HYDRAULIC QUICK COUPLER PRESSURE DROP

Thesis for the Degree of M. S.

MICHIGAN STATE UNIVERSITY

JAMES BERMANN

1971

ABSTRACT

HYDRAULIC QUICK COUPLER PRESSURE DROP

BY

James Bermann

This study was undertaken to investigate the pressure drop which occurs in hydraulic quick couplers due to the inherent restrictions to fluid flow.

The application of hydraulic quick couplers is widespread in agriculture and is of concern to those associated with the use of hydraulic equipment. The solution of the problem of misapplication of these components appears to be the planned use of specific types based upon their flow characteristics.

A few manufacturers supply with their couplers a set of test result data, upon request, which aids in the correct utilization of these handy and convenient units.

Prior experience with hydraulic equipment and requests from users prompted a further investigation of the flow characteristics of the four basic types of couplers.

Included in the investigation were pressure drop and temperature rise of the fluid and coupler with relation to volume of flow.

The basic test unit consisted of a Vickers PV-2032, 30 gpm hydraulic pump driver by a 10 hp electric motor operating at a system pressure of 500 psi. The pump was capable of variable delivery volume from 0 to its maximum capacity by handwheel control. The pressure drop test equipment consisted of a 120 inch differential pressure manometer capable of reading a maximum differential pressure of 68.75 psi. Associated with the mano-

meter was a set of hydraulic pressure gages of 500 psi capacity. The pressure gages were employed to check the total pressure drop across the test couplings to determine whether the differential would exceed the limits of the manometer and flush the manometer fluid (mercury) into the hydraulic system.

The hydraulic pressure drops through the couplers tested showed a significant problem exists at high flow rates. One coupler showed a pressure drop of 325 psi at a flow rate of 23 gpm.

The temperature differential measured in the fluid before and after the coupling was less than 3 degrees farenheit. Fluid temperature in the 60 gallon reservoir using SAE 10 hydraulic fluid rose a maximum of 11 degrees during 30 minutes of testing.

The tests conclusively proved that especially for high flow rates near or exceeding the manufacturers flow specifications, large pressure drops occur in most couplings tested.

A test of pressure drop at 250 psi was performed on each coupling to determine if varying the pressure would have an effect on the pressure drop through the coupler. These tests showed no apparent changes in the total pressure losses. It can therefore be assumed that the initial tests were a true indication of the flow characteristics of that particular coupler.

Approved Carl F. Albrecht
Major Professor

Approved B A Stout
Department Chairman

HYDRAULIC QUICK COUPLER PRESSURE DROP

By

James Bermann

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

MASTER OF SCIENCE

Department of Agricultural Engineering

1971

G68414

ACKNOWLEDGMENTS

The author would like to express his sincere appreciation to all who assisted in any manner in the completion of this investigation.

Special appreciation is afforded Professor L. K. Pickett for his suggestions and assistance in assembling components for the test device construction.

Much appreciation is extended to Professor C. F. Albrecht for his moral support and encouragement.

A special "thank you" is given to Mr. John Ojala, Public Relations Manager, Vickers Hydraulics, Troy, Michigan, for his work in obtaining the test unit, hydraulic pump-electric motor-reservoir assembly.

The author is grateful to the many hydraulic coupler manufacturers who supplied at no cost the various types of units to be tested.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

The findings in this thesis do not constitute a condemnation or endorsement of any manufacturers product, merely a study of representative types.

INTRODUCTION

It was in the middle 1930's when the tractor hydraulic system became popular. The use of remote hydraulic components followed soon, specifically being used to raise pull-type implements and angle offset disc harrows.

In the post World War II days the advancements of wartime developments of hydraulics moved toward the agricultural industry. The transfer of hydraulic power to a detachable implement posed some problems associated with the disconnecting of hydraulic lines from the power source, namely, the tractor.

Tractor hydraulic power as a percentage of PTO power has increased from 20% in 1955 to 50% in 1964 (Zimmerman, 1966).

The advantages of hydraulic power are numerous and the application of this type of power transmission is still expanding. Many agricultural machines exclusively use hydraulic power for all functions of that machine. Some of the components are detachable and interchangeable with a unit that is also hydraulically powered.

One of the disadvantages of hydraulics besides low efficiency is most systems intolerance to dirt, foreign particles, and other pollutants.

Quick disconnect couplers have been used where oil lines have been used in a situation requiring frequent connection and disconnection. They have also been employed when it is desirable to have a self sealing connector on a line to eliminate the necessity of capping the line, to avoid the loss of oil and introduction of foreign material into the oil and system.

Although the couplers are convenient, they do present a restriction to the flow of fluid. The significance of this restriction is manifested by a drop in pressure through the coupler with a resultant loss of efficiency in a dynamic application of fluid power. The couplers under high flow conditions have, in some cases become hot enough to preclude handling and operation with bare hands.

It is a logical assumption that most coupler manufacturers have tested their own units to determine the flow characteristics. Many have this data available. Still others may be reluctant to publish this information or simply do not have it available.

Another interesting characteristic of the coupler flow patterns would be the misapplication or usage in a system where the manufacturers specifications are exceeded. The use of a coupler that is too small or that has too high a pressure drop is not easily noticed prior to actual operation. It usually manifests itself as a cylinder that is slow in lifting or a hydraulic motor which will not develop its potential horsepower or related characteristics.

OBJECTIVES

In view of these problems, the objectives of this investigation are twofold. The first set of objectives are:

1. To construct and assemble a pump system which is capable of variable volume up to an arbitrary flow rate of 30 gpm and a pressure of a significant value to make valid determinations of pressure drop.
2. To construct and assemble a measuring system or device which will lend itself to accurately determining the pressure drops across test couplers as well as measuring, with reasonable accuracy, the flow rate through the couplers. Also it is necessary for the investigation of temperature rise in the fluid through the coupling; to have a method of determining the fluid temperature both upstream and downstream of the test unit coupling.

The second set of objectives are:

1. To measure, in a representative sampling of the four major types of quick couplers used in agricultural applications, the pressure drop and temperature rise.
2. To develop a set of recommendations for the application of quick couplers by type.

BACKGROUND INFORMATION AND TERMINOLOGY

Quick Disconnect Couplers

To simplify the classification of various types of quick couplers used in agricultural applications this thesis will use those already established (John Deere, 1967). The four basic types of quick couplers are:

1. Double poppet
2. Sleeve and poppet
3. Sliding seal
4. Double rotating ball

Quick couplers usually consist of two halves; the body and the plug. The body usually has a spring loaded seal as does the plug. This seal retains the fluid and protects it from contamination. As the plug is inserted into the body the seals are forced open to allow the free flow of fluid. A locking device holds the two halves together and seals them.

The double poppet coupler shown in Figure 1 has a self sealing poppet in each coupler half. When they are closed or in the uncoupled position the poppets seal in the oil as they seal out foreign material. When they are pushed into the coupled position, the poppets are forced from their seats into an open position. The coupler halves are locked into place by a series of steel balls in the body which are held in place by a spring loaded outer sleeve.

Some double poppet couplers use large steel balls in place of the

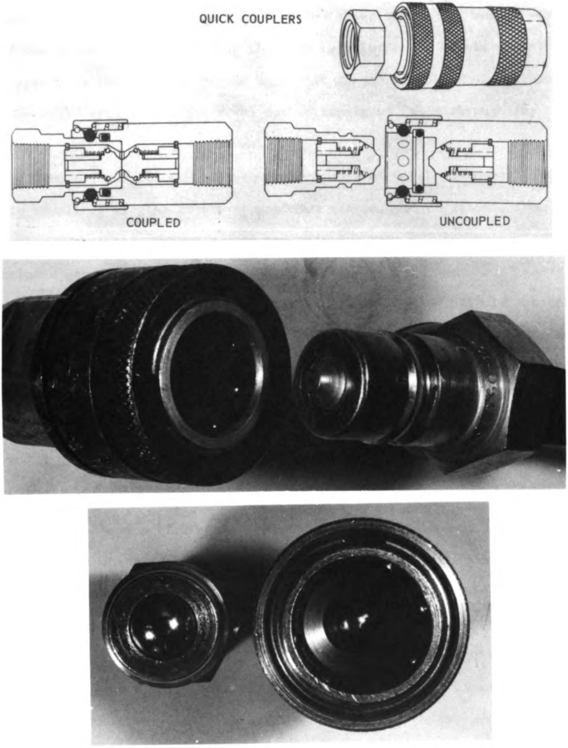

Figure 1.--Double Poppet Hydraulic Quick Couplers

poppet which are spring loaded to operate similarly. The traditional advantage of the use of the steel balls in place of the shaped poppet has been that the balls are considerably harder and resist wear. Wear of the poppet tip has added to the flow restriction of double poppet couplers as they age and become worn. It is conceivable that extreme wear could actually shut off the entire supply of fluid through the coupler.

The majority of the listed manufacturers of quick disconnect hydraulic couplings use the double poppet type design. It is assumed from experience that this occurs due to the relative ease of manufacture and the related production cost.

The sleeve and poppet couplers, used almost exclusively in aircraft applications usually have a self sealing poppet on the plug, and a sliding tubular valve and sleeve in the body. The extended sleeve shown in Figure 2, inserts first and gives an added margin of sealing against oil loss or dirt or air entry.

One manufacturer of agricultural hydraulic equipment uses the sliding seal coupler or commonly called the sliding gate. In Figure 3 the coupler is shown to have a sliding gate which covers the fluid port in each half of the unit when it is disconnected. As the two halves are slid together the seals are forced from covering the ports. In most cases due to the design of this type coupling a copious amount of fluid may leak out. The coupler halves besides being locked together by their respective "tracks", are locked by a sliding bolt pin on one of the coupler halves.

