boosters
(2) Zero Hour Duplex Electric Bombs enclosed in 8'x 2 7/8" O.D. Fiberglass Sealed Tube containing (2) 12 Hour Time Clocks
10' - 3" Fiberglass Nipple
3"x 2 1/2" Swage
207' Fiberglass T&C
Fiberglass Bull Plug
10'
8'
ROUGEOT OIL & GAS CORP.

Fiqure 10

TORPEDO #2 CLEANOUT DRILLING ASSEMBLY



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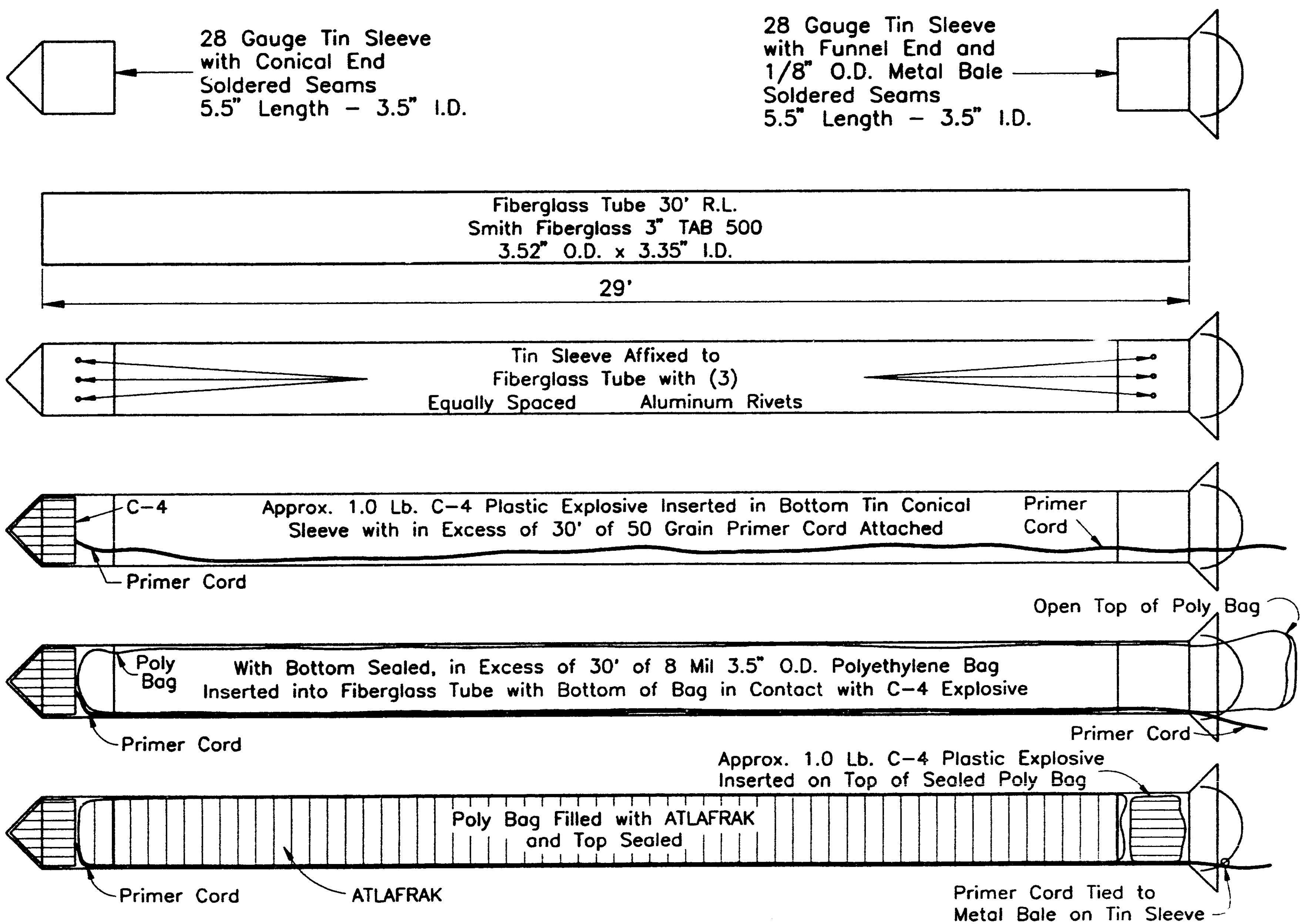
ROUGEOT OIL & GAS CORP.

