FIELD STUDY AND STIMULATION APPROACH
CONGER (PENN) FIELD
STERLING COUNTY, TEXAS

BY

JIM JOHNSON AND BILL KAMP

THE WESTERN COMPANY OF NORTH AMERICA

ABSTRACT

With existing demands for oil and gas at continued higher prices, there has become a greater interest in previously uneconomical reservoirs. The Cisco and Canyon formations in Sterling County, Texas fall into this category. In particular, the Conger (Penn) area has enjoyed rapid and continuous development since 1977. Hydraulic fracturing has been required to stimulate for commercial production. Stimulation practices have been reviewed and a more efficient approach developed to provide maximum productivity at an optimum cost.

INTRODUCTION

The Conger (Penn) Field is located some six (6) miles South and seven (7) miles West of Sterling City, in Sterling County, Texas. (See Figure 1). This encompasses an area of some 58,000 acres. Since completion of the Dorchester Exploration - Conger "19" NO. 1 in December 1974, some 54 gas wells and 105 oil wells have been completed (through December 1979). Oil production began in 1977 with a majority being completed in 1978 and 1979. Through December 1979, a total of 3,331,814 barrels of oil have been produced. Along with oil production 16,604,202 MCF casing head gas has been produced. Gas production through December 1979 was 27,398,333 MCF. With this sort of production potential in the area, future development both infield and outer edge areas should be good.

Principle operators are R. C. Bennett, Blanks Energy Corp., C & K Petroleum, Champlin Petroleum, John L. Cox, Dorchester Exploration, Marathon, Southland Royalty, Texaco, and Wagner & Brown. Wagner &

Brown has a majority of wells in the area. Drilling up to this point has been on 160 acre spacing. However, with existing low porosity and permeability in the reservoir, infield drilling may be in order. Production from the Cisco and Canyon varies from well to well depending upon pay development; however, all wells require hydraulic fracturing to stimulate for production at a commercial level. After initial completion, production tests indicate potentials ranging from 10 to 331 BOPD. Water production has varied from a low of 1 BWPD to 150 BWPD. GOR's range from 1142:1 to 35200:1. During the initial stages of development, gelled water or crosslinked gelled water systems were utilized to stimulate for production. Most treatments, however, that were reviewed for this report consisted of fracturing with a refined guar gel crosslinked system. (See Table 1).

The Western Company has had the privilege of participating in the stimulation of ±75% of the completions in the field. This paper concentrates primarily on the stimulation approach being used and also deals with some suggestions for a more efficient fluid recently developed for this type reservoir.

LITHOLOGY AND RESERVOIR CHARACTERISTICS

Oil and gas production in the Conger (Penn) Field is from Cisco and Canyon members of the Pennsylvannia Age. Overall interval from the Cisco through the Canyon is ±1000 feet in thickness. Individually, the Cisco covers an interval of 150 to 200 feet and the Canyon an interval of 150 to 250 feet.

Cisco and Canyon zones in this area consist primarily of fine grained Quartzosic sandstone with interbedded shale and some carbonate stringers. Figures 2,3,4 & 5 show typical gamma ray-acoustic velocity logs of the producing intervals. Table 1 gives the thickness of each zone.

Laboratory analysis have been conducted on several core samples. X-ray diffraction analysis indicates the presence of quartz, feldspar, dolomite, koalinite, chlorite, and mixed layer - illite/montmorillonite. Some siderite is indicated in one of the X-ray analysis test. The rock is described as a feldspathic, fine-grained sandstone with slightly expandable interstitial clay. The siderite is most likely acting as a cementing agent. Scanning Electron Micrographs (Figures 6 thru 10) indicate the presence of siderite, illite, and montmorillonite. These clay minerals tend to be dissolved and dislodged by aqueous solutions, and may cause a problem with fines, which can cause plugging near the well bore. The use of potassium chloride brines and clay stabilizing chemicals should alleviate any associated problems.

The formation has a solubility from 3 to 25 percent in 15% hydrochlorics acid. It also contains from .57 to 2.98% soluble iron in 15% HCl. In a mixture of 5% HCl - .6% HF from 5.7 to 27.5% soluble iron is indicated (Table 2). The presence of iron dictates the need for an iron-chelating agent in the stimulation fluids.

Core analysis data indicates that formation permeabilities range from a low of less than .1 to a high of 0.5 millidarcys. In some isolated instances permeability may be as high as 3-4 md. Porosities thru the pay section will range from 8 to 10 percent. Water saturations vary, depending upon permeability values, from 40 to 50 percent in a producing zone.

RESERVOIR FLUID CHARACTERISTICS

Water production does not appear to be much of a problem in the Conger area. Initial potentials appear to be in a range of one (1) to ten (10) percent. The produced water has moderately high dissolved solids content, 8.0 pounds per gallon, and is slightly corrosive due to its acidic nature. There appears to be little evidence of scaling, but ION concentrations are such that calcium sulfate scale is possible. Table 3 shows a typical water analysis in the field.

The oil phase from reservoir fluid falls in a range of 38 to 42 API Gravity. There are slight paraffin components, however, they have not proven to be a major problem.

Production decline curves were prepared on several wells selected at random. Figures 11 and 12 show typical oil production, and Tables 4, 5, and 6 give monthly production for several gas wells.

TREATMENT TECHNIQUE

After zone or zones of interest in the Canyon and Cisco are selected and perforated, stimulation programs are generated. A majority of wells in the area are treated using the limited entry technique. Where both Cisco and Canyon zones are encountered, a baffle ring and bomb is used for separating the two zones. By using this technique, both zones can be treated in a single trip to the well. An injection rate of 1.5 to 2 BPM per perforation is normally utilized to provide a differential pressure of 400-500 PSI across perforations. In instances where a baffle ring and bomb is utilized, the lower zone is perforated, acidized, and fractured; in flush, acid is pumped to be spotted across the upper zone; a bomb is run to seat in baffle ring and pressure tested; then, Upper zone is perforated and fractured. Frac volumes are shown in Table 1.

Most of the frac treatments performed in the Conger (Penn) Field consisted of water-base gels, namely cross-linked guar gum systems. Recently a new frac fluid system has been utilized in the general vicinity. This fluid is a cross-linked gelled acid system. Type frac fluid systems selected for use in this area take into consideration:

1.) Effective viscosity
2.) Sand carrying ability
3.) Friction reduction properties
4.) Compatibility of the fluid to the formation and reservoir fluids

From core studies, the frac fluid presently being used appeared to be the most applicable for use with minimum incompatibility problems.

TYPICAL TREATMENT PROCEDURE

1.) With acetic acid spotted across lower zone and hole loaded with 2% KCl water, perforate selectively with 15-20 holes.
2.) Break down perforations and establish injection rate.
3.) Frac with ±40,000 gallons cross-linked gel containing 1 # 20/40 mesh sand per gallon at ±2 BPM/perforation.
4.) Flush with 2% KCl Water, spotting 1500 gal acid across upper zone to be perforated.
5.) Run bomb to seat in baffle ring and test bomb.
6.) Perforate upper zone.

7.) Breakdown perforations and establish injection rate.

8.) Frac with ±40,000 gal cross-linked gel containing 1 ppg. 20/40 mesh sand per gallon at ±2 BPM per/perforation.

9.) Flush with slick 2% KCl Water.

10.) Leave well shut-in overnight, then commence load recovery.

COMPUTER STIMULATION DESIGN

Computer studies were conducted to determine fracture penetrations and productivity increases (J/Jo) that should have been achieved with the various frac volumes utilized. Fracture heights used in computer print out programs were varied from 50 to 200 feet. Proppant concentration remained constant at 2.15 darcy-feet (Figure 13), which is the maximum conductivity that can be achieved with an overburden pressure of 3500 psi. From Figure 13, it is seen that proppant concentration required to achieve a conductivity of 2.15 darcy-feet is ±680 pounds per 1000 feet. Reservoir properties and frac fluid properties used in computer calculations are listed in Tables 7 and 7A.

Results from the computer study are presented in Table 8 and plotted in Figures 14, 15 and 16. Figure 17 shows productivity increase contrast as a function of penetration. It can be seen from Figure 17 that L/r_e ratios in excess of .5 provide very little increase in productivity ratio. Frac treatments utilized provided for fracture lengths ranging from 200' to 700' depending upon injection rate and fracture height. From Figure 13 it can be seen that productivity is maximized at a sand concentration of 680 pounds per 1000 feet. The amount of sand to be pumped is calculated as follows:

$$\text{Sand (lb)} = 2 \times 50 \times 680 \times 0.6 \text{ lb/ft}^2 = 40{,}800 \text{ lbs.}$$

By way of comparison, fluid characteristics of a new stimulation fluid (CWA-3) cross-linked gelled acid were used in a similar computer design study. As is seen in Figures 14, 15 and 16, and is tabulated in Table 9, fracture penetration is achieved. Fluid characteristics of this product are most compatible with the formation and reservoir fluids, and should prove to be far superior to presently used fluid systems. As is readily seen in Figure 17, at L/r_e of .6 a productivity increase of ±1.5 fold above that obtainable with present fluid systems is indicated.