The double rotating ball coupler used by one manufacturer is shown in Figure 4. This particular coupler is an adaptation of the double poppet type connector but utilizes an indented lever to open the poppets after

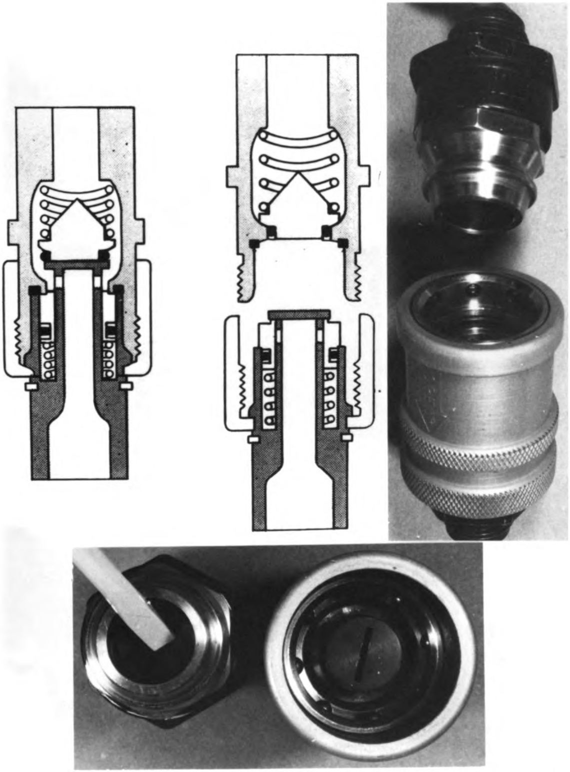

Figure 2.--Sleeve and Poppet Hydraulic Quick Coupler

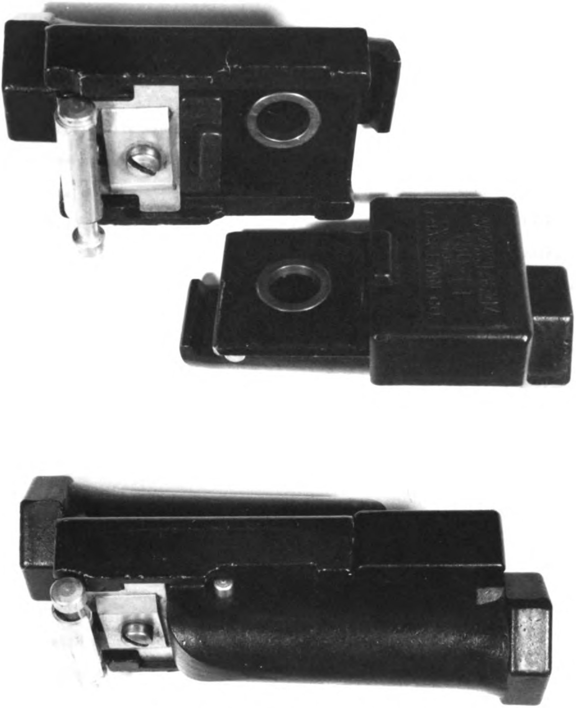

Figure 3.--Sliding Seal Hydraulic Quick Coupler

the plug and body have been disconnected. This type of coupler is connected by inserting the line plug into the body with the lever so positioned to preclude fluid loss, and then is turned to force open the poppet balls, allowing the oil to flow. When the coupler is disconnected, pulling the line plug rotates the lever to close the valve balls minimizing the loss of oil. The coupler halves are locked by a ring of small steel balls similar to the double poppet type coupler. When the line connected to the line plug is pulled it puts pressure on the sleeve that the coupler assembly is mounted in. When this pressure is exerted it rotates the release lever and disconnects the plug as it closes the ball valves thereby releasing the line to the coupler without damage. Similar devices are available for the other types of couplers although they are not an integral part of the manufactured assembly.

Many of the couplers used in agricultural applications are manufactured with pipe thread connections to facilitate use with standard fittings and pipe used for water systems. This standardization of thread dimensions has greatly broadened the use of the quick coupler to include areas besides oil hydraulics.

Of the various sources consulted there was little information available on the flow characteristics of the various types of couplers. A few manufacturers had extensive test result data. Others could do no more than say the maximum flow and pressure recommended is as follows, with no reference to pressure drop.

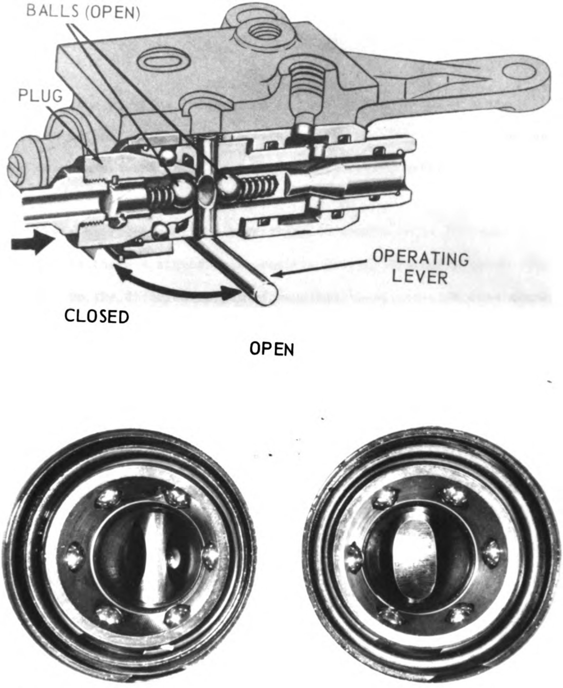

Figure 4.--Double Rotating Ball Hydraulic Quick Coupler

STATEMENT OF THE PROBLEM

When the previous information is reviewed and related library research is concluded it is evident that the problem of coupler pressure drop measurement and study is one that could prove valuable in hydraulic component application and use.

The requirements of the investigation should be as follows:

1. Is there a significant pressure drop in hydraulic quick couplers?
2. Do the different types of couplers using the same size connecting conduits vary in pressure drop?
   (Which type has the greatest or least drop?)
3. Is there a significant temperature rise in the fluid due to the restrictions caused by quick couplers?
4. Is the equipment constructed to investigate the flow characteristic adequate and accurate enough for valid data accumulation and analyzation?

DESIGN AND CONSTRUCTION OF THE TEST EQUIPMENT

Differential Pressure Manometer and Gage System

Most manometer applications involve the use of water as the fluid media with total pressures of less than 150 psi. Under these conditions glass or clear plastic tubing is sufficiently strong to contain the pressure and still afford a reasonable degree of clarity for reading. When mercury is used as a manometer fluid and pressures approach 500 psi it is necessary to seek other materials to contain the manometer fluid and related pressures sensed.

Mercury has a specific gravity of 13.546 and a density of 847 pounds per cubic foot. Due to its density and melting point, it affords a relatively ideal application to manometer use. (Marks, 1958) The U-tube manometer expresses the difference in pressure in the tube arms as a total difference of the fluid levels in the arms.

The tubing selected for use in the test application was nylon pressure tubing having an outside diameter of 1/4 inch, and an inside diameter of 0.150 inches. The test burst pressure was 2500 psi. Although the tubing was not transparent it was translucent enough to be read easily. The test pressures did not exceed 500 psi and the fluid temperatures were below 100° F. It was expected that further use of the equipment at the termination of these tests may exceed the test values. Tygon tubing with a listed burst of 1800 psi and temperature tolerance of 221° F. is much more transparent but has an elongation of 400% at high temperatures. (U.S. Plastics Corp., 1970)

The ends of the nylon tubing were joined to standard 1/8 inch black pipe with nylon pressure tube fittings. The fittings had a standard gage nut securing the tubing to the fitting on one end and male pipe threads on the other. The force to pull out the tubing from the compression type fitting was 35 pounds at 1700 psi.

The manometer was isolated from the pressure connections by two hand valves in the 1/8 inch pipe line. Two 500 psi pressure gages were mounted near the manometer outlets with common connections and isolation valves. Tape repair blades cut to length were nailed to the wooden uprights to form the manometer scale. In Figure 5, the center gage was placed for future use in determining maximum pressure to be applied to the manometer using a 1.7 safety factor, relative to manometer tube fitting failure.

Two line levels were fastened to a plate on the base of the manometer-gage assembly to be used in conjunction with the four leveling screws located on the corners of the base, as illustrated in Figure 5. The entire unit was then mounted on casters for ease of positioning and movement.

Pump-Motor-Reservoir Assembly

It was estimated that the maximum flow necessary to test couplers used on agricultural equipment would be near 30 gpm. Due to the estimated safe working pressure of the manometer tube fittings it was determined that 500 psi would be an acceptable test pressure.

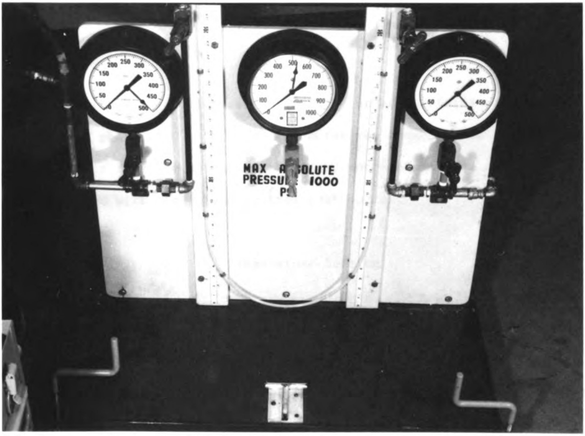

Figure 5.--Pressure Measuring Manometer and Gages

A Vickers PV-2032, 30 gpm, piston type variable displacement pump, was secured along with a 60 gallon base type reservoir. If it is assumed that the pump efficiency is 70% the following holds true:

$$\text{Pump Input hp} = \frac{\text{psi x gpm x } 0.000583}{\text{efficiency}}$$

$$12.49 \text{ hp} = \frac{500 \text{ x } 30 \text{ x } 0.000583}{.70}$$

Assuming that an electric motor will run at overloads near 25%, a 10 hp, 3 phase, 240 volt, 1150 rpm motor was connected to the pump shaft with a flexible coupling. Standard motor protection and control was utilized with a magnetic control push button.

