BEFORE THE
OIL CONSERVATION COMMISSION
SANTA FE, NEW MEXICO
DECEMBER 12, 1960

IN THE MATTER OF:

CASE 2146 Application of Humble Oil & Refining Company for an oil-oil dual completion. Applicant, in the above-styled cause, seeks an order authorizing the dual completion of its D. H. Crockett Well #1, located in Unit C, Section 21, Township 15 South, Range 36 East, Lea County, New Mexico, in such a manner as to permit the production of oil from the Caudill-Wolfcamp Pool and the production of oil from the Caudill-Devonian Pool through the annulus between strings of 5½-inch casing and 2½-inch tubing and through 2½-inch tubing, respectively.

BEFORE:

Elvis A. Utz, Examiner.

T R A N S C R I P T O F P R O C E E D I N G S

MR. UTZ: Case 2146.

MR. MOORE: Case 2146. Application of Humble Oil & Refining Company for an oil-oil dual completion.

MR. BRATTON: Howard Bratton, appearing on behalf of Humble Oil & Refining Company. We have one witness. I ask that he be sworn.

(Witness sworn)

J. E. WILLINGHAM,

called as a witness, having been first duly sworn, testified as

follows:

DIRECT EXAMINATION

BY MR. BRATTON:

Q Will you state your name, address and occupation?

A I am J. E. Willingham. I am a Senior Superintendent Engineer of Humble Oil & Refining Company. I live in Midland, Texas.

Q Have you previously qualified before this Commission as an expert witness and had your qualifications made a matter of record?

A Yes, sir.

Q Are you familiar with the application in the instant case and the subject well?

A Yes, sir, I am.

MR. BRATTON: Are the witness' qualifications acceptable?

MR. UTZ: Yes, sir, they are.

Q (By Mr. Bratton) Will you explain, Mr. Willingham, what Humble is applying for in this case and the cause of the application?

A We are applying for an oil-oil dual completion, and it is single string dual. I wanted to introduce this in this way. We have deliberated in calling this hearing. We did not call it casually, and we recognized that many similar requests in the past have been requested and have been denied by the Commission, and we are not saying that our request is something that should be uni-

versal because we ourselves limit this type of installation to selective wells. What we are hoping to demonstrate is the fact that there are special cases which do require this type of installation in order to have an efficient operational system. I am going to show in this hearing six major points: First, that the new developments in our work on techniques make this type of installation, that is, single string dual, very attractive. Two, that new development in corrosion preventions are suited to this type of installation in that you can inhibit corrosion in the annulus. Three, that due to the fact we have 5½-inch 23 casing, we would suffer a severe loss of productive capacity if we used parallel strings instead of single string. Four, due to our structural position, if we don't get the oil we will be drained. Five, that the efficiency of oil production in the tubing casing annulus is actually better than it is in the single string, for example, in 2½-inch tubing. And six, that if we are forced to make a parallel tubing dual well, actually, it will result in us leaving commercial oil production in the reservoir. In that sense, it would be waste. And I realize that this is a big bit to chew off in a hearing. I am going to try to summarize it and keep to the major points, and I realize that some of the things I am going to be telling you, in all probability, you might have read about them, they have probably not been proceeded in the hearing before where they requested a single string dual. That is my introduction.

(Whereupon, Applicant's Exhibit No. 1 was marked for identification.)

Q Will you refer to your Exhibit No. 1, Mr. Willingham, and explain what it is?

A Exhibit No. 1 is a map showing the position of the well. It is located in red. And I have drawn on this and I want to point out these have rough contours. We had not verified the contours, we did not want to use those in the exhibit. What it does illustrate, this is the contour of the Devonian, that is our wells circled in red, it's low at the structure, and I want to emphasize that in the Devonian, if we do not get the oil now, since this is an oil drive reservoir, this oil will be swept out of the way and we will lose it.

Q What is the location of this well, Mr. Willingham?

A It is 660 feet from the North line and 1980 feet from the West line of Section 21, Township 15 South, Range 36 East in Lea County, New Mexico.

Q What formation are we talking about now?

A We are talking about the Devonian and Wolfcamp.

Q This is the Caudill-Devonian or Caudill-Wolfcamp?

A Yes, it is the Caudill Field.

Q There is no question but what the Humble well is downdip?

A That is true.

(Whereupon, Applicant's Exhibit No. 2 was marked for identification.)

Q Turn to your Exhibit No. 2, Mr. Willingham, explain what it is.

A This is just a schematic sketch of our dual completion installation. As you will see, it's a single packer which we are setting. The packer we have perforated at intervals with 2½-inch tubing. Without going into detail, you will notice that the top of our cement is 3700 feet, which is well above the perforated intervals, and we will have a seating nipple with the sliding sleeve mandril you have above that so we can go in and plug it off, and so we can swab it off at 2½, and we will go back in and close our sliding sleeve. I don't believe I will go into any more detail, it's self-explanatory.

Q What kind of reservoirs with regard to the kind of mechanisms?

A The Wolfcamp is dissolved gas drive, and on the Devonian is water drive.

Q What are the bottom hole pressures of the two reservoirs?

A The Wolfcamp was, on last measurement, was 3590, and the Devonian was 3260 pounds per square inch.

Q Do you have 5½-inch casing in the well?

A Yes, sir.

(Whereupon, Applicant's Exhibit No. 3 was marked for identification.)

Q Turn, then, to your Exhibit No. 3, Mr. Willingham, and explain what it is and what it shows.