SUMMARY

In conducting this field study several observations were made and are presented in summary for future benefit.

1.) Treatment techniques have been refined to the point that all zones are completed selectively, efficiently and economically.
2.) Both Cisco and Canyon zones require fracturing to establish satisfactory production rates.
3.) Improvements in frac fluid systems could be utilized to increase fracture penetration and hopefully productivity contrast. This is indicated on wells recently treated with the new cross-linked gelled acid system.

NOMENCLATURE

H	Fracture Height, Ft.
J	Productivity index after fracturing
J_o	Productivity index before fracturing
K	Formation permeability to reservoir fluid, md.
K_f	Proppant pack permeability to reservoir fluid, md.
L	Frac Length from wellbore, Ft.
r_e	Propped fracture width, In.
WK_f	Conductivity of the fracture, md./in.

REFERENCES

1.) Western Company Stimulation Program Library
2.) "Engineered Limited Entry", a Western Company Publication
3.) Craft, B.C., and Holden, W.R., and Graves, E.D., Jr.; Well Design Drilling and Production, Prentice Hall, Inc., Englewood Cliffs (1962) 483-533.

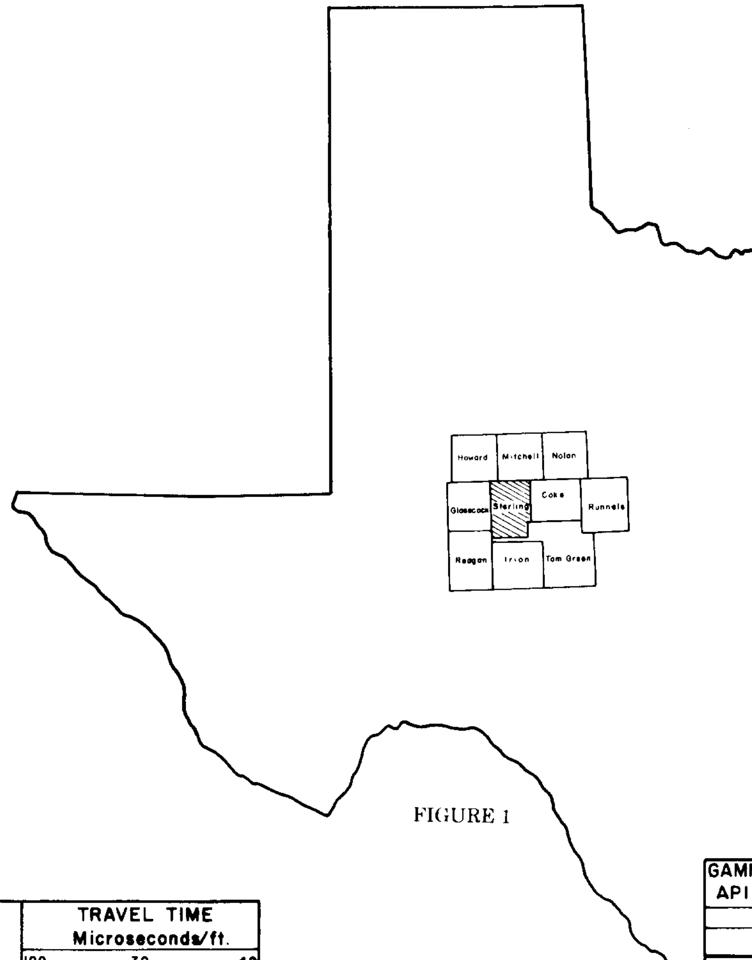


FIGURE 1

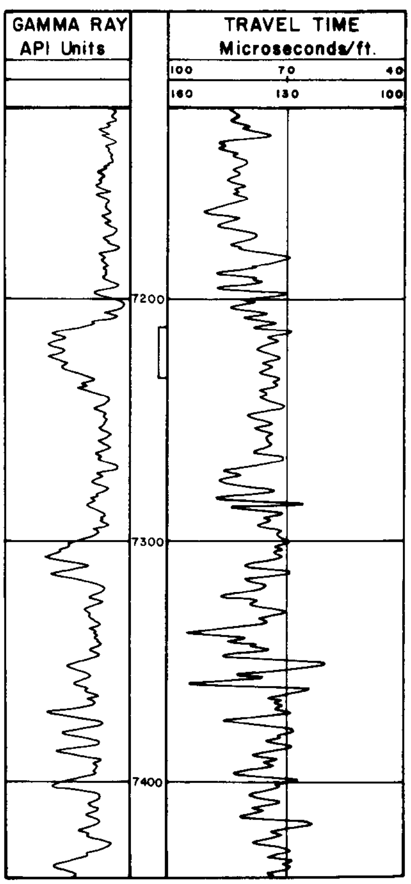


FIGURE 2

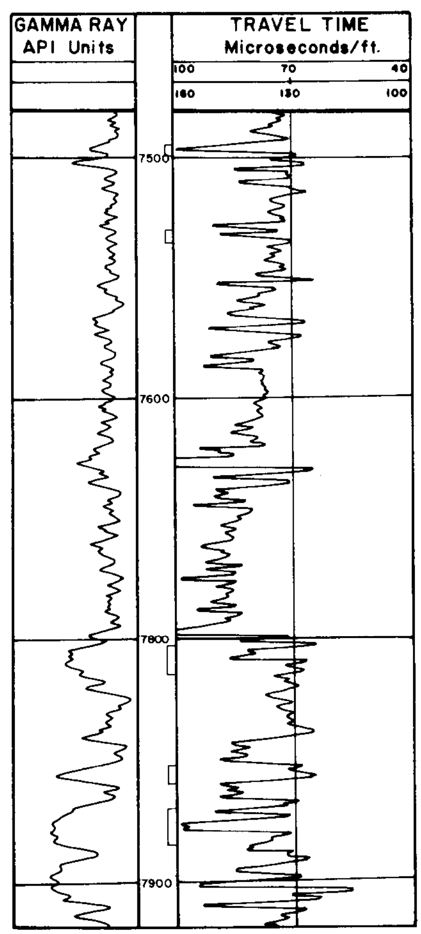


FIGURE 3

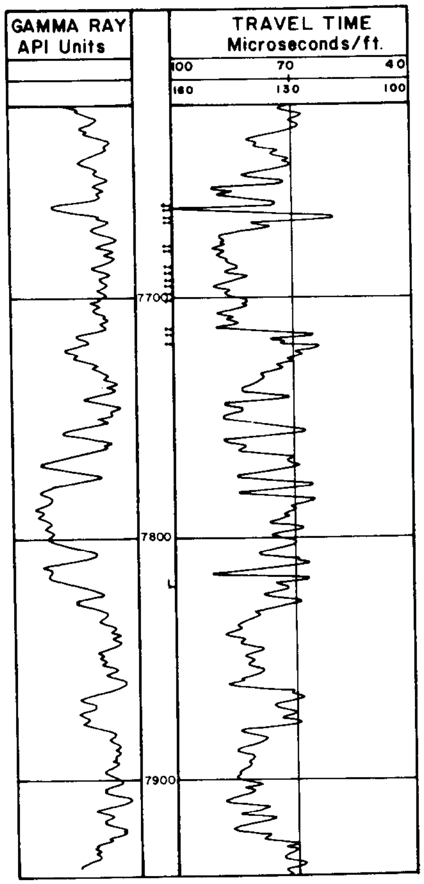


FIGURE 4

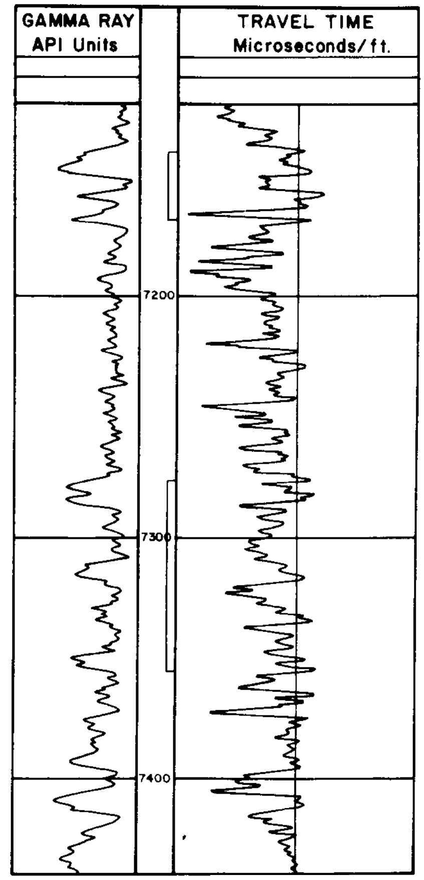


FIGURE 5

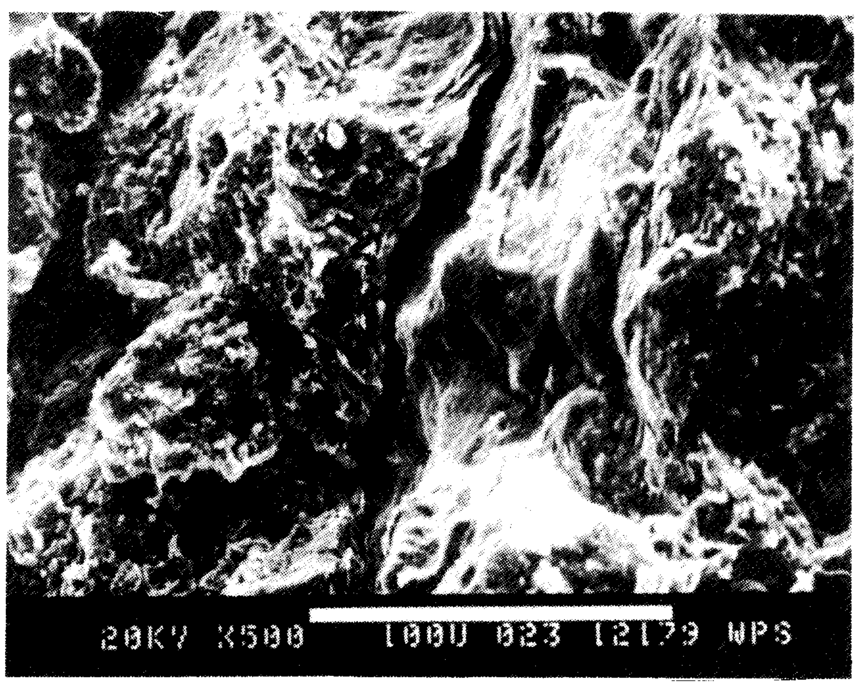


FIGURE 6—A VIEW OF A MICROFRACTURE BETWEEN QUARTZ GRAINS

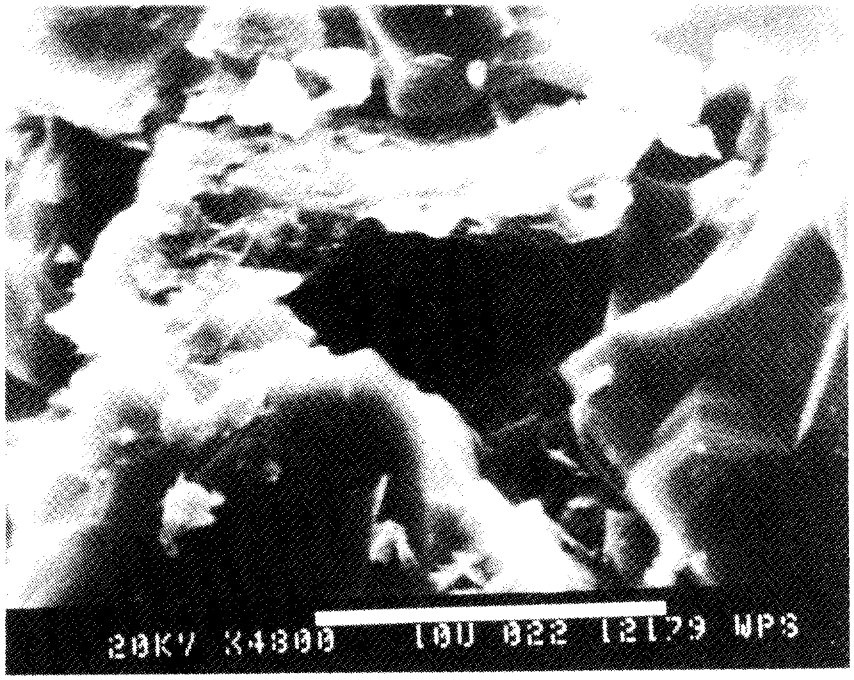


FIGURE 7—A FAIRLY CLEAN PORE SURROUNDED PREDOMINATELY

FIGURE 8—A HIGH MAGNIFICATION VIEW OF A LAYER OF ILLITE/MONTMORILLONITE OVERGROWTH ON QUARTZ SHOWING DELICATE, NEEDLE LIKE CLAY PROJECTIONS.

FIGURE 9—A PORE SURROUNDED BY QUARTZ ON LEFT, TOP RIGHT, AND FAR RIGHT. MIXED LAYER CLAY IS LOCATED DIRECTLY AROUND THE PORE OPENING.

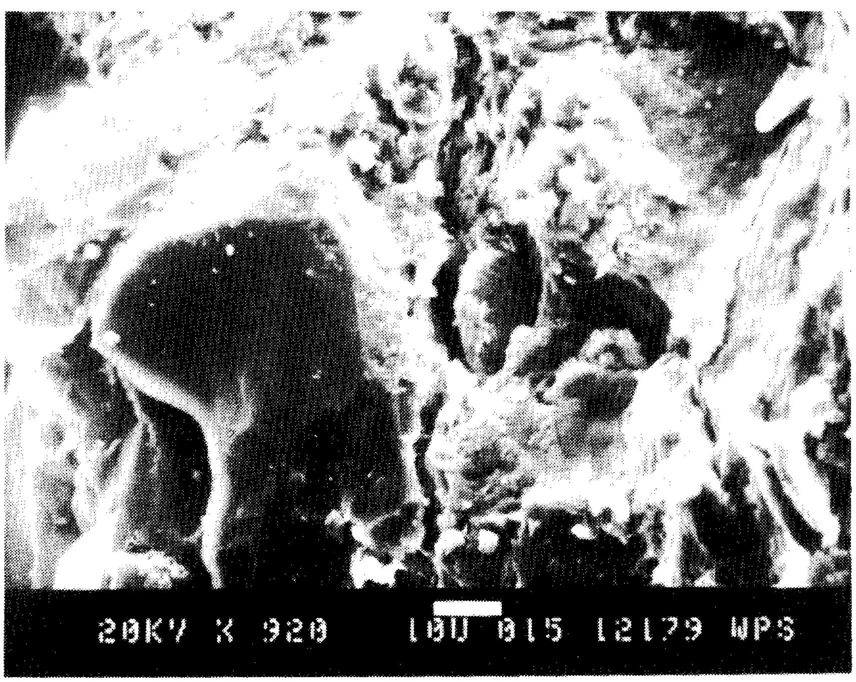


FIGURE 10—A VIEW OF A PARTIALLY FILLED MICROFRACTURE

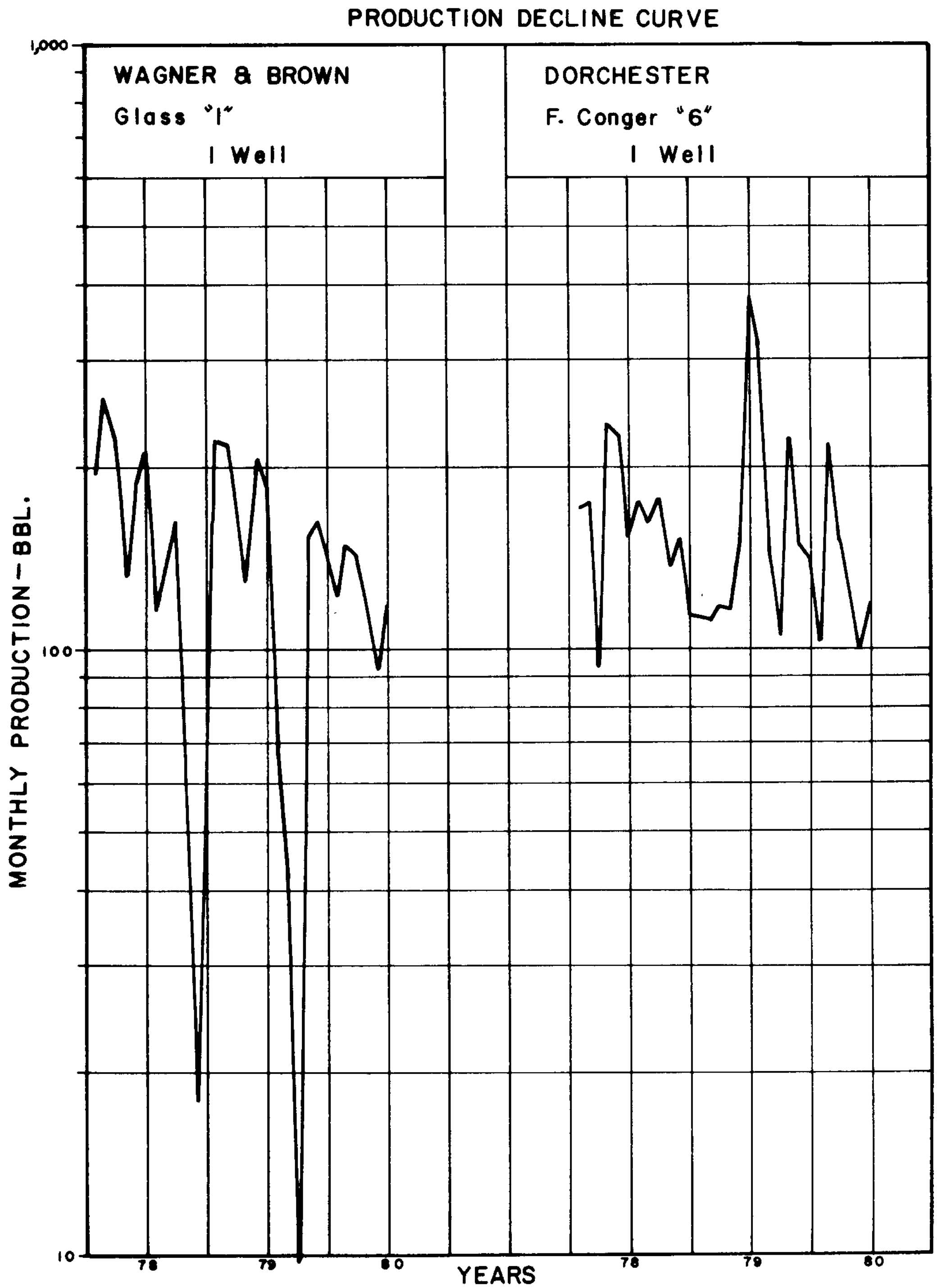

PRODUCTION DECLINE CURVE
WAGNER & BROWN
Glass "I"
I Well
DORCHESTER
F. Conger "6"
I Well
MONTHLY PRODUCTION - BBL.
1,000
100
10
78
79
80
78
79
80
YEARS