Temperature Sensing

Due to the expected temperature ranges of from 80 to 120 degrees Fahrenheit, iron-constantan thermocouples were used in conjunction with a two channel chart recorder. The thermocouples were epoxied into brass 1/8 inch pipe fittings and inserted into the main flow line, one immediately in front of the test coupler and the other immediately behind it, as shown in Figure 8.

Flow Measurement and Pressure Control

A standard portable hydraulic tester was utilized to measure the flow rate and to apply line restriction downstream of the test coupler thereby controlling system pressure. This unit as shown in Figure 9,

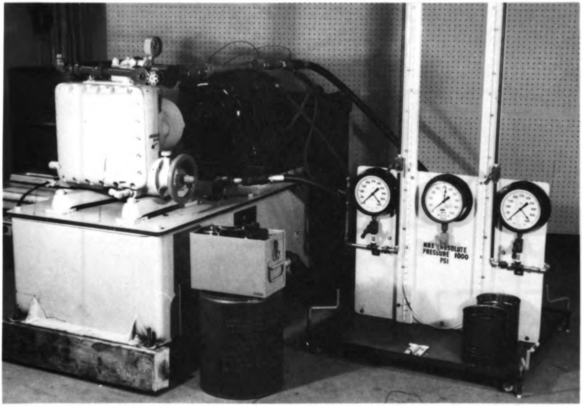

Figure 6.--Overall Test Apparatus

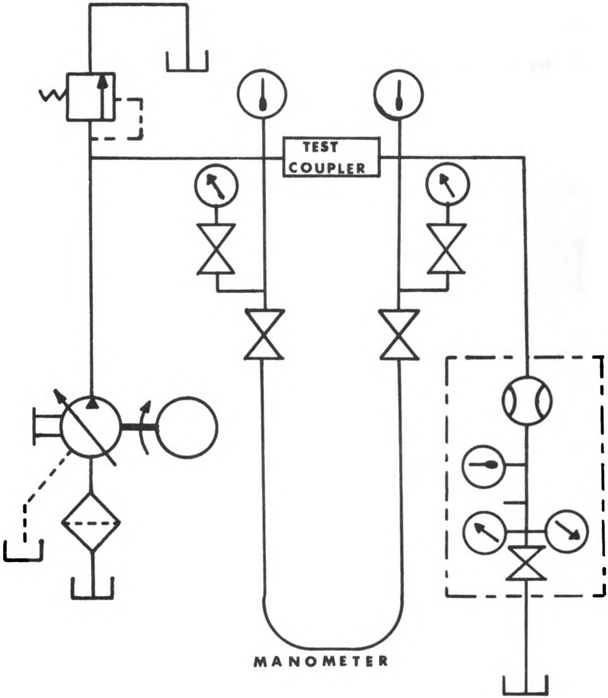

Figure 7.--Hydraulic Schematic of Test Apparatus

also has a fluid temperature gage which was used to determine fluid temperature rise during the tests.

Hydraulic Fluid

The fluid used was Military Specification hydraulic oil of SAE 10 weight, having nomenclature MIL-H-46001A.

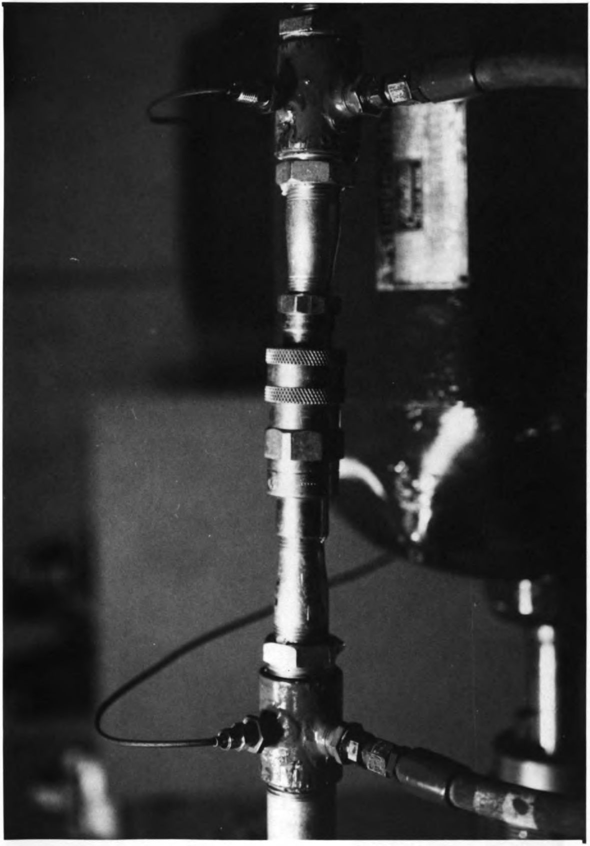

Figure 8.--Coupling in Test Position (showing thermocouples)

Figure 9.--Hydraulic Tester

CONSIDERATIONS AND TEST PROCEDURE

Due to the possibilities of failure of some of the parts on the test equipment a relief valve was employed in the main pressure line. Mercury, especially when it is heated and becomes gaseous, is potentially poisonous. It was therefore handled by the operator using rubber gloves while charging the manometer. The test operator had to be very careful when opening the manometer gages. If they were not opened precisely at the same time the pressure would flush the manometer fluid into the hydraulic line and hence to the reservoir.

The pump, when started on a relatively low flow setting, due to the position of the reservoir, would not start pumping fluid immediately, and it was necessary to turn the handwheel control to a relatively high setting before the pump started pumping. This, in some cases, caused such a surge of fluid that it often cracked the line relief valve.

Test Procedure

Prior to the actual tests the manometer and pressure gages were individually calibrated. Then a dynamic calibration was performed using a standard 1 inch pipe nipple, 5 inches long. The upstream gage (abbreviated U.S.) as shown in Table 1, was used as a standard and was pressurized in 25 psi increments at 2, 8, 16 and 30 gpm.

TABLE 1.--Pressure Gage Calibration, 2 gpm

Upstream Pressure	Downstream Pressure
25	24
50	49
75	74
100	99
125	125
150	150
175	176
200	203
225	228
250	254
275	279
300	304
325	329
350	354
375	379
400	404
425	428
450	454
475	480
500	505

TABLE 2.--Pressure Gage Calibration, 8 gpm

Upstream Pressure	Downstream Pressure
--	--
50	50
75	74
100	98
125	125
150	150
175	177
200	204
225	228
250	254
275	274
300	304
325	327
350	353
375	378
400	405
425	427
450	456
475	477
500	503

TABLE 3.--Pressure Gage Calibration, 16 gpm

Upstream Pressure	Downstream Pressure
--	--
--	--
--	--
100	99
125	125
150	150
175	177
200	203
225	229
250	254
275	280
300	304
325	327
350	355
375	380
400	405
425	428
450	454
475	479
500	506

TABLE 4.--Pressure gage calibration, 30 gpm

Upstream Pressure	Downstream Pressure
--	--
--	--
--	--
--	--
--	--
--	--
--	--
200	203
225	229
250	254
275	279
300	304
325	329
350	355
375	381
400	405
425	430
450	455
475	480
500	506

At the low pressures and high flow rates it was not possible to obtain a true reading due to the high velocity fluid flow causing high pressure readings.

The actual set up and performance of a test was as follows:

1. Install test coupler in the test equipment.
2. Record temperature of fluid and surface temperature of coupler.
3. Start and run pump until flow fluctuations cease at a system pressure pressure of 150 psi and flow of 5 gpm.
4. Reduce flow to 1 gpm, increase pressure to 500 psi.
5. Record pressure drop through coupler from 1 to 30 gpm in 1 gpm increments with the upstream pressure set at 500 psi.
6. Record temperature of the hydraulic fluid at the inlet and outlet of the coupler for each flow.
7. Record surface temperature of coupler by reading the spot check thermometer at each flow.

RESULTS AND DISCUSSION

The results of the tests performed are presented in Tables 5 through 13. The upstream pressure, that is the pressure recorded for fluid prior to entering the coupling, is abbreciated by the "U.S. Press.", as is the downstream pressure, "D.S. Press.", for the fluid leaving the coupling. The total pressure drop is the difference between "U.S. Press." and "D.S. Press." and is expressed merely as drop. Throughout the tests it was observed that the recorded temperature differential of the fluid through the coupler never varied more than 3° F., hence the elimination of this record on the test sheet. It is assumed that the temperature differential is negligible, probably due to the large reservoir capacity and the relatively little effect the heating of the coupler has on its overall temperature.

The following Tables 6-13, illustrate the respective results of the tests performed on the other couplers made available by the various manufacturers. They represent the types used in agricultural applications.

A calculated K factor for use in the classical head loss formal formula (Yeaple, 1966) was also developed for each coupler:

$$H_L = K \frac{V^2}{2g} , \qquad K = H_L \frac{2g}{V^2}$$

H_L = head loss, ft.

K = factor, dimensionless

V = fluid velocity, ft./sec.

g = acceleration of gravity, 32.2 ft./sec.^{2}

TABLE 5.--Coupler Test Sheet, coupler A

Air Temperature: 70° F.

Fluid Temperature (prior to test): 80° F.

Fluid Temperature (end of test): 86° F.

Coupler Type: double poppet, ½ inch pipe threads

Coupler Temperature (start): 70° F.

Coupler Temperature (finish): 92° F.

Coupler Material: cadmium plated steel

Flow (gpm)	U.S. Press	D.S. Press (corrected)	Drop
1	20*	16	4
2	50*	45	5
3	100*	95	5
4	500	495	5
5	500	495	5
6	500	495	5
7	500	490	10
8	500	485	15
9	500	485	15
10	500	474	26
11	500	473	27
12	500	475	25
13	500	470	30
14	500	465	35
15	500	460	40
16	500	455	45
17	500	450	50
18	500	449	51
19	500	440	60
20	500	436	64
21	500	429	71
22	500	425	75
23	500	420	80
24	500	415	85
25	500	407	93
26	500	400	100
27	500	396	104
28	500	385	115
29	500	381	119
30	500	380	120

*due to low volume pumping this was the max. pressure that could be obtained.