Figure 11

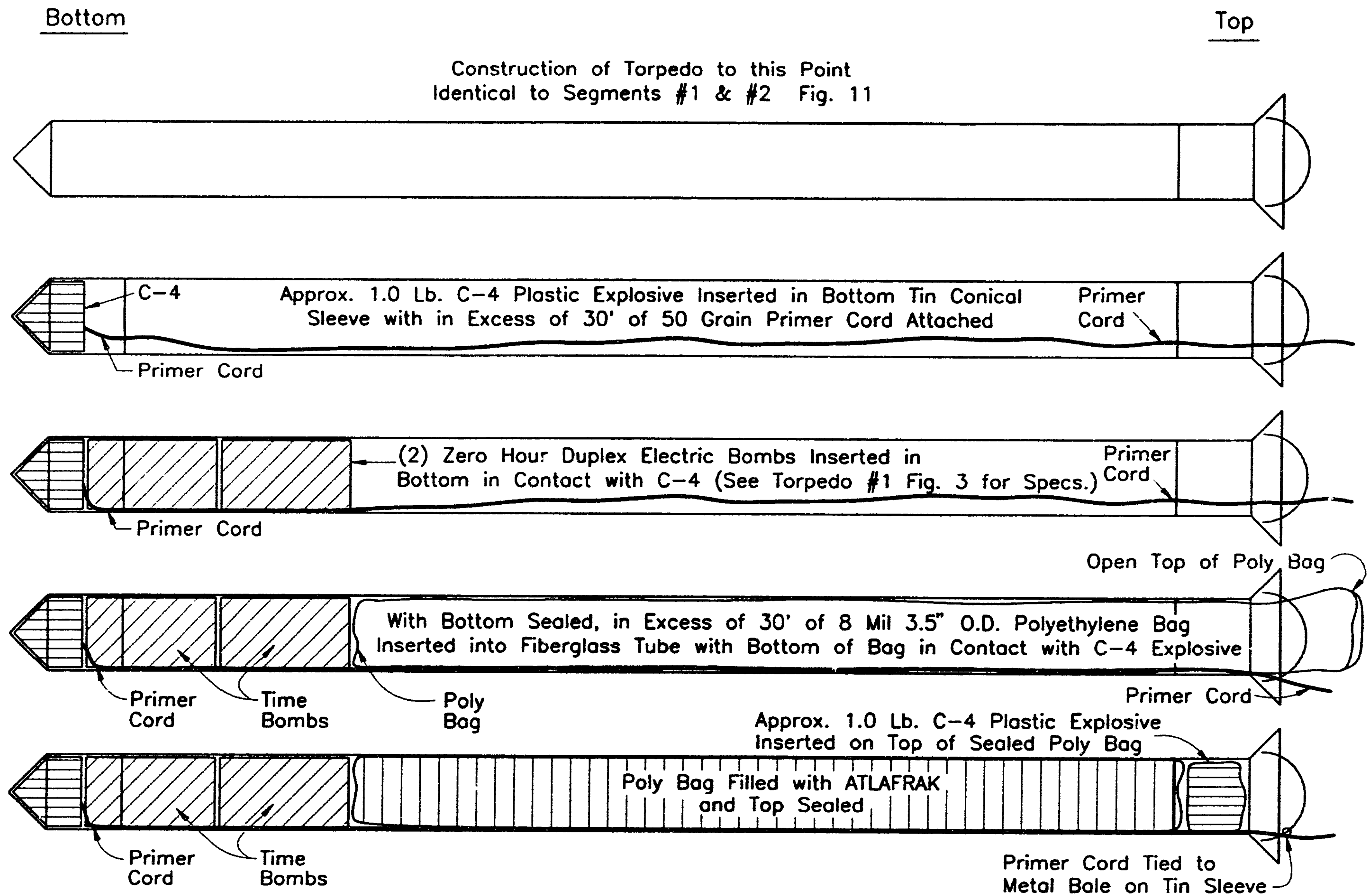
TORPEDO #3 - SEGMENTS #1 & #2