A This is a history of our well showing the decline in oil production, increase in water production, and the reason this is being presented, it illustrates the fact that first of all we have taken the well just like it is producing in the Devonian. It is now pumping through 2½-inch tubing, and you will notice we predict that well will reach the economic limit over on the right-hand side, lower side, at 13 barrels per day in early 1964, the beginning of 1964. And I have done some calculations, and you can't make a detailed engineering calculation, you've got to assume your declines, but what this indicates is if we have to go to inch and a half tubing, we will suffer a 38 barrel drop in our oil production, which will reduce our life of our well by two years and will result in us leaving approximately 15,000 barrels of oil in the reservoir.

(Whereupon, Applicant's Exhibit No. 4 was marked for identification.)

Q Turn, then, to your Exhibit No. 4, Mr. Willingham, and explain it.

A This Exhibit is in two parts, the first part shows Crockett No. 1, which is the offsetting well in the Caudill Field, and it shows several well tests, the most recent being in October, 1960. We are pumping 439 barrels of salt water and 60 barrels of oil for total fluid of 499 barrels per day. The second page illustrates two different pumping levels. We think our pumping level is going to stay around 5,000 feet. We have calculated producing pumping volumes for 10,000 just for the sake of illustra-

tion. But looking at the 5,000 for the pumping level, if you will notice with 2½-inch tubing we can rod pump 602 barrels per day. If we have to go to inch and a half tubing our production will drop to 210 barrels per day. Now, this is fluid and if you will notice, since we are producing now 499 barrels a day, we will take a very substantial drop in our productive capacity.

Q This, then, referring to your previous Exhibit, explains why 2½-inch tubing is required to pump the Devonian in order to protect your correlative rights and prevents the leaving of this 15,000 barrels in the reservoir?

A Yes, sir, that is true.

Q Then, the Devonian is a water drive, and this is down structure?

A That's right.

Q Anything else you would care to point out in connection with Exhibit No. 4?

A I might point out that if we run parallel inch and a half hydrill we will have to spend $24,000 more for tubular gas than we will for the present installation, and another consideration, you can drill another well, but another well would cost us approximately $300,000 and would be extremely difficult to justify the drilling of it from an economic standpoint.

MR. NUTTER: You said it would cost twenty-four for the hydrill. What size hydrill?

A Inch and a half.

MR. NUTTER: To both strings?

A Yes, sir. In other words, that is two strings of inch and a half as compared to one string of 2½.

Q (By Mr. Bratton) Is that all you have in connection with Exhibit No. 4?

A Yes, sir.

(Whereupon, Applicant's Exhibit No. 5 was marked for identification.)

Q Turn, then, to your Exhibit No. 5, Mr. Willingham, and briefly explain it, if you can.

A Exhibit No. 5 is more or less the history of multiple completions and as far as duals are concerned, and the main reason I am giving you this, it's something to talk from. We've got several different sketches in the back part of it. If you are interested, it does have the history of the development of dual completions. Turning back to Figure 12, now, I know that you are not affected by what happened in Texas. The reason I am using this Exhibit, this is where I have had my experience and where, when I talk about my experience, I am going to talk about it in Texas, but actually, we don't have anything in New Mexico to compare it to. This shows the number of dual completions if it were made in Texas, oh, from 1940 to 1958, and you will notice, starting in 1950 is when they really became popular, that in '48 and '49 the reason there weren't very many made was because when they first started, if they didn't have adequate packers, they had a lot of

operation problems. I remember it wasn't until 1950 that the industry had the equipment to really dually complete its wells. From 1950 to '56, you will notice that there were, in '53, were three hundred fifty wells completed in this nature during the year, and by 1956 this had grown to better than one thousand wells per year.

Following this, in 1957 and '58, and from then on the parallel string tubing came into being and part of these are parallel string duals from 1956 on. And I wanted to state to the Examiner that I have had personal experience with approximately 150 wells of this nature in twenty different fields, and I can say with real sincerity I think that is an installation that provides the industry with a tool that will help itself to produce some kinds of wells. I am not saying we should have it in all kinds of conditions within the abnormal pressure. If we had sand surrounding the formation, we would not want this type of dual completion.

The next figure is Figure 13, and this is the type of installation we are talking about. This is a single string, single packer dual with sliding sleeve mandril, and below this is a landing nipple. And the reason for this, we can block off the Devonian which is the lower completion and swab the Wolfcamp and the upper and then close our sliding sleeve and pull the plug and we've got our zones separated, with this type of installation with the 5½. If we had one and a half tubing, we couldn't do many of the things we will be able to do with this installation. For instance,

we can go through this with a small tubing string and do workover work we can squeeze with the perforation through this tubing string. We can go in and wash sand through this tubing string.

Turning to Figure 14, this is another type of single string dual in which you use two packers. The advantages of this installation is you can cross over from one zone to another and as shown in "C," you can do wire line work overwork with this tool without moving the workover rig on it. That is, you can squeeze cement, you can wash sand, and you can do several different types of installations.

Figure 15 is the type "F," is a parallel string dual, and you will notice that we have two different types here. We have the single packer and the dual packer type. I wanted to point out one thing while I am here, if we had the type installation shown in "A" and we were producing this well and we were not a prudent operator, we could have corrosion in this installation as well as we could, turning back to Figure 12, because we've got this exposed for the corrosion. With the dual parallel we've also got this one exposed to corrosion, and I'm not saying that the type "A" parallel string dual isn't a good one because it is, because you need to vent gas and circulate hot air and paraffin control and many other things I think it's a good installation, but what I'm pointing out is some of the problems of this type of dual are similar to the one we have in our other type. That, briefly, is all of this, Mr. Bratton. I thought we might come back to this.