Calculated K factor = 23.2 (at 15 gpm)

The temperature of the fluid at the completion of the test 32 minutes later was 86° F. The fluid temperature difference before and after the coupler was measured as a maximum of 2° F. and was deemed insignificant. The surface temperature of the coupler, however, rose from 70° (air temperature) to 92° at the close of the testing.

The determined K factor at the median flow value of 15 gpm is then:

$$H_L = 40 \text{ psi} \times \frac{2.31 \text{ ft.}^*}{1 \text{ psi}} = 92.4 \text{ ft.}$$

$$V = (\text{estimated for } \tfrac{1}{2} \text{ inch std. pipe}) = 16 \text{ ft./sec.}^{**}$$

$$K = 92.4 \, \frac{64.4}{256} = \underline{\underline{23.2}}$$

* (King, 1954)

** (BeGe, 1963)

A sample test was performed at an upstream pressure of 250 psi. The total pressure drop at each flow increment remained within 3 psi, therefore it was assumed the drops recorded were relatively constant. The difference in drops can probably be attributed to the flow pattern changes in the various connecting fittings.

TABLE 6.--Coupler Test Sheet, coupler B

Air Temperature: 72° F.

Fluid Temperature (prior to test): 78° F.

Fluid Temperature (end of test): 82° F.

Coupler Type: double poppet, ball type, ½ inch pipe threads

Coupler Temperature (start): 65° F.

Coupler Temperature (finish): 79° F.

Coupler Material: cadmium plated steel

Flow (gpm)	U.S. Press.	D.S. Press (corrected)	Drop
1	500	500	0
2		500	0
3		499	1
4		498	2
5		495	5
6		495	5
7		494	6
8		494	6
9		491	9
10		490	10
11		486	14
12		484	16
13		480	20
14		476	24
15		475	25
16		470	30
17		467	33
18		462	38
19		460	40
20		451	49
21		448	52
22		445	55
23		440	60
24		436	64
25		427	73
26		424	76
27		420	80
28		415	85
29		405	95
30		399	101

Calculated K factor = 14.4 (at 15 gpm)

TABLE 7.--Coupler Test Sheet, coupler C

Air Temperature: 64° F.

Fluid Temperature (prior to test): 82° F.

Fluid Temperature (end of test): 90° F.

Coupler Type: double poppet, ½ inch pipe threads

Coupler Temperature (start): 65° F.

Coupler Temperature (finish): 92° F.

Coupler Material: cadmium plated steel

Flow (gpm)	U.S. Press.	D.S. Press. (corrected)	Drop
1	500	500	0
2		500	0
3		500	0
4		495	5
5		493	7
6		490	10
7		488	12
8		484	16
9		480	20
10		475	25
11		470	30
12		466	34
13		462	38
14		460	40
15		452	48
16		448	52
17		444	56
18		440	60
19		431	69
20		425	75
21		420	80
22		415	85
23		407	93
24		399	101
25		392	108
26		381	119
27		375	125
28		365	135
29		356	144
30		345	155

Calculated K factor = 27.7 (at 15 gpm)

TABLE 8.--Coupler Test Sheet, coupler D

Air Temperature: 64° F.

Fluid Temperature (prior to test): 87° F.

Fluid Temperature (end of test): 95° F.

Coupler Type: double poppet, ball type, ½ inch pipe threads

Coupler Temperature (start): 70° F.

Coupler Temperature (finish): 91° F.

Coupler Material: cadmium plated steel

Flow (gpm)	U.S. Press.	D.S. Press. (corrected)	Drop
1	500	500	0
2		500	0
3		500	0
4		500	0
5		500	0
6		497	3
7		497	3
8		496	4
9		493	7
10		490	10
11		487	13
12		485	15
13		481	19
14		475	25
15		473	27
16		470	30
17		460	40
18		455	45
19		450	50
20		448	52
21		445	55
22		440	60
23		437	63
24		425	75
25		420	80
26		415	85
27		410	90
28		400	100
29		395	105
30		390	110

Calculated K factor = 15.6 (at 15 gpm)

TABLE 9.--Coupler Test Sheet, coupler E

Air Temperature: 65° F.

Fluid Temperature (prior to test): 85° F.

Fluid Temperature (end of test): 90° F.

Coupler Type: double rotating ball, ½ inch pipe-open port

Coupler Temperature (start): 70° F.

Coupler Temperature (finish): 80° F.

Coupler Material: steel plug and components with cast iron housing

Flow (gpm)	U.S. Press.	D.S. Press. (corrected)	Drop
1	500	500	0
2		499	1
3		499	1
4		499	1
5		498	2
6		496	4
7		494	6
8		494	6
9		494	6
10		494	6
11		490	10
12		480	20
13		480	20
14		478	22
15		475	25
16		470	30
17		467	33
18		460	40
19		450	50
20		440	60
21		431	69
22		426	74
23		420	80
24		420	80
25		418	82
26		415	85
27		410	90
28		408	92
29		406	94
30		405	95

Calculated K factor = 14.4 (at 15 gpm)

TABLE 10.--Coupler Test Sheet, coupler F

Air Temperature: 70° F.

Fluid Temperature (prior to test): 74° F.

Fluid Temperature (end of test): 83° F.

Coupler Type: double poppet, ½ inch pipe threads

Coupler Temperature (start): 74° F.

Coupler Temperature (finish): 80° F.

Coupler Material: cadmium plated steel

Flow (gpm)	U.S. Press.	D.S. Press. (corrected)	Drop
1	500	500	0
2		500	0
3		500	0
4		500	0
5		500	0
6		499	1
7		498	2
8		496	4
9		494	6
10		493	7
11		490	10
12		480	20
13		476	24
14		474	26
15		467	33
16		462	38
17		456	44
18		452	48
19		448	52
20		443	57
21		439	61
22		434	66
23		426	74
24		423	77
25		419	81
26		410	90
27		405	95
28		397	103
29		390	110
30		381	119

Calculated K factor = 19.1 (at 15 gpm)

TABLE 11.--Coupler Test Sheet, coupler G

Air Temperature: 70° F.

Fluid Temperature (prior to test): 83° F.

Fluid Temperature (end of test): 91° F.

Coupler Type: sliding seal

Coupler Temperature (start): 71° F.

Coupler Temperature (finish): 88° F.

Coupler Material: cast aluminum

Flow (gpmP	U.S. Press.	D.S. Press. (corrected)	Drop
1	500	500	0
2		500	0
3		500	0
4		500	0
5		500	0
6		500	0
7		500	0
8		500	0
9		500	0
10		499	1
11		499	1
12		499	1
13		496	4
14		495	5
15		494	6
16		491	9
17		490	10
18		488	12
19		485	15
20		482	18
21		481	19
22		480	20
23		478	22
24		474	26
25		470	30
26		468	32
27		465	35
28		465	35
29		458	38
30		458	42

Calculated K factor = 3.4 (at 15 gpm)

TABLE 12.--Coupler Test Sheet, coupler H

Air Temperature: 76° F.

Fluid Temperature (prior to test): 88° F.

Fluid Temperature (end of test): 98° F.

Coupler Type: sleeve and poppet, ½ 37° flare

Coupler Temperature (start): 80° F.

Coupler Temperature (finish): 97° F.

Coupler Material: aluminum

Flow (gpm)	U.S. Press.	D.S. Press. (corrected)	Drop
1	500	500	0
2		500	0
3		494	6
4		485	15
5		475	25
6		467	33
7		461	39
8		450	50
9		441	59
10		435	65
11		425	75
12		416	84
13		401	99
14		384	116
15		374	126
16		358	142
17		342	158
18		330	170
19		320	180
20		308	192
21		290	210
22		277	223
23		261	239
24		245	255
25		216	284
26		195	305
27		- *	-
28		- *	-
29		- *	-
30		- *	-

*back pressure exceeded 500 psi on upstream gage

Calculated K factor = 72.7 (at 15 gpm)

TABLE 13.--Coupler Test Sheet, coupler I

Air Temperature: 77° F.

Fluid Temperature (prior to test): 88° F.

Fluid Temperature (end of test): 99° F.

Coupler Type: sleeve and poppet, ½ inch 37° flare

Coupler Temperature (start): 75° F.

Coupler Temperature (finish): 90° F.

Coupler Material: aluminum

Flow (gpm)	U.S. Press	D.S. Press. (corrected)	Drop
1	500	500	0
2		495	5
3		485	15
4		477	23
5		471	29
6		460	40
7		448	52
8		440	60
9		427	73
10		415	85
11		405	95
12		385	115
13		370	130
14		355	145
15		340	160
16		318	182
17		304	196
18		282	218
19		262	238
20		246	254
21		226	274
22		205	295
23		175	325
24		- *	-
25		- *	-
26		- *	-
27		- *	-
28		- *	-
29		- *	-
30		- *	-

*back pressure exceeded 500 psi on upstream gage

Calculated K factor = 92.4 (at 15 gpm)

In most cases when operating at flow rates above 10 gpm, the manometer fluid level oscillated wildly. The amplitude of the oscillations usually exceeded the height of the manometer and hence flushed the manometer fluid into the reservoir. This necessitated reloading the manometer to a usable level; a somewhat tedious process. The fluid variations were assumed to be a result of the turbulence created in the flow line by various fittings and taps.

Also, at high flow rates, the pressure gage indicating needles oscillated requiring interpolation for point reading.

Throughout the tests various sounds of labor were heard coming from the pump and flow lines. Minor leaks occurred in the piping system and were subsequently repaired. The fittings used to mount the test couplers required the use of dry seal raw teflon tape to seal them after many tests.

It was observed that virtually no visual fluid contamination occurred except for the mercury which was assumed to be flushed into the reservoir sump; no attempt was made to reclaim it during the tests.