Fiqure 12

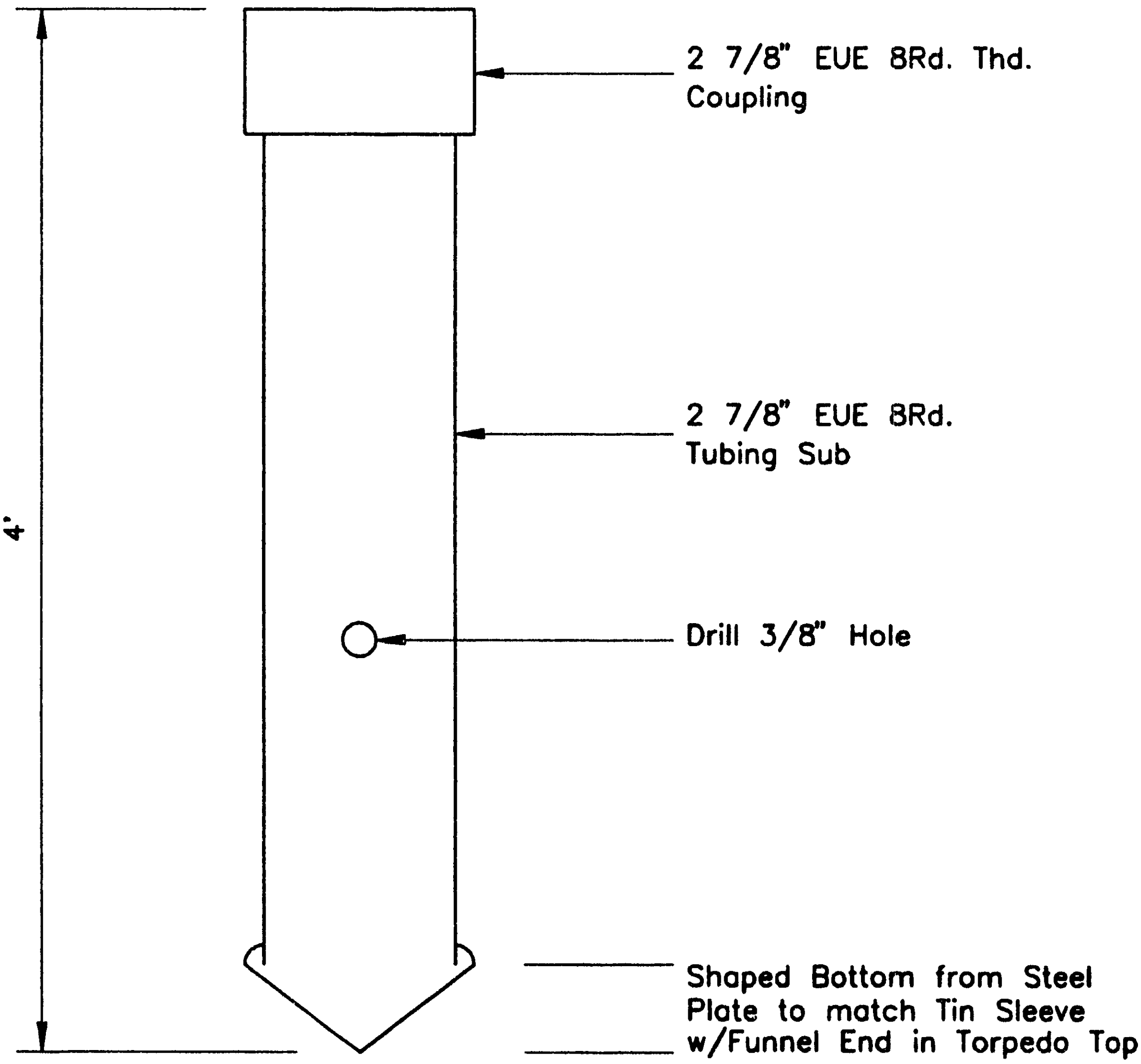
ROUGEOT OIL & GAS CORP.