(Whereupon, Applicant's Exhibit No. 6 was marked for identification.)

Q Let's turn to Exhibit No. 6, Mr. Willingham.

A Exhibit No. 6 we had our, in Crockett 2 we have a Wolfcamp producer, and we felt that one of the Commissioner's concerns is, naturally, corrosion. So we had this gas analyzed to see how corrosive it was, and, as you will notice, the CO^2 is a little larger than one percent better than volume on 024. The hydronsil of it is very minor. I'm not saying this gas isn't corrosive. I will say that generally with this type of material in the gas you would not expect severe corrosion at all, and you would expect this could be very easy to handle.

Q What if you do have corrosion, Mr. Willingham? Is there any technique for controlling it?

A Yes, sir, there are several. I wanted, if we could, to turn back to Figure 12 on the Exhibit we just passed, and I want to illustrate this is one thing we can do. Excuse me, Figure 13 -- I beg your pardon. We could get a back plug in your landing nipple, open our sliding sleeve mandril and pump oil with a corrosion inhibitor out into the formation, for I am sure that you have been hearing more and more about this type of corrosion inhibitor. This is one step that we can take. Another step we can take is instead of forcing it into the formation, we can even circulate this inhibitor. Now, we don't feel on this particular well we are going to do this, but we can do it. Another thing I wanted to show

when, for unexpected severe corrosion, another thing we can do, the industry now has wire line tools in which when you can have a side pocket mandril and put a tool like this into it, and you can pump, it has a check valce, and you can go in and regularly pump in an inhibitor in the formation by setting your backing plug and use this approach rather than your sliding sleeve mandril if you wanted to. Another approach, you can take -- these were on my desk, and my supervisors accused me of having taken tranquilizer pills -- I wanted to show you some of these. It doesn't hurt to handle them. This is what you call a pellet type inhibitor. This is a new thing to the industry, and you can get these in various sizes, you can get them granular if you want to. In other words, you can get them of this nature (indicating). This is a new thing and hasn't been on the market very long. But we have known for several years they have used string inhibitors when we drop strings down the tubing, and they're very good in inhibiting corrosion, and you can take the same approach with the pellets or granular material. You have a lubricator and take your lubricator put these pellets into it, put some oil into it and pull it into the annulus and then having this drop and shutting your well in for several hours.

Q Mr. Willingham, recognizing that the Commission, of course, is very concerned about the question of corrosion, how would you detect corrosion, how could you detect it before any damage is done?

A There are several ways you can do this. For one thing, you can inspect the choke on the well and your flow line, where it enters the flow line, you can locate your wellhead equipment. A better way would be putting a coupon in and your well produced, say, after a month or two or three months, you can take this coupon out, and it would be put in with a designated weight. You can weigh it, then when it, for example, after you got through, weigh it again and see how much metal you lose and by that way you would know you were suffering corrosion.

Q If the Commission should so designate, would you be willing to put in these coupons and report the results of periodic inspection of them?

A Yes, sir, we would be glad to, if the Commission took that approach. I want to emphasize I really feel with the test the range is we are not going to have corrosion. I can understand the Commission's concern of getting someone that isn't a prudent operator with this type of installation and let it go on and not pay any attention to it. If the Commission decided to, we would be glad to put the coupon in.

Q For my information, Mr. Willingham, would you intend starting to use your pellet inhibitor immediately, or would you intend putting your coupon in and evaluating the BGS of the gas?

A We would, first of all, we wouldn't inhibit until we saw we were having corrosion, and then we would put the inhibitor in and study the effects of the coupon to see how often we had to

treat the well to retard the corrosion.

Q You would be willing to do this at such periodic intervals as the Commission might desire to detect whether you are getting into corrosion problems, and if you find that you are, how would your method of inhibiting it work?

A Yes, sir, we would be glad to. Mr. Bratton, we also have some literature on these pellets. As you notice, I have just -- they got them in various different sizes, and this is some literature on it. There is more than one company that has these on the market. I will leave this, I wasn't going to leave it as an Exhibit, because it's advertizing literature. I thought you might be interested in knowing these are on the market as a commercial product, it's not something we have gotten up to treat a special well.

Q You believe, Mr. Willingham, that there is small likelihood of severe corrosion in this well from production through the annulus, and if there is, with these methods now available, you can inhibit it?

A Yes.

Q And with the methods of detection, that you could detect it early enough to prevent damage to the reservoir --

A Yes, sir.

Q -- or loss of oil through a break in the casing?

A Yes.

Q Is this corrosion treatment problem, if there is one, in

your proposed installation, similar to the problem you would have in a parallel string dual completion such as in Figure 15, example A?

A Yes, sir, in fashion, and if you treat that well with this type of corrosion inhibitor. Commonly, though, what we use in there is a string of this material, about this large and about that long (indicating), and drop these strings down so you would have to follow putting these in separately. It's easier to put it in one long string.

Q Is there anything else you would care to state about the question of corrosion, Mr. Willingham?

A I believe I have covered it.

Q Now, recognizing that there might be a question in the Commissioner's mind as to the efficiency of it producing -- of it producing through the casing tubing annulus, have you looked into the question of whether you will lose the efficiency of your producing mechanism by producing it into the annulus?