FIGURE 11

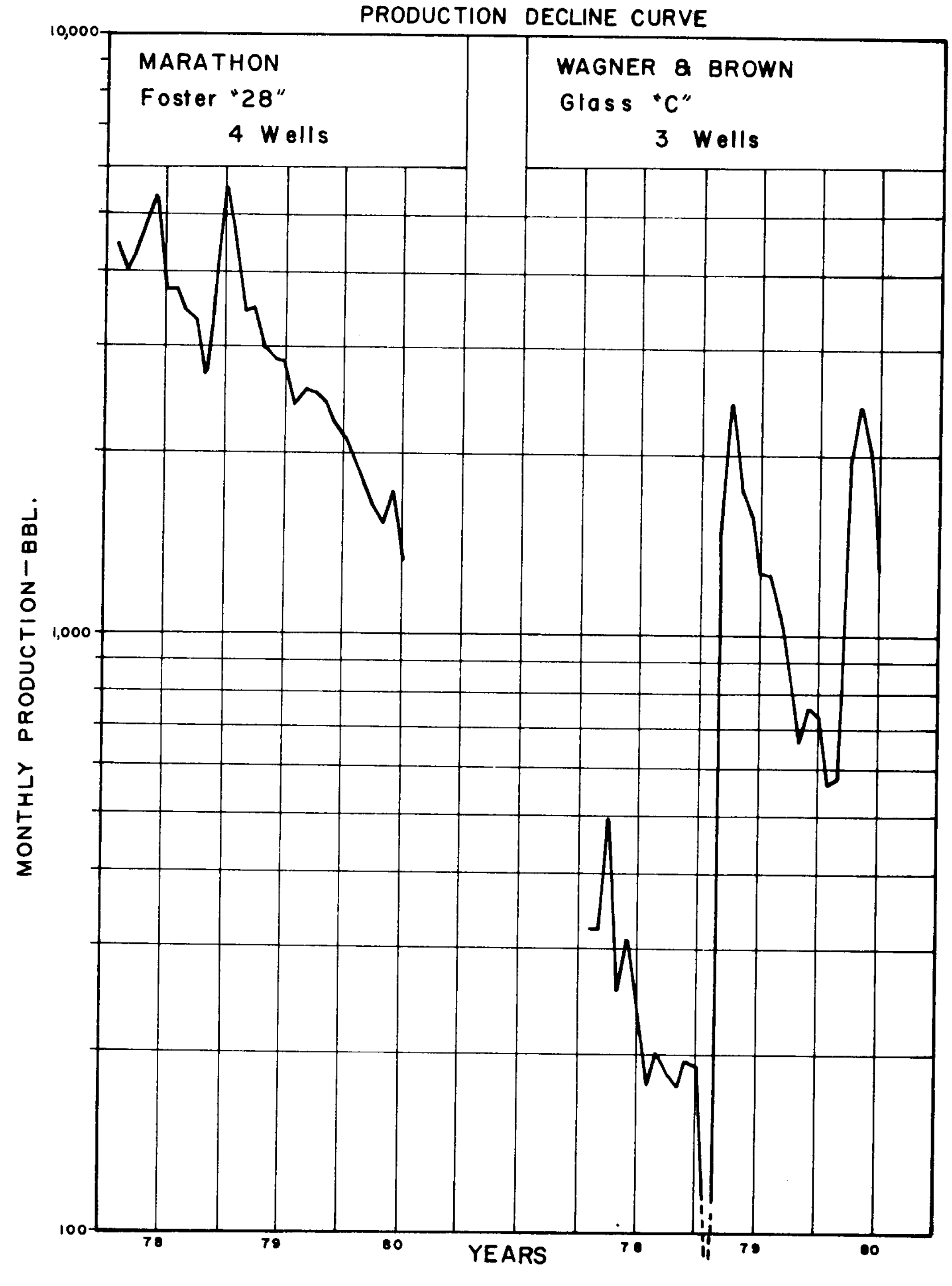

PRODUCTION DECLINE CURVE
MARATHON
Foster "28"
4 Wells
WAGNER & BROWN
Glass "C"
3 Wells
MONTHLY PRODUCTION—BBL.
10,000
1,000
100
78
79
80
YEARS
78
79
80