TORPEDO #3 - SEGMENT #3
TIME BOMB ASSEMBLY



Fiqure 13

TORPEDO #3 PUSHING TOOL



ROUGEOT OIL & GAS CORP.

Wilson 25
Project Cost Analysis

Vendor	Description	Amount	Torpedo #1 Cost		Torpedo #2 Cost		Torpedo #3 Cost	
			Torpedo	Cleanout	Torpedo	Cleanout	Torpedo	Cleanout
Zero Instrument Co.	(2) Two time bombs	606.15	606.15					
Enloe Supply & Equipment	Backhoe to dig water line	100.00	100.00					
Enloe Supply & Equipment	Misc. parts - water hook-up	239.32	239.32					
Enloe Supply & Equipment	3 in transition	42.18	42.18					
A.H. Eichenberg	2' X 7" pipe	23.00	23.00					
Wal-Mart	Misc. materials	11.26	11.26					
Potter's Welding Service	Fabricate transition	100.00	100.00					
Stanley Filter Co.	New filter element	81.41		81.41				
Potter's Welding Service		425.00	425.00					
Gibson's Machine Shop	Parts for Bomb	288.60	288.60					
O.K. Tank Trucks	Haul-in tank	100.70		100.70				
Explo - Midwest	Atlafrak - Job #1	2633.98	2633.98					
Prairie Supply	Fittings	233.16	233.16					
C & G Oilfield	Poly pipe for Bomb	160.93	160.93					
D & R Hot Oil Service	Steam poly to straighten	110.00	110.00					
Sperry Lumber Co.	Misc. supplies	9.59	9.59					
Kiefer Pump and Supply	Seating cups for BHP	34.68		34.68				
Tri-am Acid and Fracturing	Pumping service	200.00		200.00				
Prairie Supply	Bushings	26.90		26.90				
Ed Emery's Well Service	Completion rig	3547.50	3547.50					
Kiefer Pump and Supply	Rod guides	86.42		86.42				
Enloe Supply and Equipment	Misc. connections	223.92	223.92					
Ed Emery's Well Service	Completion Rig	5717.50		5717.50				
Kurt Lauterbach	Dinner For Rig Crew	24.04		24.04				
Enloe Supply & Equipment	4 1/2 in connection	38.67	38.67					
Enloe Supply and Equipment	Acetylene rig	25.50		25.50				
Enloe Supply and Equipment	Rod Coupling	37.37		37.37				
Sperry Lumber	10 ft. PVC	2.04	2.04					
Ken Park	Dig Pits	75.00		75.00				
Carl Harmon	Nite watch	20.00		20.00				
U.S. Post Office	Postage to Smith F.G.	13.95			13.95			
A-1 Frac Tank Rental	Frac tank rental	275.00		275.00				
Conley Corporation	Time bomb carrier	274.40			274.40			
Highway 11 Supply	Connections	40.00		40.00				
Explo Midwest	Atlafrak	1026.44			1026.44			
Highway 11 Supply	Teflon Tap & gloves	62.39			62.39			
Highway 11 Supply	1 in. socket	1.58				1.58		
Highway 11 Supply	Welding machine rental	20.00			20.00			
Highway 11 Supply	Welding machine rental	22.03				22.03		
James Perkins	Haul Fiberglass	120.00			120.00			
Pruitts Tool	Grinding Tool - Fiberglass	3.17			3.17			
Hampell Oil	Fiberglass pipe dope	85.32			85.32			
Sperry Lumber	Screening, parts	25.49				25.49		
Highway 11	300# gauges	39.94				39.94		
Highway 11	150# railroad union	7.88				7.88		
Highway 11	10 ft. 1 1/4 pipe	19.34				19.34		
Highway 11	Ball & seat - BPV	27.08				27.08		
Gibson Machine	Mill slots in Gas anchor	200.00				200.00		
Ed Emery Well Service	Completion rig	4987.50			1462.50	3525.00		
Zero Instrument Co.	2 time bombs	639.00			639.00			
Ed Emery Well Service	Completion Rig	6981.80				6981.80		
Prairie Supply	Misc. Connections	87.90				87.90		
Explo - Midwest	Atlafrak	2313.46			2313.46			
Petro Data	Back-off pipe	450.00				450.00		
Prairie Supply	Parts to repair BPV	134.68				134.68		
O.K. Tank Trucks	Haul out water	896.67				896.67		
Oilwell Fracturing	Gel for circulating	517.27				517.27		
Bones Tool Co.	Jar rental	1306.25				1306.25		
Kiefer Pump and Supply	Convert pump to cup pump	374.99				374.99		
Triumph - LOR	Stabilizer rental	825.55				825.55		
Explo - Midwest	Atlafrak	1318.23					1318.23	
Explo - Midwest	Detonating Caps	192.08					192.08	
Zero Instrument Co.	(1) - Time Bomb	307.74					307.74	
Ken Alexander	(1) - Time Bomb/Tin Ends	471.02					471.02	
Alan's Well Service	Completion Rig	1595.00					935.00	660.00
Otto - Cupler	Bomb Expenses	431.01					431.01	
O.K. Tank Trucks	Fluid Hauling	99.69						99.69
Prairie Supply Co.	Stripping Rubber	122.27						122.27
Ed Emery's Well Service	Completion Rig	1423.56						1423.56
Tri-Am Acid & Fracturing	Pumping Service	340.00						340.00
Cimarron Mud Co.	Guar Gum Gel	250.00						250.00
Cimarron Mud Co.	Guar Gum Gel	250.00						250.00
		43554.50	8795.30	6744.52	6020.63	15443.45	3655.08	3145.52