A Yes, sir. I'll have to explain what I did. I went to the literature and found that it's very limited in this nature. Now, as I say, I know from field experience and I am confident I looked at many well tests, I never noticed any difference between flowing wells in the tubing and wells flowing in the annulus in this size installation. But what I had to do finally, I had to go to Dr. Kirkpatrick at Texas University and use some material he had for gas lift. And I can leave this for an exhibit if the

Commission would like. I did an article on a list of people in Houston whereby I marked that portion that refers to the efficiency.

Q If you would please mark it as Exhibit No. 7, Mr. Willingham.

A All right, sir.

(Whereupon, Applicant's Exhibit No. 7 was marked for identification.)

Essentially, what we do -- Before I discuss this graph, I want to explain Table 2 which precedes this. I might talk where two of us can see it. We took a well as completed in the Wolfcamp and assumed it was producing in the tubing. This well was producing 165 barrles per day with the GOR of 3150. What we did, we assumed that we were going to operate at 10,000 feet, just as an illustration, and we went to the curves on the Kirkpatrick which showed that with a constant use of energy, in other words, using the 3100 tube, 11 foot per day barrel, you can produce 215 in the 2 7/8 5½-inch annulus. In other words, if you have less friction, you can actually produce more fluid.

Looking at it the other way, though, what it would mean to you in ratio, you can use the curve to show that theoretically the ratio would drop from 3150 to 2300. We all know gas breaks out, you cannot begin to be able to reduce this ratio. What this illustrates is that is an official mechanism. I want to point this out, we state this, that in your letters we don't know and the industry

doesn't know it because the study has never been made, and you get larger in your annulus. In other words, if you went to 95 and the string of 2-inch, it's conceivable you would have slippage in your oil, and water would begin to drop through your gas, and you wouldn't produce it out of the hole. But we know from experience that with this size installation we have been able to produce it without having this problem. Now, this curving, without going into details on it, at the bottom we have our lifting depth, and on the left-hand column we have the least relative producing rate. For example, if you will follow the 2½-inch curve, that is this curve right here, down to the 10,000 foot level, you will notice this has a relative rate of .77, whereas your 2½ and 5½ installation, that is this one right above it, has a relative producing rate of 1, which means that if you take one over .77 times 165 barrels of oil it is producing, you will end up with 215 barrels per day. And this is very complicated, I do know,as the curves have been verified with field results. I want to mention this one thing to the Commission; this is something to think about. There is one way of really telling on your efficiency, in other words, if we were granted permission to make a 2½-inch by 5½-inch annulus producing after its GOR was higher than the other two wells in the same reservoir, we've got two offsetting wells, if that ratio was higher we would know this was inefficient. I am confident we will find, though, that the ratio will be the same, and that concludes my point on that.

I would like, if it's permissible, to leave this one copy. I got this Air Mail Special over at the office, and this is the only other copy I have.

Q Now, Mr. Willingham, summarizing on the two problems that undoubtedly concern the Commission with respect to this type of installation, as to the corrosion problem, you are confident that you could detect, by means of these coupons, corrosion prior to the time it has done any material damage in the well?

A Yes, sir, we could.

Q And you would be willing to put in these coupons and submit the results of the periodic inspection to the Commission office there in Hobbs --

A Yes, sir.

Q -- or in Santa Fe, as desired?

A Yes, sir.

Q You are confident by means of improved techniques in corrosion inhibition that if there does develop corrosion, you could inhibit it?

A Yes, sir, that is true.

Q And you would be willing to demonstrate to the Commission or show to the Commission the results of tests to show the effectiveness of the corrosion inhibition methods which you propose to adopt --

A Yes, sir.

Q -- if corrosion should occur?

A If the Commission desires, we will certainly do it.

Q Too, as to the question of dissipating the reservoir energy, you are confident that this installation in this size hole will not dissipate the reservoir energy in the Wolfcamp?

A Yes, sir, I am.

Q And also as a result of comparing the GOR in this well with the adjoining wells, you are confident that you can detect if by some chance there is a dissipation of the reservoir energy?

A Yes, sir, we could. In other words, we will have to be testing the wells anyway, and it will be very simple to compare the erosion.

Q If the Commission should permit this installation, would you be willing for the Commission to provide in its order that it is keeping the case open for such further orders as the Commission might make depending upon the results of the development in the well?

A Yes, sir. I can certainly understand the Commission's attitude because of the industry implication of this thing.

Q Now, also, Mr. Willingham, you do not recommend this type of installation as a general rule, and you do not believe that the Commission is granting it under this circumstance would be any precedent for widespread adoption of this type of installation?

A No, sir. I will say Humble itself would not want this type of installation in many different types of wells and to re-emphasize it, would not want a well making sand, or that you fraced,

or a well making formation sand, or a well you fraced with a lot of sand, and dissipate sand problems. I do think you object to a pressure will nor a well that showed from test it had quite a considerable hydrogen sulfate or CO^2 in it.

Q Do you believe in this well this type of installation is essential to protect Humble's correlative rights in the two reservoirs?

A Yes, I do.

Q In your opinion, the granting of this would be in the interest of conservation?

A Yes, sir.

Q Do you have anything else you would care to state in connection with this application, Mr. Willingham?

A No, sir. I believe I've covered all I wish to say.

Q Were Humble's Exhibits 1 through 6 prepared by you or under your direction?

A Yes, sir.

Q And Humble's Exhibit No. 7 is a reproduction of a letter directed to you?