In Figures 10 through 18, pressure drops recorded for the respective couplers are plotted. In the case of couplers H and I the scales are necessarily expanded. The pressure drops were recorded to the nearest 1 psi, and flow rates are plus or minus 2% according to the hydraulic tester manufacturer.

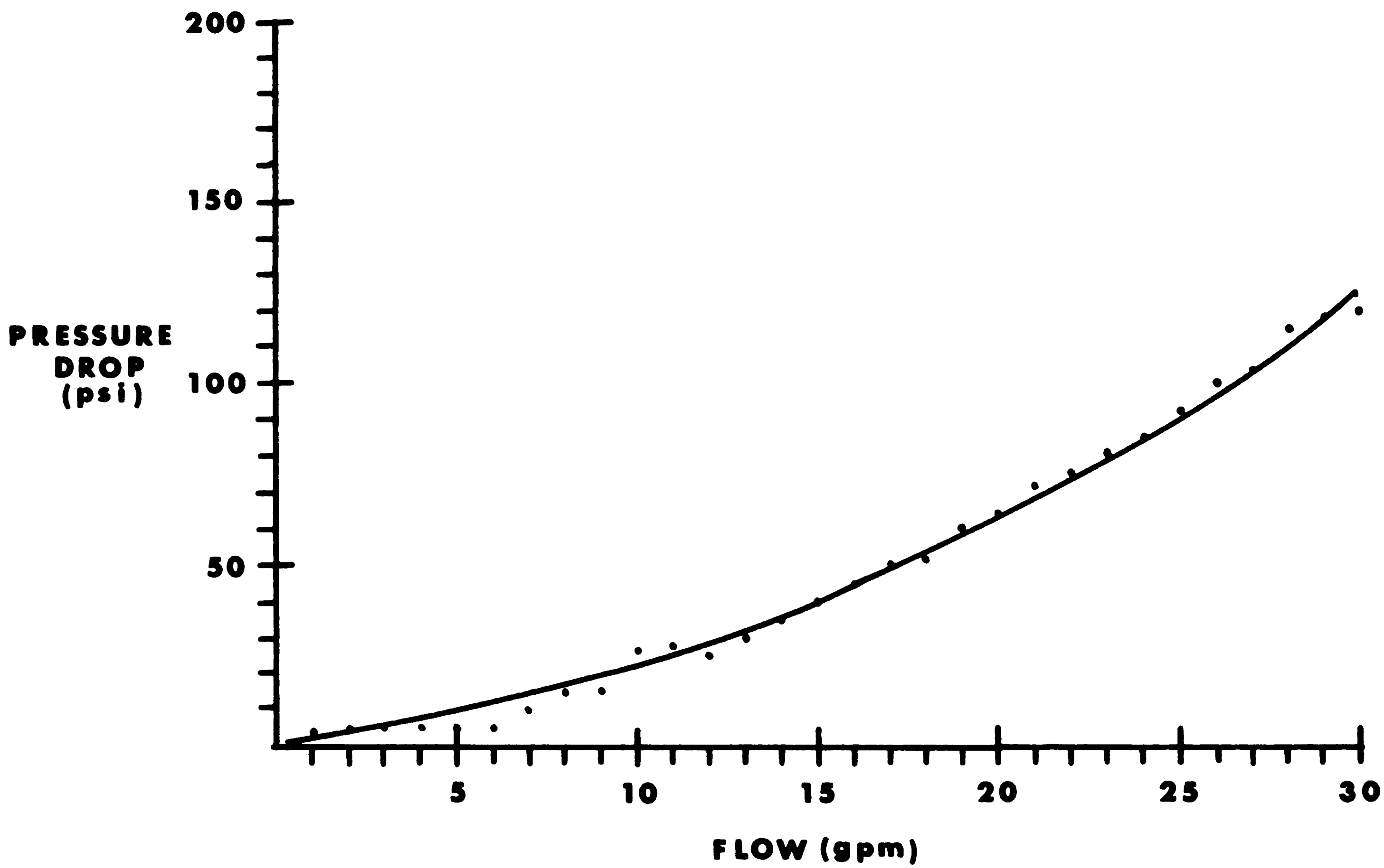

Figure 10.--Pressure Drop Curve, coupler A

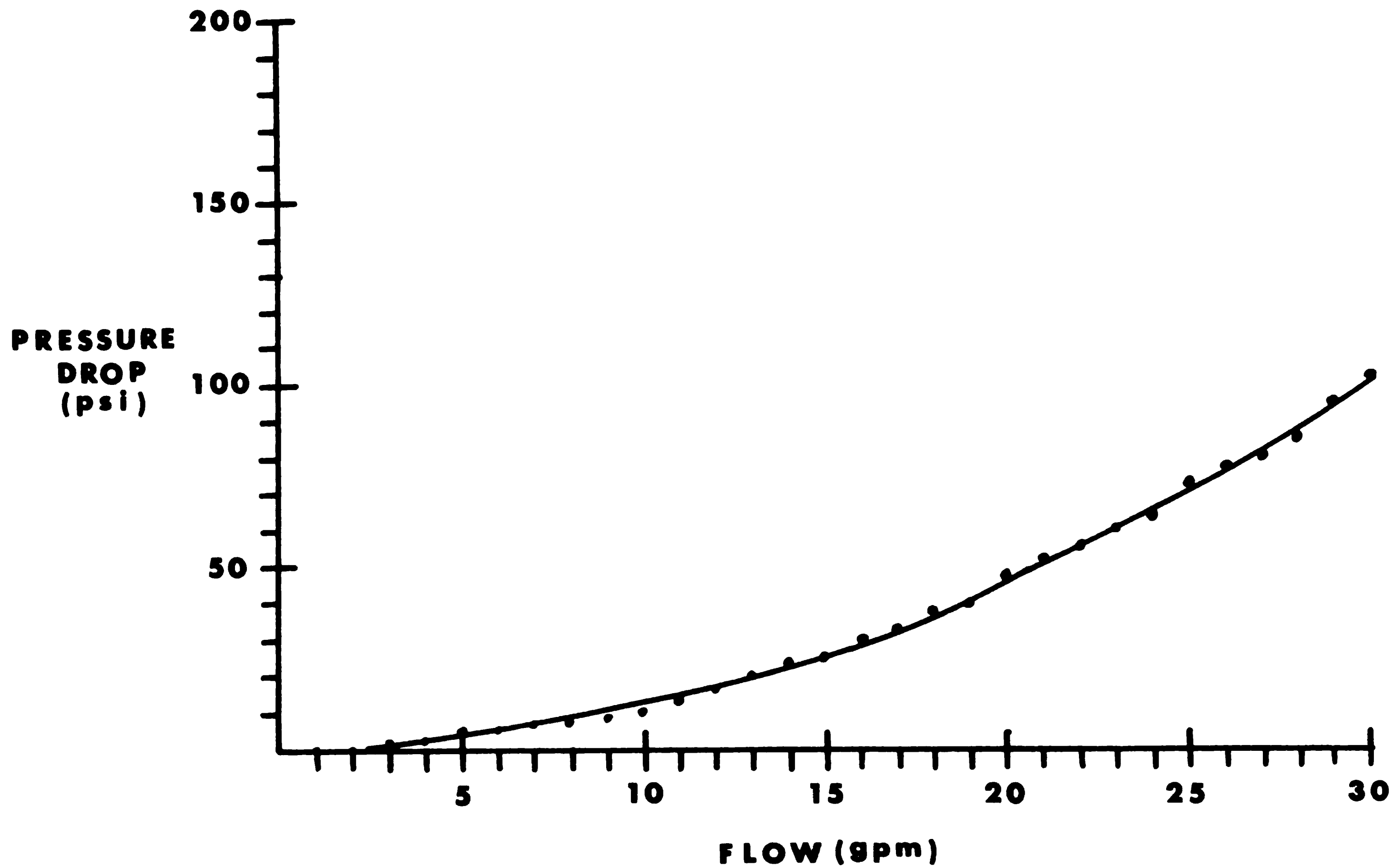

Figure 11.--Pressure Drop Curve, coupler B

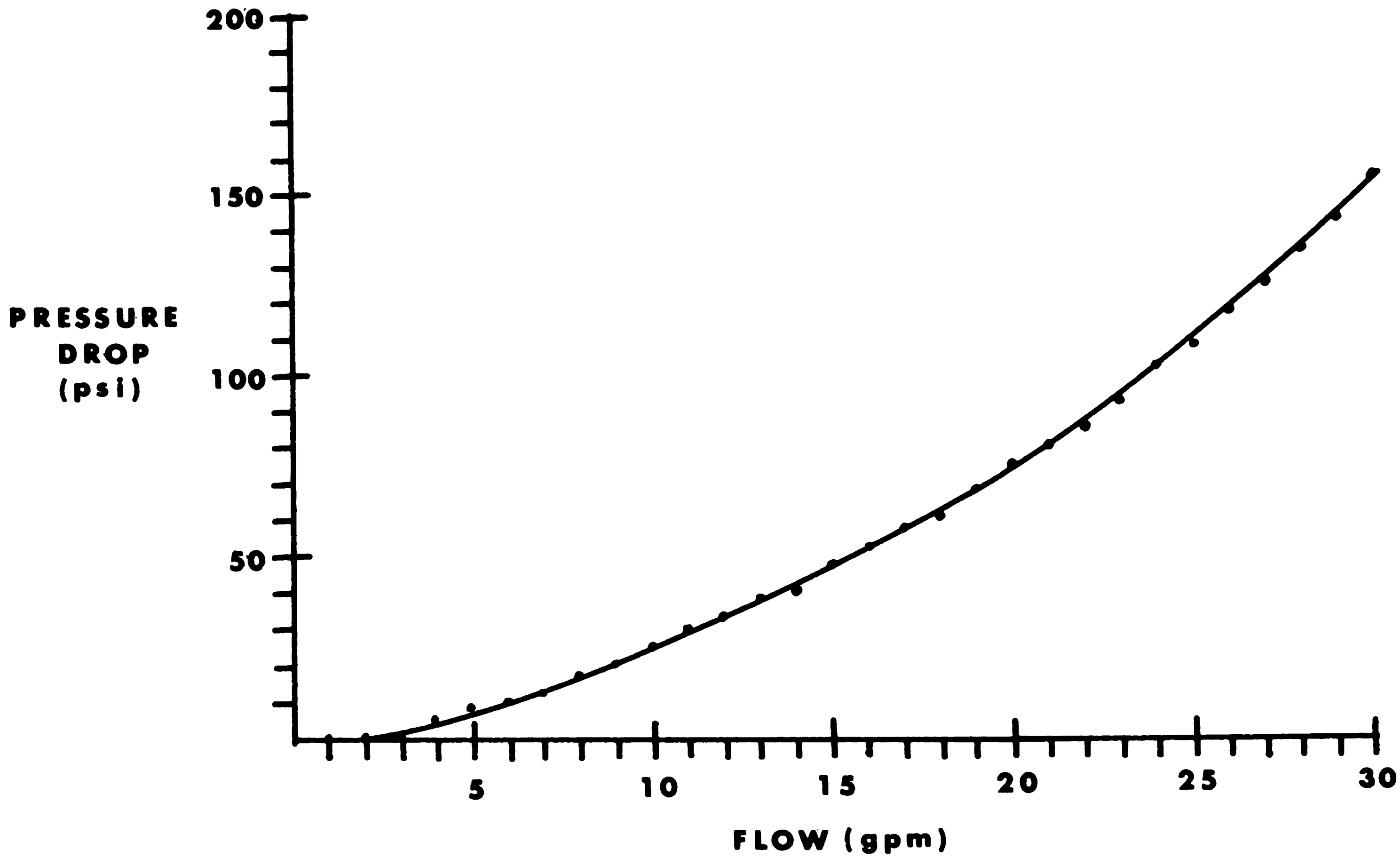

Figure 12.--Pressure Drop Curve, coupler C

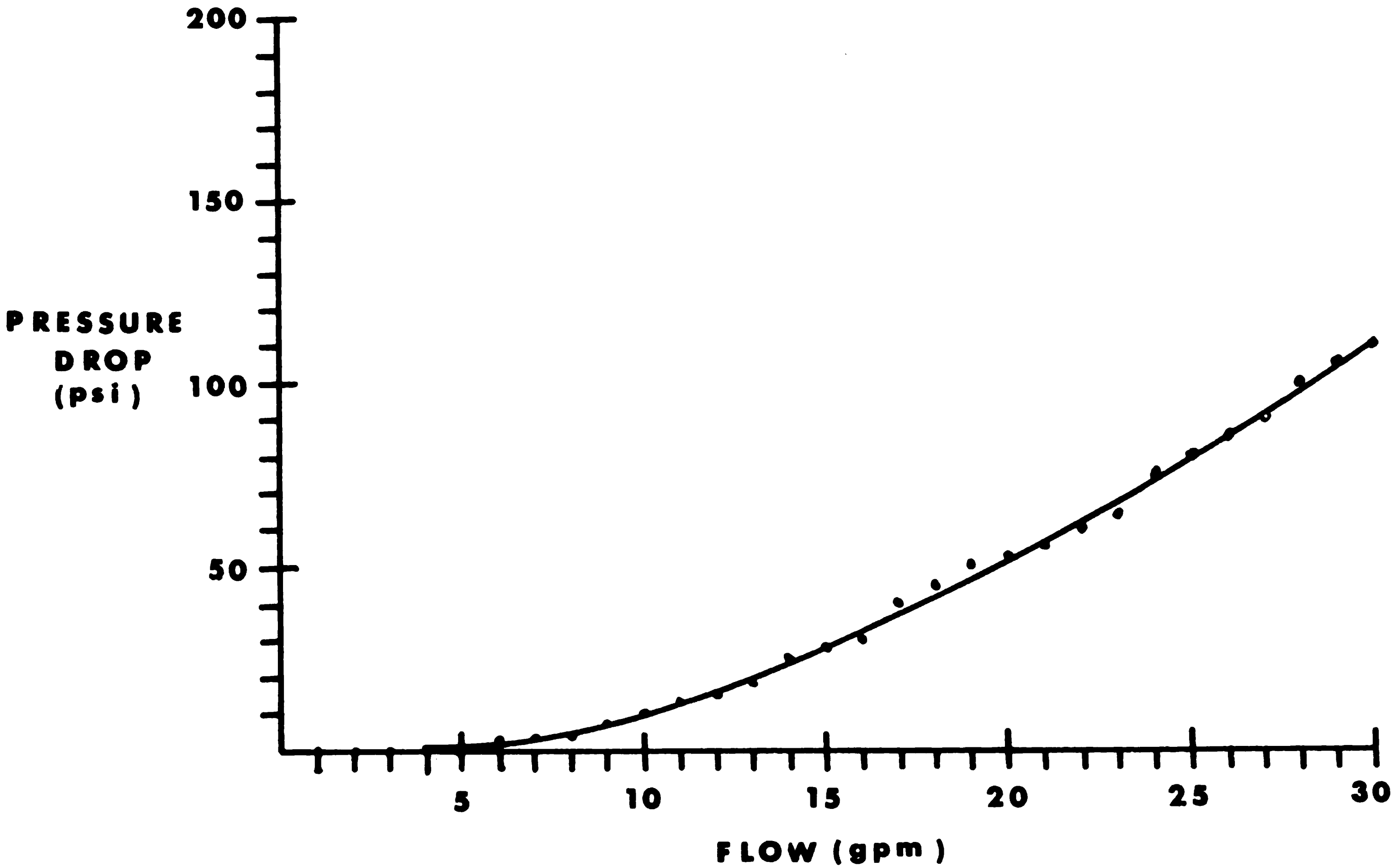

Figure 13.--Pressure Drop Curve, coupler D

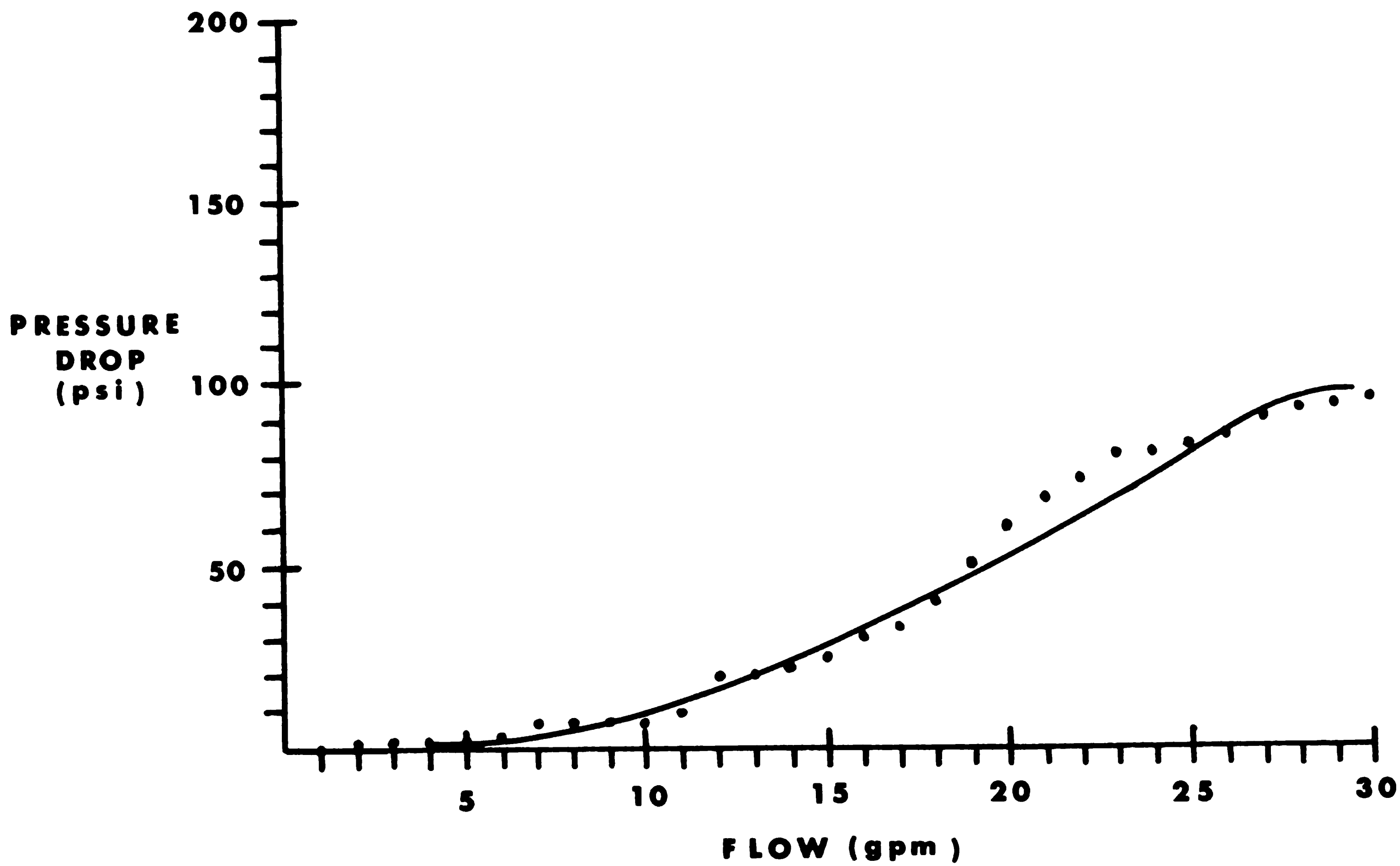

Figure 14.--Pressure Drop Curve, coupler E

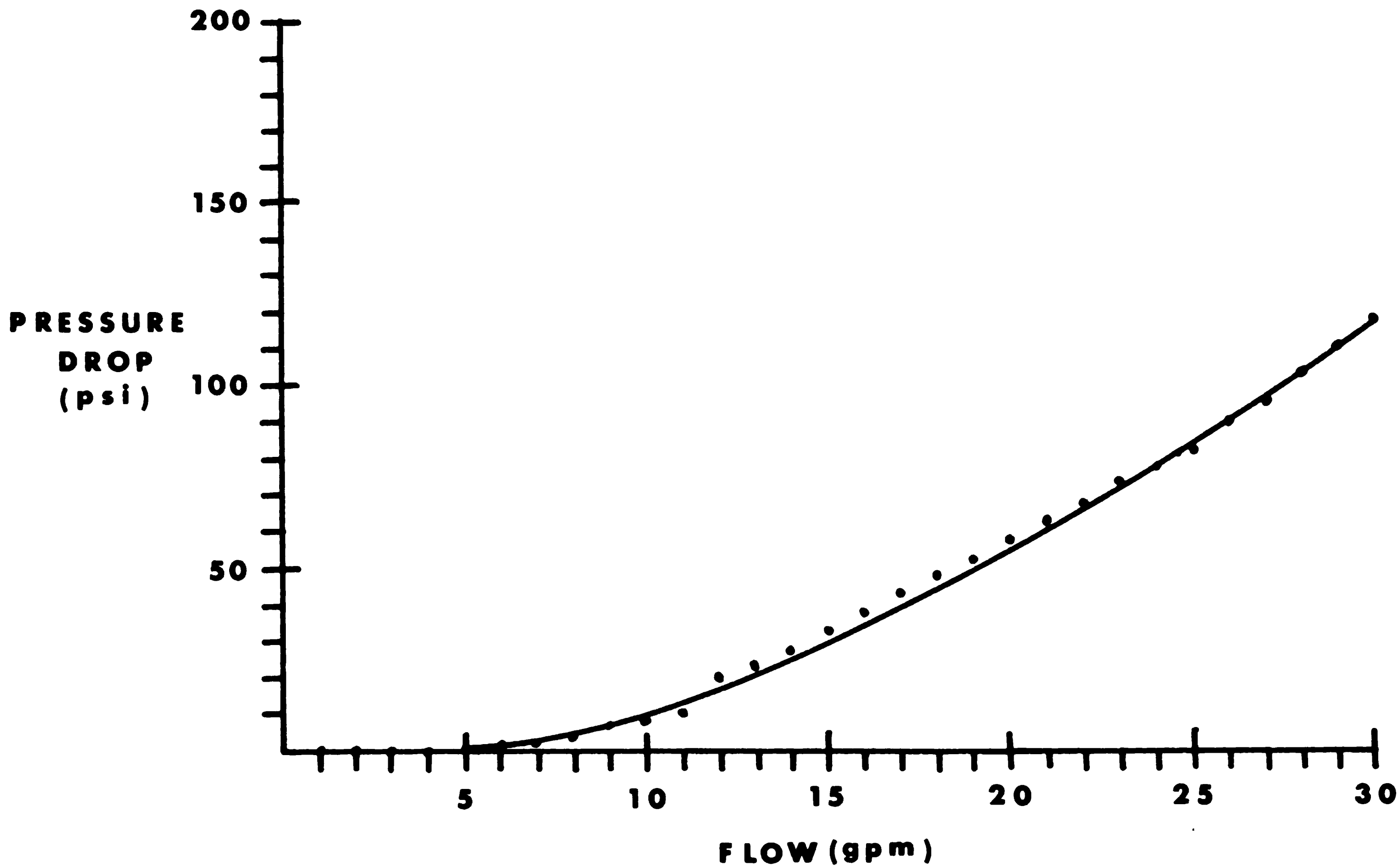

Figure 15.--Pressure Drop Curve, coupler F

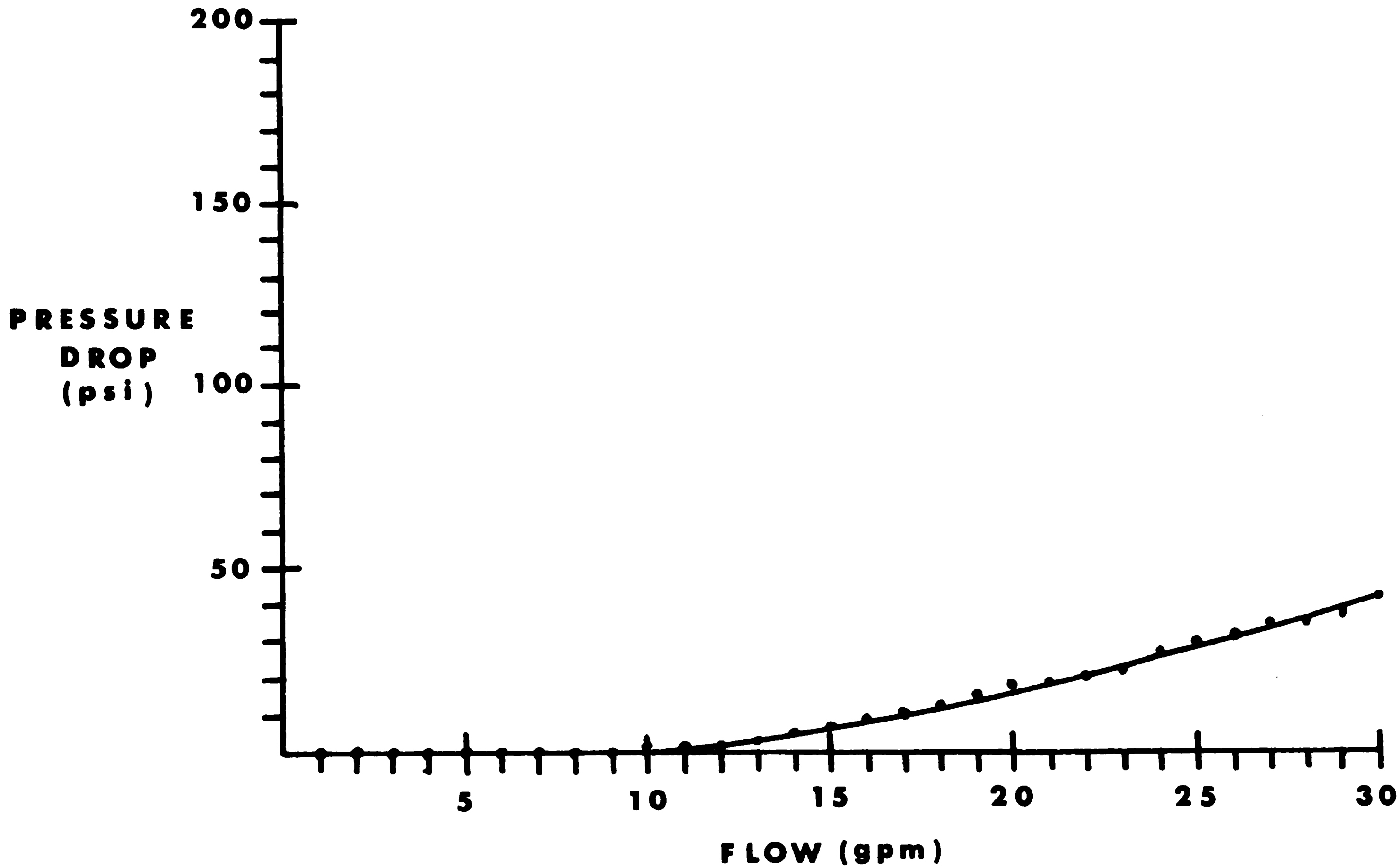

Figure 16.--Pressure Drop Curve, coupler G

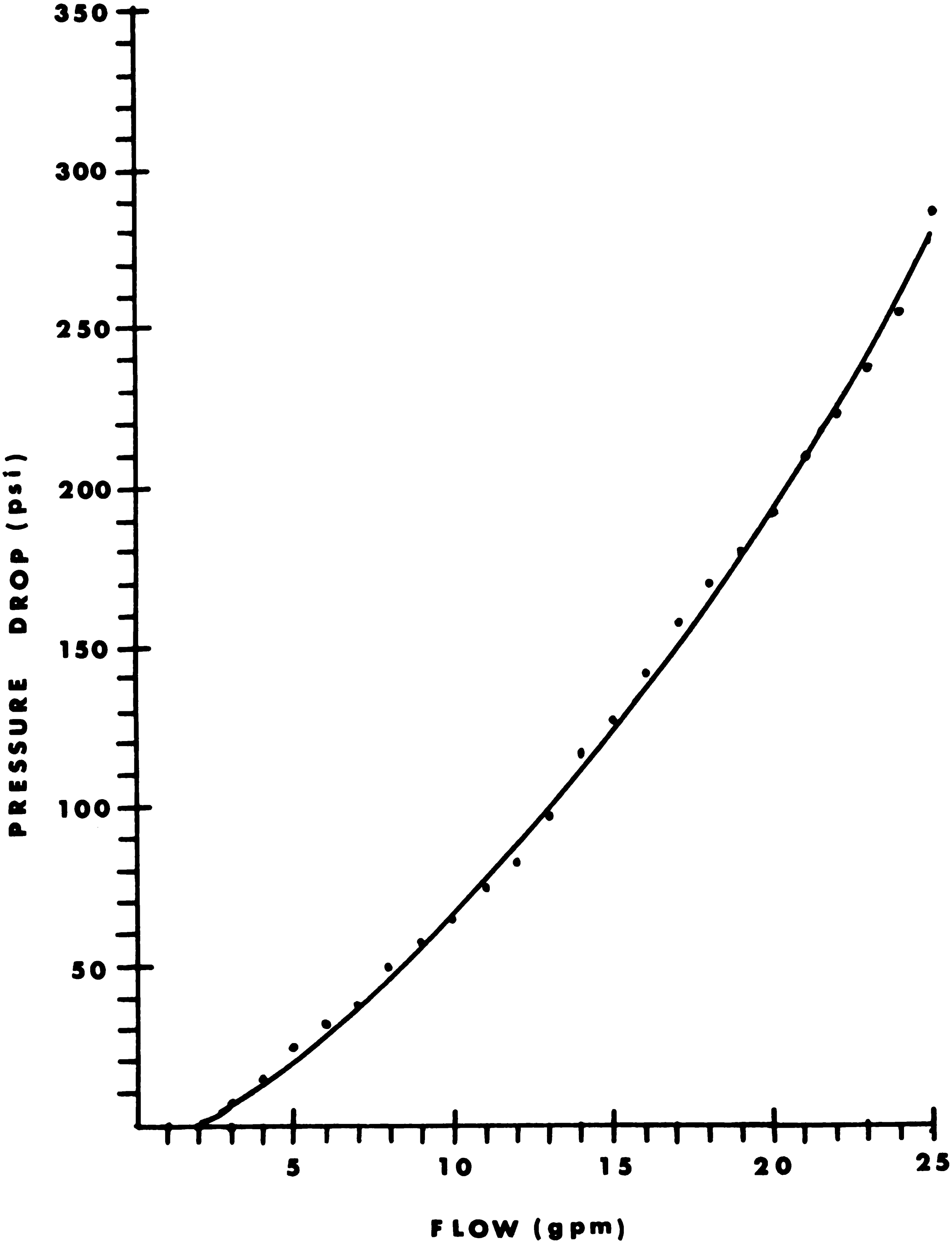