FIGURE 12

20-40 MESH SAND CONDUCTIVITY

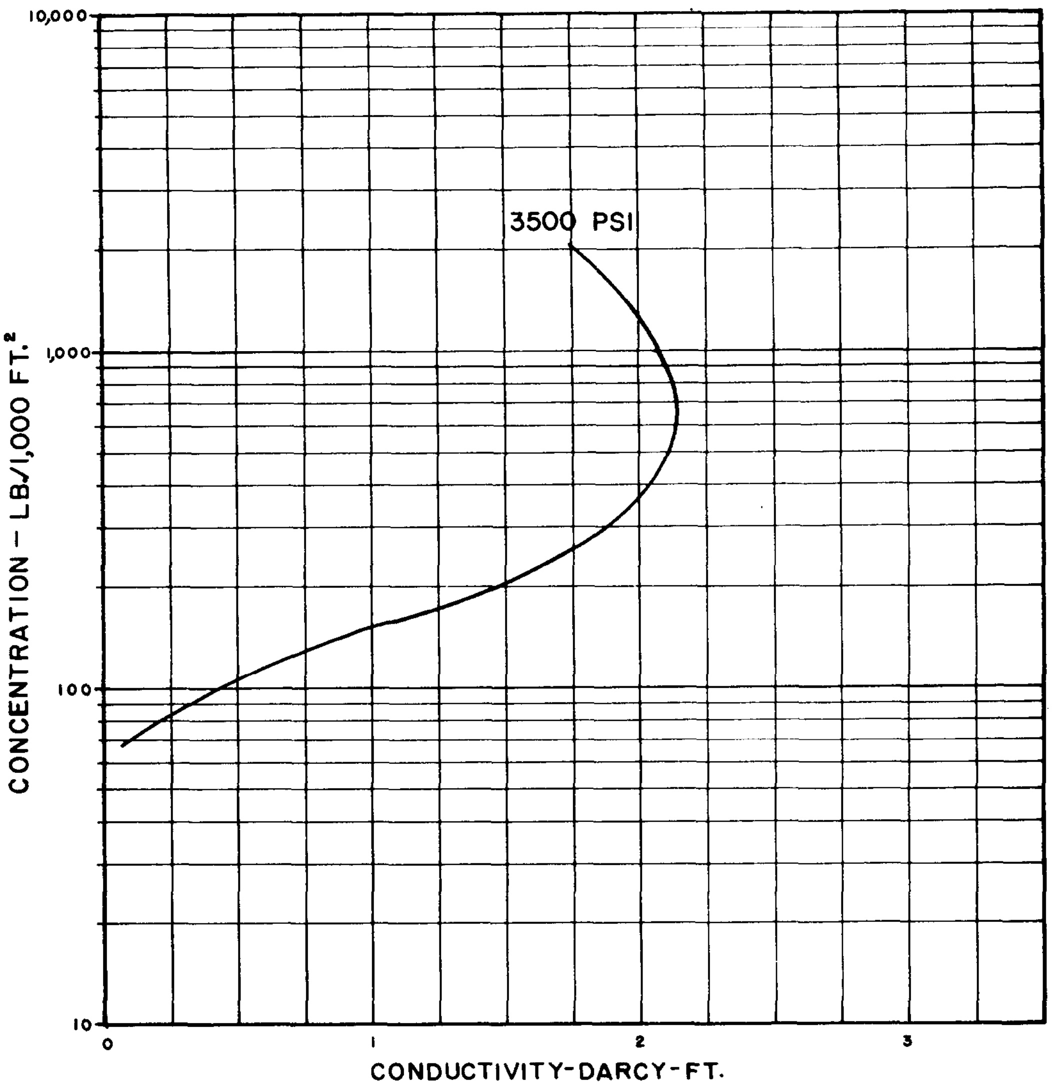


FIGURE 13

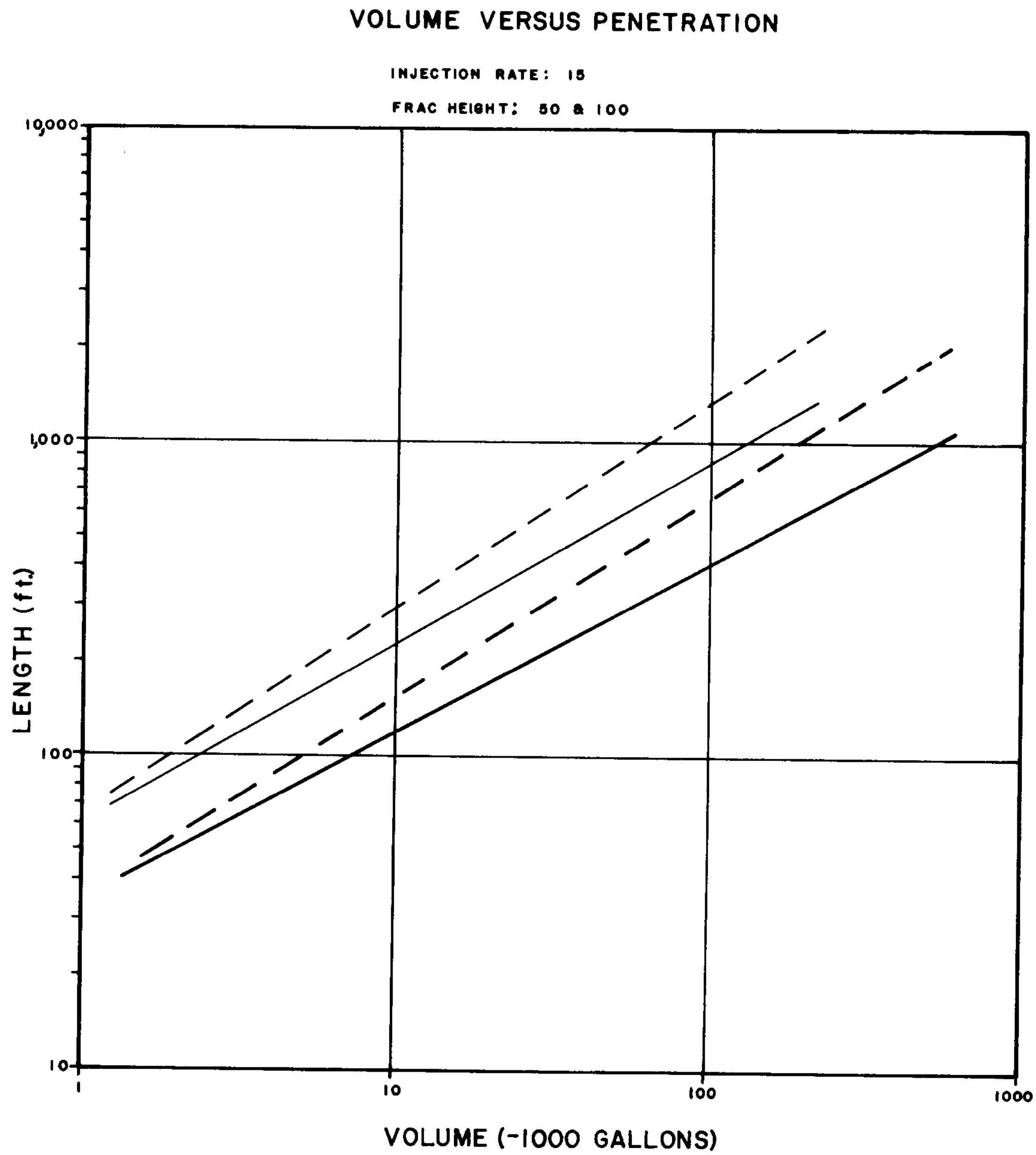

VOLUME VERSUS PENETRATION
INJECTION RATE: 15
FRAC HEIGHT: 50 & 100
10,000
1,000
100
10
LENGTH (ft.)
1
10
100
1000
VOLUME (-1000 GALLONS)