A Yes, it is a letter that was sent to me.

MR. BRATTON: We would offer Humble's Exhibits 1 through 7 in evidence.

MR. UTZ: Without objection, the Exhibits 1 through 7 will be entered into the record.

(Whereupon, Humble's Exhibits Nos. 1 through 7 were received in evidence.)

CROSS EXAMINATION

BY MR. UTZ:

Q What has your second point on the type of completion or type of well, as you would not want to use this installation in, to do with pressure?

A Abnormal pressures.

MR. NUTTER: By that, I suppose you mean extremely high pressures?

A I believe with 3,000 or 4,000 or greater pressure, this particular well would have 2300 casing, which is quite strong, but I think even with that, I think if you were getting up in pressure over 4,000, you would not be prudent, you would stand a chance of having a blowout if you did develop a leak.

BY MR. NUTTER:

Q Mr. Willingham, you stated if this application were not approved that Humble would be drained and be deprived on its fair share of the oil in place. Which reservoir were you referring to?

A The Denonian.

Q How about the Wolfcamp? Are you being drained in the Wolfcamp at the present time?

A I feel we could be, I don't believe we are being drained at the present time, however.

Q As a matter of fact, how many wells are completed in the

Wolfcamp?

A We have two.

Q Does anyone else have any wells?

A Mr. Nutter, I can't answer that. I don't know. I feel sure, though, that there will be some completions made in it because there are many wells in that area, and they should have the Wolfcamp in them.

Q I see. Now, here on Exhibit 3, Mr. Willingham, where you have drawn these red lines in here on this production decline curve, you show a drop of 38 barrels per day.

A Yes, sir.

Q In the amount of oil you would be recovering, is that -- what is that drop of 38 barrels per day based on?

A It's based on the well tests that I showed in Exhibit 4.

Q In Exhibit 4?

A Yes, sir.

Q Where at the present the latest test indicates you are making about 60 barrels of oil and more than 400 barrels of water per day?

A Yes, sir.

Q Well, now, over on Page 2 (f) Exhibit 4, you show that by the installation of 1½-inch tubing pumping fluid from 5,000 feet you would recover 210 barrels per day maximum capacity. Is that the figure that you were using to show this 38 barrel per day loss?

A Yes, sir. I have the calculations with me, as a matter of fact.

Q Well, I was just interested in what tubing size you were referring to.

A Inch and a half.

Q In other words, the red figures here indicate the production that you would obtain using 1½-inch tubing?

A Yes, sir. Mr. Nutter, I want to say this, you can't make a real accurate estimate of this, I mean you can make a general estimate. As you well know, your fluid levels and you have well changes, and your amount of water changes, and, but with the data we had I made the best estimate that I could.

Q Water production is actually going down here at the present time, too, is it not --

A Yes, that is correct.

Q -- by the curve on Exhibit 3?

A Yes, sir.

Q Mr. Willingham, you stated that,in your opinion -- first of all, do you know when the parallel type of tubing string dual completion was first used in Texas?

A I asked that question because I felt someone might bring it up. I was told in Houston that they went back and looked and they said they felt they got started in 1956, and it gradually grew in popularity to where it has displaced many of the single string duals.

Q Do you know that you showed 1958 as being the greatest year here, and some 1350 dual completions authorized that year? Are all these oil-oil dual completions?

A No, sir.

Q Some have gas completions?

A Yes, sir, and no way to tell from the records, we had to take what we could, no way to tell from the records which are which.

Q So if a man had a gas-oil dual completion, it would be reflected on this chart here?

A Yes, sir, all is parallel string there, that is why I had -- I said 1956 backs the single string duals.

Q Well, now, when you were comparing the efficiency of the installation on Page -- Figure 13, with the efficiency of Figure A, as far as corrosion resistence was concerned --

A Yes, sir.

Q -- you were attributing the corrosion on the gas that would be in the casing, I presume. Now, would the liquids have a corrosive effect also?

A Definitely, I think you would be more worried by the gas than you would by the oil.

Q If you had the installation shown in Figure 13, would you have -- would you be producing oil up through the annulus?

A Yes, sir.

Q And if you did have corrosion, and you got a leak, you

would have an opportunity for oil to escape from the annulus into some porous formation, would you not?

A Yes.

Q Would you have that condition in Figure 15?

A Yes, sir, you would.

Q Supposing your tubing fluid levels were standing just above the bottom of the tubing there in 15, and you would have gas in the annulus on up above, you would have your fluid production coming on up through the tubing, wouldn't you?

A Yes, sir, that is true.

Q So if you did develop a leak on up here, the most you would lose would be some gas into the porous formation?

A That is true, that is reasonably true, that is right. You will notice in one Exhibit we showed cement up to 3700 feet, and there is one thing, if you did develop a casing leak above 3700 feet, you would be able to detect it, in between your protective string and your oil string you would develop pressure there.

Q Does the intermediate bottom go below 3700 on this well?

A I think I can tell, I don't know that offhand.

Q Our files would reflect that, I am sure.

A Yes, sir. Within our hard rock country, even if it does not, I am sure, I am confident it does go below 3700 feet for that deep a wildcat because it was 14,000 feet even if it did I feel that pressure would work up between the oil string too, and the protective string, and you would find gas bleeding, or you would

have a pressure gas gauge for protective measure.

Q Now, you stated, Mr. Willingham, you observe 1550 duals in twenty fields. Were all of those duals, this type of completion?

A Approximately -- I am estimating here, I would say approximately two-thirds of them were oil-oil duals.