Figure 17.--Pressure Drop Curve, coupler H

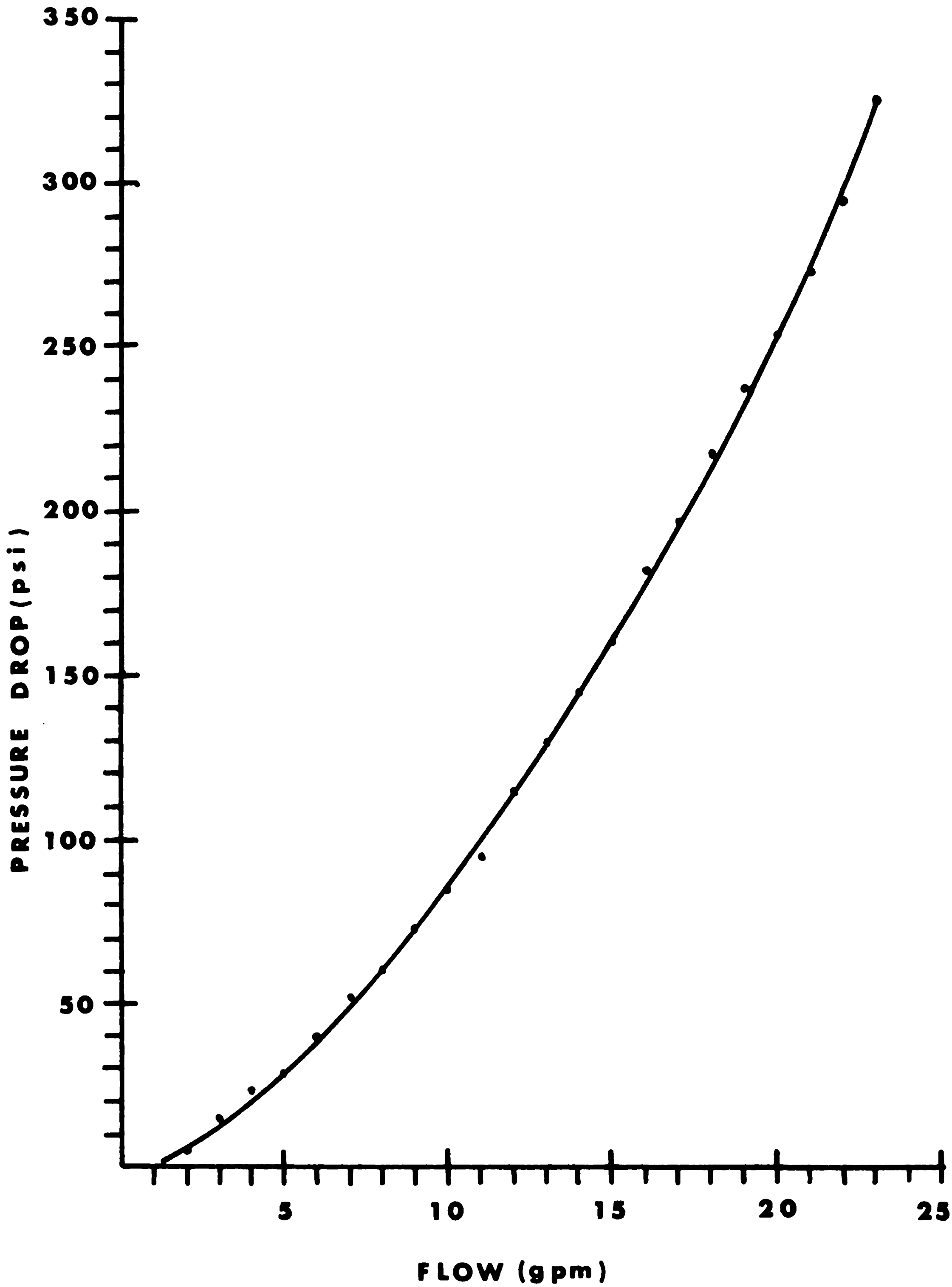

Figure 18.--Pressure Drop Curve, coupler I

The coupler temperature rise, as indicated in Figure 19, is a measurement of the change of surface temperature during the duration of a test sequence; usually 30-32 minutes. Coupler C showed the greatest net increase although the temperature extremes, 65 and 92 degrees, were not considered excessive. Again, due to the large reservoir capacity, it was assumed that the aforementioned expected high temperatures of the coupler itself were not reached. Coupler C, a relatively common double poppet, ½ inch pipe thread, cadmium plated steel unit, had a higher pressure drop in relation to others of the same type.

Coupler F had the lowest net temperature increase although its recorded pressure drop was not greatly different than others of the same type. The physical mass was relatively the same as other double poppet, steel units, and its appearance had no distinguishing marks.