FIGURE 14

VOLUME VERSUS PENETRATION

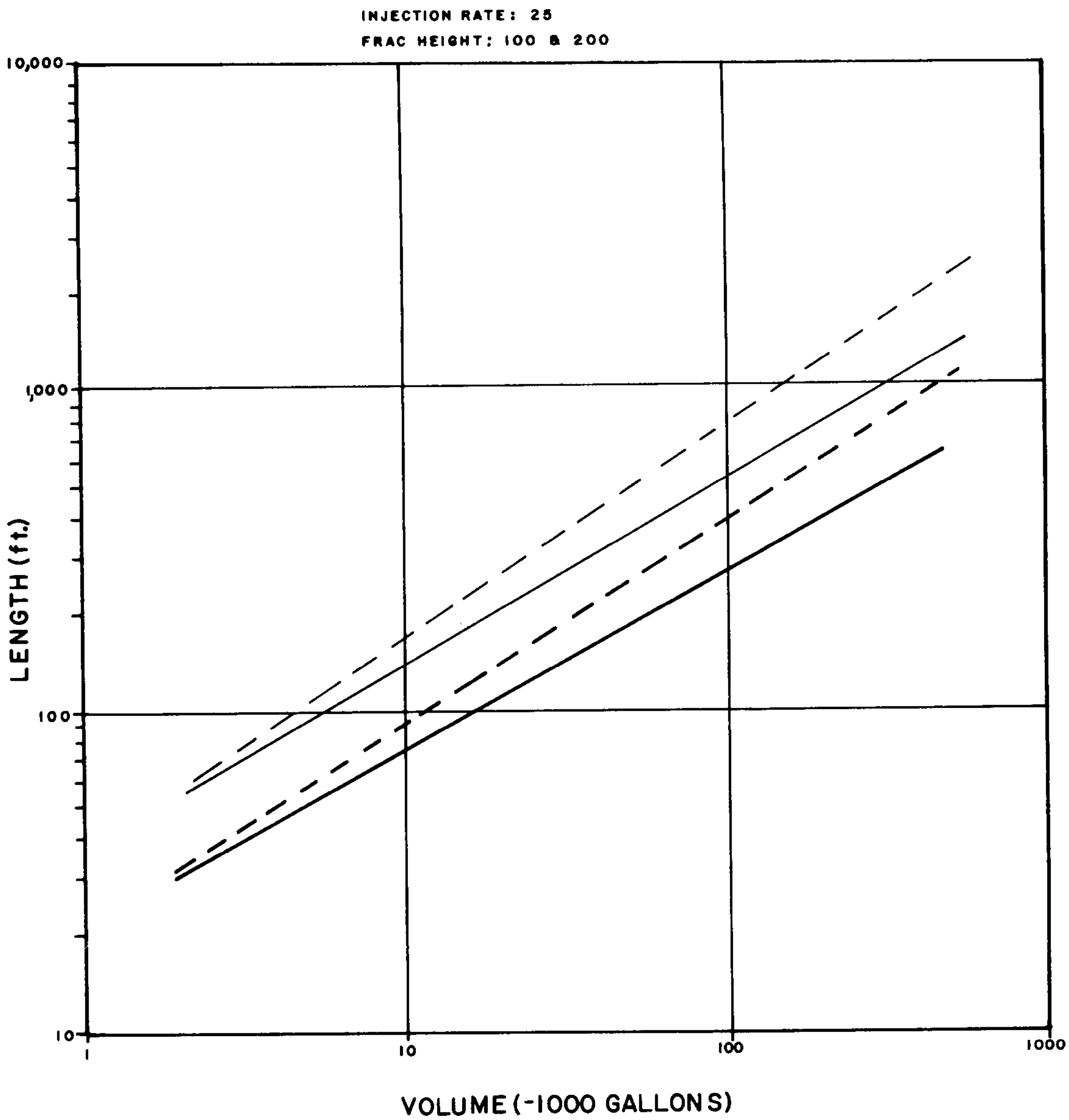


FIGURE 15

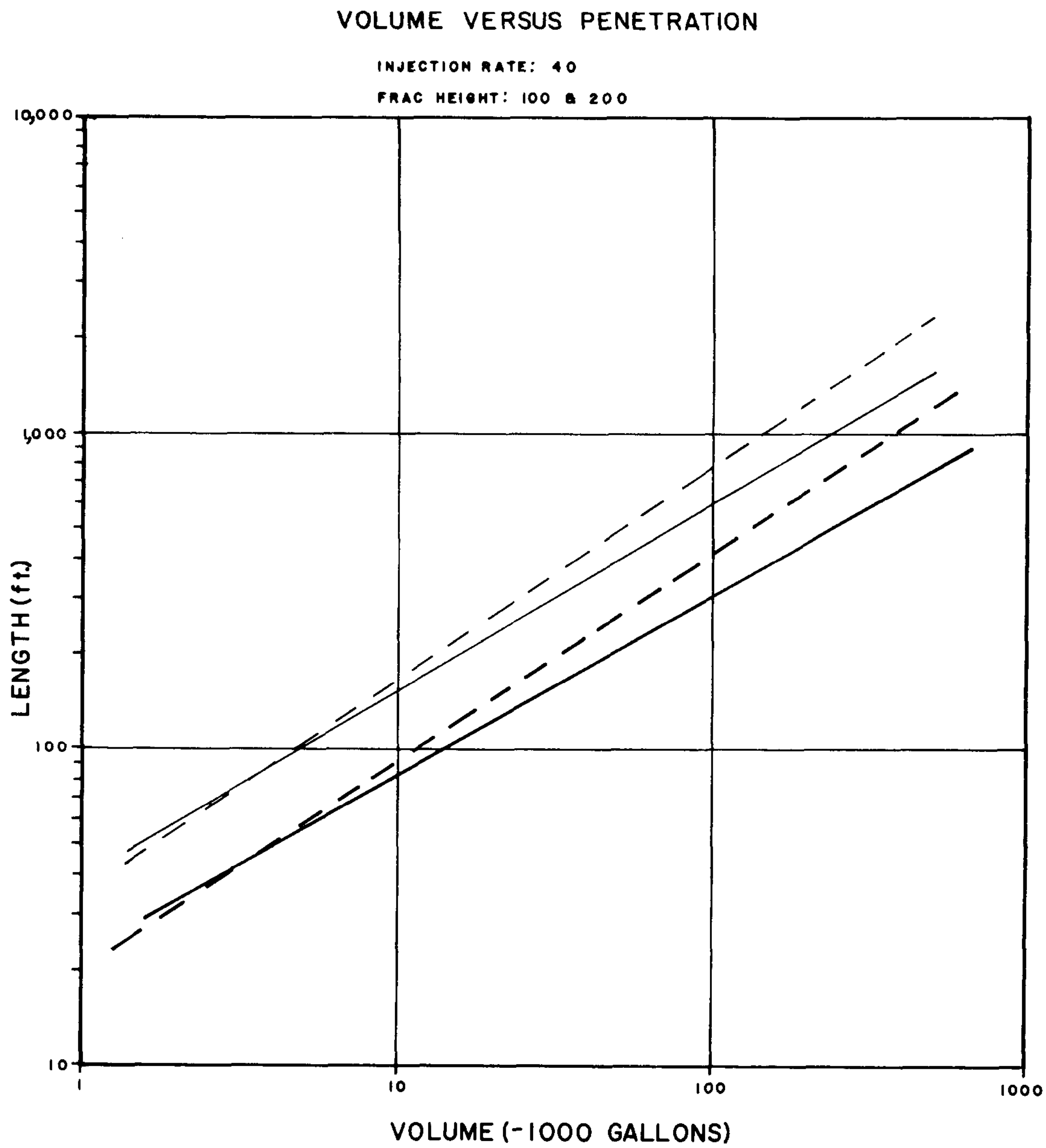

VOLUME VERSUS PENETRATION
INJECTION RATE: 40
FRAC HEIGHT: 100 & 200
10,000
1,000
100
10
LENGTH (ft.)
1
10
100
1000
VOLUME (-1000 GALLONS)

FIGURE 16

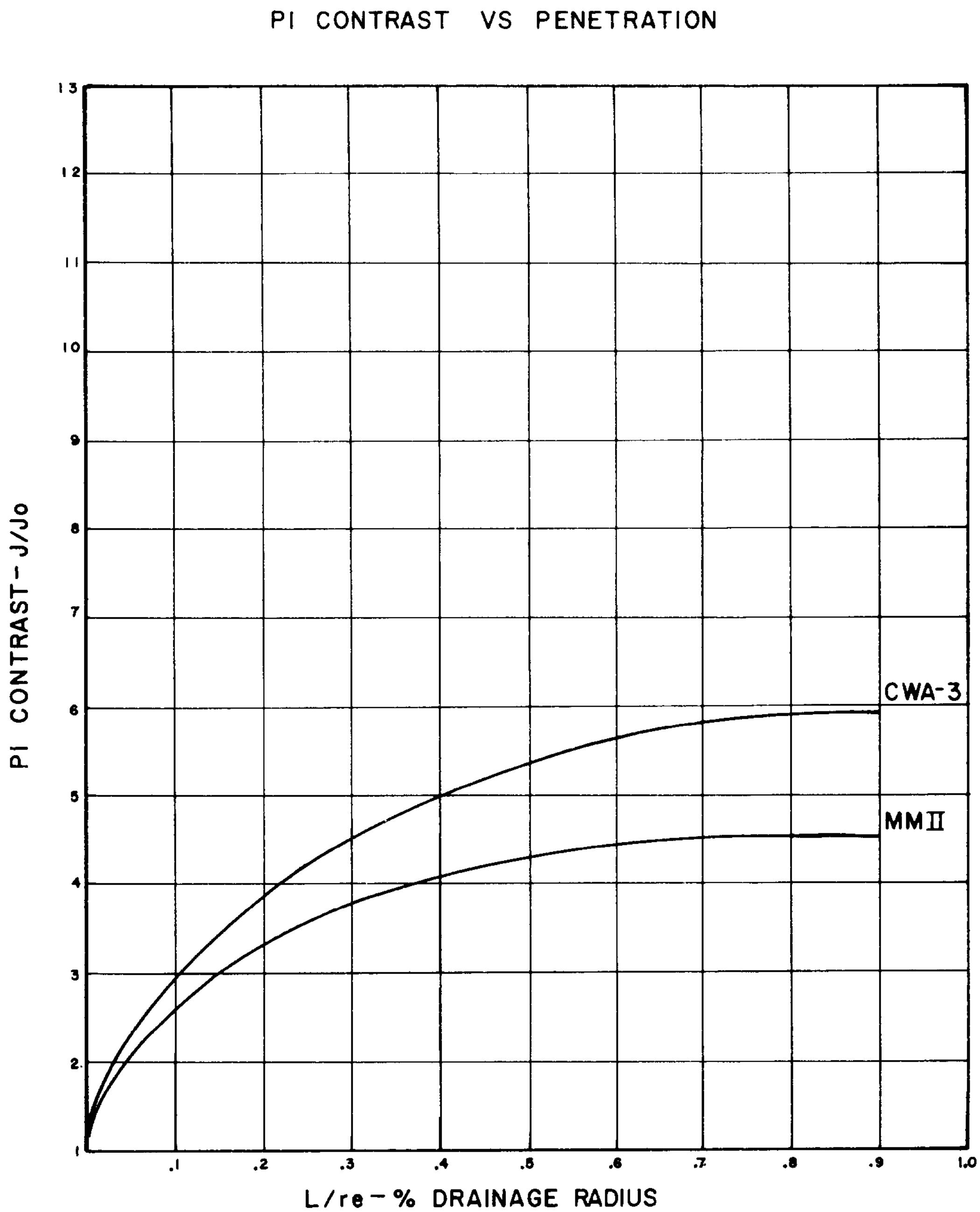

PI CONTRAST VS PENETRATION
PI CONTRAST - J/Jo
L/re - % DRAINAGE RADIUS
CWA-3
MM II
1
2
3
4
5
6
7
8
9
10
11
12
13
.1
.2
.3
.4
.5
.6
.7
.8
.9
1.0