Wilson 25
Production Analysis

Open Hole/Shot

	Footage	BOPD	BWPD	BFPD	BOPD/FT.	BWPD/FT.	BFPD/FT.
Natural Production	1052	5.82	2.50	8.32	0.0055	0.0024	0.0079
After Torpedo #1 Cleanout	627 (1)	2.40	12.00	14.40	0.0038	0.0191	0.0230
Increase Factor					0.6919	8.0536	2.9039
Torpedo #2 - Incremental Production	217	5.50	9.60	15.10	0.0253	0.0442	0.0696
Increase Factor					4.5814	7.9966	8.7985
Torpedo #3 - Incremental Production	87	1.68	4.50	6.18	0.0193	0.0517	0.0710
Increase Factor					3.4905	9.3494	8.9818
Wilson 25 production (current)		9.58	26.10	35.68			

(1) The polyethyiene debris from Torpedo #1 partially plugged the well approximately 652' from the casing point. All the oil production downstream of the polyethylene debris was cut off. However, up to 10 barrels of saltwater per day may be leaking through the polyethylene debris. For analysis purposes, the "increase factors" are based on the original well bore's oil and water production per foot amounts.

APPENDIX C

Wilson 25
Atlafrak Characteristics

CHARACTERISTICS:

Bulk Density at 20°C	1.32 GM/CC
Detonation Velocity	4000-6000 FPS*
Explosion Pressure	112,750 PSI
Explosion Temp.	3926°C
Gas Generation	16.01 Cu.Ft./Lb.
Absolute Weight Strength	1466 Cal/Gram
Absolute Bulk Strength	1935 Cal/cc
Recommended Use Temperature Range	-20 to 150°F
Water Pressure Resistance	At Least 600 Feet of Water
Dot Classification	Class A, Type 5

*Depends on Diameter

*U.S.GPO:1993-761-027/60068

END

DATE FILMED

3/31/93