Q And you never saw one that you thought was less efficient than tubing flow?

A No, sir, I never did.

Q Have you ever made any recommendations to Humble they complete a well without tubing in it --

A Yes, sir.

Q -- with large diameter casing?

A Not with large diameter casing because there,I don't deny there is going to be a point of where you are going to have slippage, and as a rule the Commission in Texas will not allow you to run a well with tubing in it above where it is 4½ inches or larger.

Q I thought we might get to the slippage in a minute, Mr. Willingham. Now, that Exhibit that shows Mr. Kirkpatrick's graph --

A Yes, sir.

Q -- now, you stated that was based on constant source of energy, is that correct?

A One of the calculations was,yes, sir.

Q And that chart was derived for the purpose of making gas lift calculation primarily, especially where in the gas limit you

do have a constant source of energy, is this correct?

A When in a continuous flow, you would.

Q At the most, it would be intermittent on the regular schedule, is that correct?

A Yes, sir. In other words, if this was based on continuous flow, you assume we had a constant amount of gas going in all the time.

Q You stated this was a solution gas drive reservoir here. In your experience, Mr. Willingham, have you not had solution gas drive reservoirs that did not flow in a regular manner but flowed in such a way it appeared there -- that either the energy was coming into the well bore intermittently or breaking out in the well bore and the well was flowing in solution?

A Yes, I have known wells --

Q Do you think a chart like this would be applicable in a place where the well is flowing in solution?

A Well, Mr. Nutter, to be quite frank, I am very desirous of having better data than we had. Unfortunately, this was all that was available.

Q As a matter of fact, the actual data that is available for multi-phase flow through vertical tabulation is rather scanty, is it not?

A That is true.

Q So it's almost impossible to determine that annular flow is as efficient as tubing flow?

A The only way that I think we can tell is to measure our gas-oil ratio after we make the installations. That ought to show up readily if we are having slippage, and the oil is dropping back throughout.

Q Mr. Willingham, to compare annular flow with tubing through there, a gauge size string of tubing, you would have to have two identical wells completed in the given pool at identical times, would you not?

A True.

Q Now, is there any other well in this pool that could be put on Wolfcamp production at the same time this one would be?

A No, sir, I don't think we could, but I will say this, though, that some of it, in fact, both of the Wolfcamp completions are fairly recent, and we should have, after the well was produced for a month or two, they should have relatively the same conditions, but I understand what you are saying is that if we have, say, Caudel 1 and Crockett 2 has pulled down, they could very easily have a gas breaking out at a higher ratio which could indicate it could give you a false assumption.

Q As a matter of fact, Mr. Willingham, from the Commission's records, it appears that the producing GOR on the Crockett No. 2 which is the other Wolfcamp well --

A Yes, sir, I have those there.

Q -- has gone up from 1200 in the month of August -- producing GOR, gone up from 1200 for the month of August to 1545 ap-

proximately in September and October over 1700 in October, this is characteristic of solution gas type for the GOR?

A The gas breaks out, then you have a gradual rise in GOR until it peaks out, and then it declines.

Q Then, it would fall?

A Yes.

Q Well, now, all of your calculations for the amount of production you can get from the Devonian pool were based on inch and a half tubing?

A Nominal inch and a half.

Q Is it possible to equip this well with any size of tubing larger than inch and a half, and then run another size of tubing to the Wolfcamp?

A You could get a special, get 2 and 6/8-inch tubing and one and a half string and produce the Wolfcamp through the 2 and 6/8, which would give you a little more capacity. You use inch and a half because it was common through -- further, if you would turn to Exhibit 3, this rather illustrates the point. We changed out in 1958 our 2-inch tubing to 2½, and you will notice what a rise we had in our bottom hole -- our oil production and our water production. Later, the well was put on pump.

Q You undoubtedly changed the size of the pump also at that time, didn't you?

A Yes, sir. It shows in 1959 we increased the size of the plunger and again we had a small increase in oil and water produc-

tion.

Q Well, now, would it be possible to put in a,take a string of something like 2½-inch hydrill tubing and install this well and then put a small diameter macaroni string into the Wolfcamp?

A The problem would be that your small string would be so small that you would have extreme difficulty in swabbing the well in, you would have considerable friction losses, when we get into this tiny string, and you've got a very limber string, if it ever broke off, you would really be in a mess with your well.

Q You could put a sliding door collector in your large diameter to swab the upper zone in, couldn't you, the way you do here on this installation?

A You could, yes, sir, but you would not be able to. Say you could cut paraffin, it turned out you had paraffin, the problem is that you are limited to very tiny tools, which is very much of a problem. The trouble with the 5½-inch, this is such a deep well even such heavy 5½-inch our take is very much reduced, we don't have very much room.

Q Now, can you pump the Wolfcamp formation with your proposed installation?

A No, sir, you cannot unless you abandoned the Devonian. You can set a plug in your seating nipple and open the sliding sleeve and pull through the piping string.

Q What would you do if you had to pump Devonian,Wolfcamp prior to the time of this economic limit on the Devonian?

A You would have to make the decision at that time whether you wanted to prematurely abandon the Devonian or Wolfcamp because you wouldn't be able to produce both at the same time. Now, there are some dual zone pumps that you can run that will produce both of them at the same time, but that is, they have to, in order to use dual zone pumps, you've got to have wells of a certain type that the dual zone pump is suited for, and, unfortunately, this isn't the type. One of them is producing great volumes of fluid, then the others would not be; and as a result you would have an installation that would be very difficult to make operate properly.