FIGURE 17

TREATMENT DATA
Conger Penn Area
TABLE 1

WELL NAME	FORMATION	TD	PERFORATED INTERVALS	TREAT. VOLUMES & TYPE	IPF	FT.^{3}/bbl.		FRAC GRADIENT
Conger 2-36	Canyon/	8000	7884-7996 (14)	110,000 gal. MMII	50 BOPD	23,180-1		.64
	Cisco		7546-7624 (9)	2,500 gal. 15% DS-30	+ Trace			.59
			7096-7514 (17)		Water			
Conger 3-36	Canyon/		7976-8110	80,000 gal. MMIII	80 BOPD	31,500-1		.61
	Cisco		7546-7639	1,500 gal. 15% DS-30	+150 BW			.64
			7062-7297					
Conger 4-36	Canyon/	8211	8037-8159 (11)	140,000 gal. MMII	35 BOPD	20,000-1		.65
	Cisco		7612-7836 (11)	2,000 gal. 15% DS-30	+2 BW			.66
Flint "A"	Canyon/	8000	7796-7939 (11)	70,000 gal. MMII	65 BOPD	13,077-1		.70
30-2	Cisco		7578-7726 (15)	1,500 gal. 15% DS-30	+2 BW			.64
Foster 1-14	Canyon/	7276	6847-7182 (18)	65,000 gal. MMII	35,200-1			.63
	Cisco		6402-6668 (11)	2,000 gal. 15% DS-30	MCFGPD	35,200-1		.65
			6148-6207 (11)					
Glass "A"	Canyon/	8370	8123-8279 (11)	85,000 gal. MMII	151 BOPD	3268-1		.63
3-13	Cisco		7772-7966 (20)	1,000 gal. 15% DS-30				.61
Glass "A"	Canyon/	8210	8063-8154 (11)	85,000 gal. MMII	250 BOPD	3100-1		.64
4-13	Cisco		7795-7907 (15)	2,000 gal. 15% DS-30	+ 5 BW			.62
			7713-7766 (11)					
Glass "B"	Canyon/	8213	7923-8194 (15)	65,000 gal. MMII	290 BOPD	2414-1	150° F	.65
3-22	Cisco		7670-7790 (15)	2,000 gal. 15% DS-30				.61
Glass "B"	Canyon/	8294	8030-8085 (11)	80,000 gal. MMII	192 BOPD	2714-1		.64
4-22	Cisco		7722-7773 (13)	2,000 gal. 15% DS-30	+20 BW			.62
Glass "C"	Cisco	8275	7984-8142 (15)	74,000 gal. MMII	174 BOPD	6184-1		.65
2-4			7596-7796 (22)	1,500 gal. 15% DS-30	+1 BW			.61
Glass "C"	Canyon/	8200	7998-8170 (15)	80,000 gal. MMIII	120 BOPD	4250-1		.65
3-4	Cisco		7627-7828 (16)	2,000 gal. 15% DS-30	+ TR WTR			.62
Glass "J"	Canyon/	8400	8167-8348 (18)	70,000 gal. MMII	75 BOPD	3253-1		.66
2-26	Cisco		7883-8046 (15)	1,500 gal. 15% DS-30	+2 BW			.64
Glass "K"	Cisco	8179	8048-8147 (15)	92,000 gal. MMII	331 BOPD	1764-1		.64
24			7795-7882 (11)	1,000 gal. 15% DS-30	+1 BW			.62
			7666-7740 (13)					.60
Hildebrand	Cisco	8207	7538-7631 (13)	75,000 gal. MMII	186 BOPD	2468-1	153° F	.62
26-4			7236-7302 (11)	500 gal. 15% DS-30	+ 1 BW			.60
Hildebrand	Cisco	8200	8059-8143 (11)	85,000 gal. MMII	75 BOPD	5667-1		.63
			7303-7650 (9)	2,000 gal. 15% DS-30	+2 BW			.60
			7660-7758 (17)					.61
			7786-7928 (10)					.62
Hildebrand	Cisco	7979	7396-7555 (18)	85,000 gal. MMII	169 BOPD	3095-1		.61
30-2			7039-7226 (11)	1,000 gal. 15% DS-30				.60
Hildebrand	Cisco	7953	7729-7857 (16)	65,000 gal. MM	124 BOPD	2331-1		.63
32-20			7444-7515 (11)	500 gal. 15% DS-30	+ TR WTR			.61
Hildebrand	Canyon/	7800	7882-8095	100,000 gal. MMII	195 BOPD	4718-1		.63
35-12	Cisco		7559-7719	2,000 gal. 15% DS-30	+ 2 BW			.62
Hildebrand	Canyon/	8225	8049-8106	110,000 gal. MMII	115 BOPD	7583-1		.63
37-18	Cisco		7616-7846	4,000 gal. 15% DS-30	+ 40 BW			.62
			7350-7417					.60
Hildebrand	Canyon/	8175	7940-8051 (11)	98,000 gal. MMIII	20 BOPD	2625-1		.65
41-7	Cisco		7026-7246 (11)	2,000 gal. 15% DS-30	+ 77 BW			.61
			7502-7710 (15)					.63
Margaret	Canyon/	8200	7800-7895 (11)	80,000 gal. MMII	10 BOPD			.63
2-13	Cisco		7075-7258 (11)	2,000 gal. 15% DS-30	+ 20 BW			.60
			7424-7579 (16)			10,000-1		.61
RAE	Cisco	8125	7492-7720 (14)	72,000 gal. MMII	176 BOPD	3625-1		.62
5-30			7890-8038 (11)	1,000 gal. 15% DS-30				.64
RAE "C"	Cisco	8061	7974-8061 (11)	90,000 gal. MMII	253 BOPD	1870-1		.63
1-3			7538-7738 (19)	1,500 gal. 15% DS-30				.61
Reynolds	Canyon/	7889	7680-7088 (15)	100,000 MM II	70 BOPD	1142-1		.62
1-11	Cisco		7394-7590 (14)	2,000 gal. 15% DS-30	+ 20 BW			.61
			7045-7174 (16)					.59
Westbrook	Canyon/	8100	7938-7986 (11)	80,000 gal. MM II	10 BOPD	24,200-1		.64
3-8	Cisco		7459-7616 (13)	2,000 gal. 15% DS-30	+ 26 BW			.62
			7221-7258 (11)					.60
Sterling N	Canyon/	8208	7940-8194 (58)	36,000 gal. CWA,				.78
Fee #1	Cisco			58,000 # 20-40 Sand				
			7695-7817	30,000 gal. CWA,				.72
				45,000 # 20-40 Sand				
Cope #3	Canyon	8451	8008-8187 (33)	80,000 gal. CWA,				.70
				247,800 # 20-40 Sand				
Cope #4	L.Canyon	8454	8161-8233 (30)	80,000 gal. CWA ,	158 BOPD			.73
				212,000 # 20-40 Sand	1036 MCF			
	U.Cisco	-	8000-8101 (30)	80,000 gal. CWA,				.72
				240,000 # 20-40 Sand				

TABLE 2

X-RAY DIFFRACTION

Sample Identification	Mineral Percentages																		
	Quartz	Feldspar	Calcite	Dolomite	Siderite	Anhydrite	Gypsum	Pyrite	Barite	Kaolinite	Illite	Chlorite	Montmorillonite	Mixed Layer Illite/Mont.	Mixed Layer Chlorite/Mont.	Total		15% HCl Solubility (%)	15% HCL Soluble Iron Content (%)	
7628 ft	81	4		5	6					tr		1		3		100		10.4	2.98	
7644 ft	88	7			1							1		3		100		4.0	0.57	
7659 ft	81	4		1	10					1				3		100		17.0	0.67	
7681 ft	86	7			2					tr		1		4		100		4.6	1.15	

Comments: All four samples are feldspathic, fine-grained sandstones, with slightly expandable interstitial clay. The siderite is most likely acting as a cementing agent.

TABLE 3

WATER ANALYSIS FROM THE WESTERN COMPANY SERVICE LABORATORY

Density	1.064 @ 73°F
PH	5.5
Iron	Good Trace
Sodium & Potassium	32930 ppm
Calcium	3000 ppm
Magnesium	632 ppm
Chloride	56400 ppm
Hydrogen Sulfide	None
Bicarbonate	451
Sulfate	1710

Resistivity = 0.116 ohm-meters @ 73°F. The Stiff-Davis Equation indicates this water to have a stability index of -0.75. A positive index indicates a tendency toward calcium carbonate deposition.

The calculated minimum saturation value for calcium sulfate 30.015 MEQ/L analysis indicates this water contains 35.568 MEQ/L. Therefore, calcium sulfate deposition is indicated.

Conger (Penn) Field Sterling County, Texas

Operator:	Stolz, Wagner & Brown
Well:	Hildebrand 904 L
TD:	8084
Upper Perf:	7551
Lower Perf:	7672

PRODUCTION HISTORY

YEAR	ANNUAL/MONTH	GAS/MCF	COND/BBLS.
75	JAN	0	0
75	FEB	0	0
75	MAR	0	0
75	APR	0	0
75	MAY	0	0
75	JUN	0	0
75	JUL	9073	198
75	AUG	19136	456
75	SEP	1486	36
75	OCT	27240	587
75	NOV	21497	530
75	DEC	21172	371
75	ANNUAL	99604	2178
76	JAN	18989	304
76	FEB	13212	245
76	MAR	13737	272
76	APR	2029	40
76	MAY	19270	364
76	JUN	15577	284
76	JUL	14026	261
76	AUG	12166	211
76	SEP	12505	53
76	OCT	5483	24
76	NOV	11664	51
76	DEC	7219	30
76	ANNUAL	145877	2139
77	JAN	4068	18
77	FEB	3931	44
77	MAR	4862	57
77	APR	4421	51
77	MAY	5406	59
77	JUN	5406	106
77	JUL	4941	69
77	AUG	6544	56
77	SEP	5621	45
77	OCT	5352	50
77	NOV	5207	27
77	DEC	4917	70
77	ANNUAL	60676	652

TABLE 5—**PRODUCTION DATA**

Conger (Penn) Field Sterling County, Texas

Operator:	Stolz, Wagner & Brown
Well:	Hildebrand 1018
TD:	8244
Upper Perf:	7695
Lower Perf:	8109

PRODUCTION HISTORY

YEAR	ANNUAL/MONTH	GAS/MCF	COND/BBLS.
75	JAN	0	0
75	FEB	0	0
75	MAR	0	0
75	APR	0	0
75	MAY	0	0
75	JUN	0	0
75	JUL	8064	418
75	AUG	6270	355
75	SEP	4561	256
75	OCT	4126	210
75	NOV	648	38
75	DEC	4840	183
75	ANNUAL	28509	1460
76	JAN	2074	36
76	FEB	5277	162
76	MAR	6022	196
76	APR	5897	194
76	MAY	6289	196
76	JUN	5085	152
76	JUL	6360	195
76	AUG	5588	160
76	SEP	6216	272
76	OCT	2694	120
76	NOV	3926	176
76	DEC	3885	164
76	ANNUAL	59313	2023
77	JAN	2920	134
77	FEB	2172	204
77	MAR	2040	19
77	APR	1925	173
77	MAY	959	124
77	JUN	2570	246
77	JUL	2372	204
77	AUG	2155	187
77	SEP	1692	188
77	OCT	1565	155
77	NOV	2081	208
77	DEC	1660	193
77	ANNUAL	24111	2035

TABLE 6

PRODUCTION DATA

Conger (Penn) Field

Sterling County, Texas

Operator:	Stoltz, Wagner & Brown
Well:	Hildebrand 7
TD:	8092
Upper Perf:	7461
Lower Perf:	7826

PRODUCTION HISTORY

YEAR	ANNUAL/MONTH	GAS/MCF	COND/BBLS.
75	ANNUAL	144190	3616
76	JAN	23730	218
76	FEB	20680	171
76	MAR	18845	166
76	APR	17386	154
76	MAY	17476	147
76	JUN	18369	148
76	JUL	17867	148
76	AUG	16847	131
76	SEP	17429	55
76	OCT	9273	30
76	NOV	15402	49
76	DEC	16593	51
76	ANNUAL	209897	1468
77	JAN	16076	53
77	FEB	13279	116
77	MAR	13874	127
77	APR	14494	137
77	MAY	15086	136
77	JUN	13991	140
77	JUL	13198	130
77	AUG	14907	106
77	SEP	13140	85
77	OCT	8537	65
77	NOV	639	3
77	DEC	13473	159
77	ANNUAL	150694	1257
78	JAN	12749	158
78	FEB	12519	139
78	MAR	13812	110
78	APR	11493	69
78	MAY	11109	151
78	ANNUAL	61682	627

TABLE 7

RESERVOIR PROPERTIES

Bottom Hole Pressure	1250 psi
Bottom Hole Temperature	155^{o}F
Formation Porosity	10%
Formation Permeability	.5
Rock Young's Modulus	5.5E to 6
Well Depth	8100'
Reservoir Fluid Viscosity	.02
Frac Gradient	.65
Drainage Radius	1320'
Formation Permeability to frac fluid	.06
Frac Heights Considered	50, 100, 200

TABLE 7A

FRAC FLUID PROPERTIES AT BOTTEM HOLE CONDITIONS

Cross-Linked Gel

Fluid Leak-off Viscosity	1.0 cp
Spurt Loss	.1 cc
N'	.52
K'	.015
Fluid Leak-off Coefficient C III	.0039 FT/SQR (min)
Specific Gravity	1.02
Specific Heat	1.00 BTU/lb_f

Cross-Linked Gelled Weak Acid

Fluid Leak-off Viscosity	1.0 cp
Spurt Loss	.1 cc
N'	.53
K'	.11
Spurt Loss	.1 cc
Fluid Leak-off Coefficient C III	.0017 FT/SQR (min)
Specific Gravity	1.1
Specific Heat	1.00 BTU/lb_f

TABLE 8

COMPUTER DESIGN, CROSS-LINKED GEL, MINI-MAX II

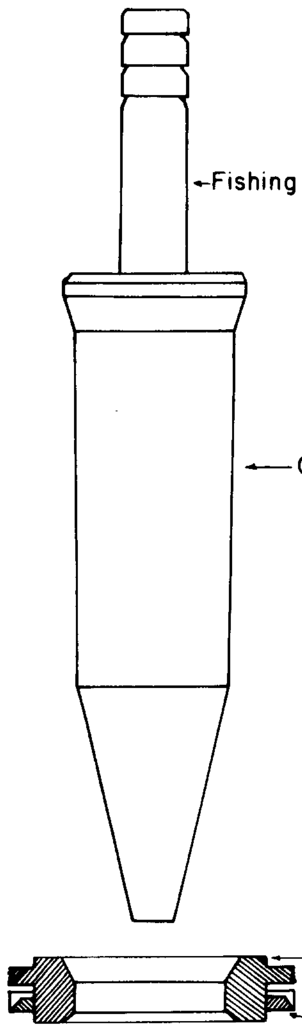
INJ RATE	FRAC HEIGHT	FRAC VOLUME	FRAC LENGTH	FRAC WIDTH	4re	PI CONSTRAST	J/Jo
BPM	FT	GAL	FT	IN			
15	50	10,000	228	.155	.17	.68	2.91
		20,000	340	.176	.26	.68	3.46
		30,000	430	.192	.33	.68	3.82
		40,000	500	.202	.38	.68	4.0
		50,000	575	.210	.44	.68	4.19
		60,000	640	.218	.48	.68	4.28
	100	10,000	119	.136	.09	.68	2.37
		20,000	174	.161	.13	.68	2.82
		30,000	216	.172	.16	.68	3.0
		40,000	250	.177	.19	.68	3.09
		50,000	285	.182	.22	.68	3.37
		60,000	311	.190	.24	.68	3.46
25	100	10,000	138	.155	.10	.68	2.68
		20,000	205	.183	.16	.68	3.0
		30,000	255	.194	.19	.68	3.09
		40,000	300	.207	.23	.68	3.37
		50,000	340	.217	.26	.68	3.46
		60,000	378	.223	.29	.68	3.59
	200	10,000	74	.152	.06	.68	2.0
		20,000	108	.161	.08	.68	2.3
		30,000	134	.166	.10	.68	2.68
		40,000	158	.175	.12	.68	2.80
		50,000	178	.183	.13	.68	2.82
		60,000	197	.199	.15	.68	2.95
40	100	10,000	153	.179	.12	.68	2.80
		20,000	230	.207	.17	.68	2.91
		30,000	295	.225	.22	.68	3.37
		40,000	350	.237	.27	.68	3.48
		50,000	400	.248	.30	.68	3.64
		60,000	441	.255	.33	.68	3.82
		70,000	490	.263	.37	.68	3.90
		80,000	530	.270	.40	.68	4.14
	200	10,000	82	.150	.06	.68	2.0
		20,000	121	.167	.09	.68	2.37
		30,000	153	.180	.12	.68	2.80
		40,000	181	.191	.14	.68	2.85
		50,000	205	.199	.16	.68	3.0
		60,000	227	.206	.17	.68	3.05
		70,000	249	.212	.19	.68	3.09
		80,000	269	.217	.20	.68	3.32

TABLE 9

COMPUTER DESIGN, CWA-3

INJ RATE	FRAC HEIGHT	FRAC VOLUME	FRAC LENGTH	FRAC WIDTH	4/re	PI CONTRAST x 10^4	J/Jo
BPM	FT	GAL	FT	IN			
15	50	10,000	295	.302	.22	1.2	3.64
		20,000	463	.344	.35	1.2	4.55
		30,000	600	.380	.45	1.2	5.14
		40,000	730	.405	.55	1.2	5.51
		50,000	845	.425	.64	1.2	5.73
		60,000	950	.441	.72	1.2	5.82
	100	10,000	154	.265	.12	1.2	2.91
		20,000	240	.305	.18	1.2	3.41
		30,000	311	.338	.24	1.2	3.82
		40,000	380	.396	.29	1.2	4.05
		50,000	425	.377	.32	1.2	4.32
		60,000	480	.392	.36	1.2	4.55
25	100	10,000	160	.296	.12	1.2	2.91
		20,000	255	.347	.19	1.2	3.42
		30,000	335	.380	.25	1.2	3.82
		40,000	400	.405	.30	1.2	4.18
		50,000	465	.424	.35	1.2	4.55
		60,000	530	.443	.40	1.2	4.91
	200	10,000	87	.281	.07	1.2	2.18
		20,000	135	.311	.10	1.2	2.78
		30,000	175	.340	.13	1.2	3.0
		40,000	210	.360	.16	1.2	3.19
		50,000	240	.379	.18	1.2	3.41
		60,000	270	.394	.20	1.2	3.55
40	100	10,000	170	.337	.13	1.2	3.0
		20,000	270	.394	.20	1.2	3.55
		30,000	365	.436	.28	1.2	4.01
		40,000	430	.460	.33	1.2	4.33
		50,000	500	.484	.38	1.2	4.73
		60,000	540	.496	.41	1.2	4.95
		70,000	625	.520	.47	1.2	5.19
		80,000	680	.535	.52	1.2	5.46
	200	10,000	90	.281	.07	1.2	2.18
		20,000	144	.314	.11	1.2	2.80
		30,000	190	.351	.14	1.2	3.1
		40,000	225	.371	.17	1.2	3.2
		50,000	260	.389	.20	1.2	3.55
		60,000	295	.407	.22	1.2	3.64
		70,000	330	.422	.25	1.2	3.82
		80,000	360	.434	.27	1.2	3.96

Casing Size	Lower	Middle	Top
4 1/2"	3.50"	3.0625"	2.6500"
5 1/2"	4.00"	3.5000"	3.0625"



CAST IRON CASING RING & BOMB