Q Now, you've got a two and one-quarter inch plunger in this pump at the present time?

A Yes, sir.

Q How many strokes is this unit operating?

A I'm not prepared to say, I don't know offhand.

Q Would you furnish us with that information?

A Yes, sir, I certainly would.

Q Could you also furnish us with the length of the stroke?

A The length.

Q I would also like to know what size sucker rods you have in this well.

A All right. Size sucker rods, number of strokes per minute, and the length of the stroke.

Q I presume you have a two-quarter inch plunger?

A I will verify the plunger size.

Q One further question, Mr. Willingham. You listed a number of conditions under which you stated you wouldn't recommend this type of installation be made, is this correct?

A Yes, sir.

Q How is the Commission to know in advance, when an applicant comes in and requests an annulus tubing dual completion, whether those conditions are going to be encountered or not?

A Well, the only way that I know is to ask those three questions. Do you anticipate formation sand, production or sand problems when you frac? Do you anticipate abnormal pressure is going to be present, and also have a test of their gas as we present it.

Q Well, now, supposing they don't know or they say they don't anticipate they will have these problems, and then the problems arise, what would you recommend that the Commission do then?

A I would think they would have to tell you whether these conditions existed before they could make that type of installation.

Q They might not anticipate is the point I mean, but then the conditions did arise, what should the Commission do in a case like that, then? The man is going to come in, "Well, I spent my money, I got this dual completion made, and I've got these conditions. Now what do I do?"

A Well, you would have quite a problem. If you had the

corrosion, of course, you can inhibit it with the technique that I have. Then when this is abnormal pressure, if he found a pressure like that, he just -- if a prudent operator, he should not make the installation.

Q Then, supposing on the third factor he went ahead and made the installation and then encountered sanding of the well?

A Mr. Nutter, there is one thing an operator could do if he didn't know the conditions that he was going to get in, he would make a double packer dual which would allow him to put his bad zone in the tubing.

Q Even if it were the upper zone through a crossover?

A Yes, sir. In other words, if it's unknown, then he doesn't know. The Commission could insist on the two-packer dual, so that he would know if he did get adverse conditions in one reservoir he could put it in the tubing and that is illustrated on this sketch. I think that is a good point on Figure 14. He could make this type of installation.

Q "B" on 14?

A Yes, sir. Actually, "A," "B" and "C" are the same installation with just different types of tools.

MR. NUTTER: I believe that is all. Thank you.

BY MR. UTZ:

Q Mr. Willingham, do you believe that a test of the Wolfcamp, say, flowing thirty days through the 2p-inch tubing, the next thirty days through the annulus would prove flow efficiency or a

reasonable accurate test to determine such --

A Yes, that would be one way of determining it in which you would know it would meet the statement Mr. Nutter mentioned, that you would have a similar condition, you would know that your well shouldn't change too much.

Q But would Humble be willing to make such a test?

A It would result in some expense on our part in order to do this, and it would mean our other side, of course, we would lose the oil production from it. Certainly, we wouldn't, well, we wouldn't be able to put the Devonian in the annulus, anyway, we would not put the Devonian in the annulus because there is no way to pump it.

Q What is the capacity of your Devonian, would it be able to make up lost allowable?

A No, sir, I don't feel that it would because of the extreme amount of water production. Now, it's possible we could, but I am not certain on that. I fear we would actually lose some oil production because of the high water volumes. Of course, now there is one thing that we could do, when we first complete this well, we are going to have to swab the well in in the tubing anyway to get it started flowing, and we could test the well at that time and then when we closed our valve we would have that test as a guide.

Q Do you feel that the prpduction will be stabilized enough so that the test would be meaningful?

A I think if we observed it and watched it to make sure it was, I think if we produced it for a couple of days and then tested it, I feel that it would be providing, of course, we would observe if we weren't getting any mud or any kind of contaminant.

MR. UTZ: Are there other questions?

MR. NUTTER: Just one.

BY MR. NUTTER:

Q Mr. Willingham, you stated that it cost three hundred thousand dollars to drill a well in here. Did you mean a Devonian well or Wolfcamp?

A Wolfcamp well.

Q Wolfcamp well?

A Yes, sir.

Q Which is approximately what depth, 10,000 feet?

A Let's see. I've got it on one of these prints. Your Wolfcamp is 10,542 to 10,580.

Q Is this a normal cost for drilling a well of this depth in Lea County?

A Yes, sir. I have, in fact, in case that came up, I brought some cost data which I wouldn't want to put this in as an exhibit, but I do have it to verify the cost.

Q That would be for a wildcat or development?

A Development well. In fact, if you would like to look, I've got it right here.

BY MR. PAYNE:

Q Mr. Willingham, you anticipate the Wolfcamp completion would be capable of making considerable in excess of top unit allowable. What about your other Wolfcamp wells in the area?

A I think initially it would probably make more than its allowable, yes, sir.

Q So that if we are going to take the type of test Mr. Utz mentioned, might be one way of determining flow efficiency. We would have to allow the well to flow at capacity for both thirty-day tests, would we not, because it might make its allowable flowing under either condition through tubing or through the annulus, and yet in actuality, one method might or might not be more efficient than the other?

A That is true. Actually, Mr. Payne, the reservoir I am worried about would be the Devonian. I don't feel you would lose any oil from the Wolfcamp, only from the Devonian.

Q I see. Thank you.

MR. UTZ: Other questions?

BY MR. MORRIS:

Q Mr. Willingham, I have been looking through this pamphlet you handed us, and I note in here that the use of these coupons to detect corrosion or measure the corrosion rate they point out here are indicative only of the corrosion rate at the point where the coupon is inserted in the line.

A That is true.

Q And that would indicate to me that it might be useful

only for measuring corrosion in the surface facilities rather than the corrosion rate, deep in the well, for instance.

A Yes, sir. However, I don't think you can run a coupon at any place and say, "Well, I had corrosion, I lost a tenth of my coupon, therefore, I know any corrosion is such a rate." In other words, this is a qualitative measure and not a quantitative measure. Whether this coupon would show you after you put the inhibitor in you stopped the corrosion you could be confident it was stopped as far as your pellets would drop and since these pellets would not melt, they have to stand in the well for a few hours before they will melt.

Q It also points out here your coupon is not effective if you have any paraffin problems in your well because your coupon will become coated. Do you anticipate any paraffin problems in this well?

A That is a penetrating question. I don't know that we can say the problem is trouble with paraffin. I can have a field that was not a paraffin field, and there isn't severe paraffin problems which we don't ever anticipate. We have isolated wells even in fields that do have paraffin problems. I would be telling an untruth if I said possibly we would have the paraffin.

Q Do you use these coupons on any installation that you presently have to detect corrosion?

A To a limited extent.

Q It just seemed to me that it might, the use of the coupon

might only be effective for determining surface corrosion rather than in the well corrosion, and they do have other methods here, it seemed, that are better suited to measuring in the well corrosion of such problems.

A The only problem in using some of the others, you would have expense in getting it down in the well, and that would be your problem. You certainly have a point there. I think the thing about this situation is that if you will turn back to the Exhibit that I gave you on the gas analysis, that is, Exhibit 6, you will notice I calculated the grains there as 3.5 for hydrogen sulfate, and the well normally is considered getting into the corrosive problems when you get over twenty grains, so you can see that we are well below what is considered your getting into the corrosion problems.

BY MR. PAYNE:

Q How expensive are these pellets and how many does it take?

A Mr. Payne, your corrosion treatment cost can vary from one hundred dollars to two or three hundred dollars per year, and you can't say how many it will take. In other words, generally, what you do is you are going to have to use coupons to judge whether or not you handle your corrosion in the past and the experience I have, I had two sticks of this sperm which are about this long that normally would protect you for about three weeks in some of the wells that we had.

MR. PAYNE: Thank you.

A One other thing I might mention here. He talked about corrosion. I am sure that you are aware that gas is a much more corrosive material than oil, and we are allowing that to be produced in the annulus, but we've got inhibitors that will control gas corrosion. We've got some very excellent corrosion inhibitors and some of them are quite similar to these.

BY MR. PAYNE:

Q Isn't it true, Mr. Willingham, in very recent years, at least, we have only allowed the annular flow of gas in the dual completions when there were no severe corrosion problems?

A Yes, sir, but in gas, any gas is corrosive, if you've got the pressure and the producing volume. In other words, if you had a well with less than two thousand pounds pressure, was producing less than a million cubic feet a day, you wouldn't anticipate corrosion. When you start getting over a million feet per day above two thousand pounds, I know if I could run water sample tests, we know when we need to treat, we are very active in that because it's good business to watch your corrosion.

MR. UTZ: Any other questions?

MR. BRATTON: Mr. Willingham, Mr. Nutter was inquiring as to what the Commission might do in instances where an operator requests this type of installation and where he might not anticipate some of it to encounter some of the situations where you believe this installation should not be used, and under those condi-

tions, do you not believe the Commission could either refuse to grant the application, if the conditions appear to exist, or might grant the application and retain the case under its jurisdiction to see what does actually happen, and if any of these conditions develop, wouldn't that be a feasible way of handling that type of situation?

A Yes, sir, they could.

Q And you do not believe, do you, that by granting this application, if the Commission should, and by placing such restrictions in the order as the Commission might see fit, if it should grant it, that it would be recruiting any widespread precedent for this type of installation?

A No, sir, I don't believe that it would. I think the seriousness with which the Commission has asked these questions is certainly deterent on any one wanting to make this type of installation. I think they are certainly going to get all the facts before they grant it.

MR. UTZ: Any other questions? The witness may be excused.

(Witness excused)

MR. UTZ: Any statements in this case? The case will be taken under advisement. The hearing is adjourned.

STATE OF NEW MEXICO)
) ss
COUNTY OF BERNALILLO)

I, LLEWELYN NELSON, Court Reporter, in and for the County of Bernalillo, State of New Mexico, do hereby certify that the foregoing and attached Transcript of Proceedings before the New Mexico Oil Conservation Commission was reported by me in machine shorthand and reduced to typewritten transcript under my personal supervision, and that the same is a true and correct record to the best of my knowledge, skill and ability.

WITNESS my Hand and Seal this, the 24th day of January, 1961, in the City of Albuquerque, County of Bernalillo, State of New Mexico.

Llewelyn Nelson
NOTARY PUBLIC

My Commission expires:
June 14, 1964

I do hereby certify that the foregoing is a complete record of the proceedings in the Examiner hearing of Case No. 2146, heard by me on March 12, 1962.
, Examiner
New Mexico Oil Conservation Commission

BEFORE EXAMINER UTZ
OIL CONSERVATION COMMISSION
EXHIBIT NO.
CASE NO.