The mean and median net temperature rises of all couplers tested closely match those of couplers G and H, with minor variation. This, by no means, is a valid assumption, because of the nature of the tests and the doubt of obtainment of a true random sample of couplers.

The fluid temperature rise during the tests were recorded as shown in Figure 20, with an average rise noted of 8 degrees which is also the median. By analyzation of the patterns it is evident that coupler A was tested at one period of time. The next series of consecutive tests included units B, C, and D. Following these were the final series including couplers F, G, H and I.

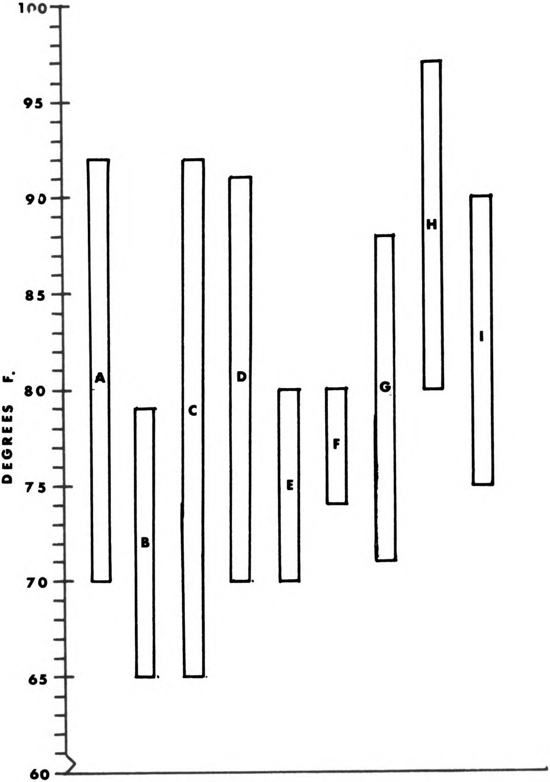

Figure 19.--Coupler Temperature Rise

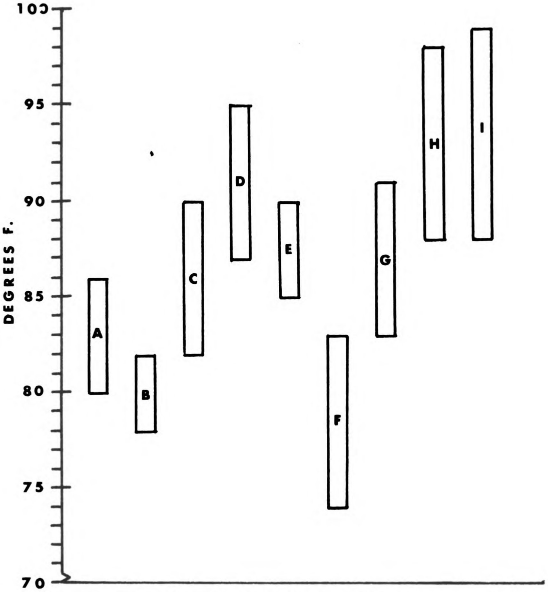

Figure 20.--Fluid Temperature Rise

SUMMARY AND CONCLUSIONS

A review of the present literature and specifications of hydraulic quick couplers indicates that the selection of these units may be based purely on the type of connecting fitting and its size.

Initial tests with a representative type of commonly used agriculturally applied couplers show that in some cases a serious pressure drop could be experienced.

The results of the tests indicated that:

1. Pressure drops may reach as much as 300 psi at 30 gpm.
2. Although the extreme pressure drops may be a result of misapplication there was no method or indication of the expected losses until actual use occurred. Coupler H and I appeared to be low pressure drop couplers.
3. High pressure drops in a unit may not especially be indicated by a marked increase in fluid temperature or the surface temperature of the coupling in a large reservoir capacity system, due to the heat dissapating capabilities of the fluid.
4. The physical appearance of the sealing and locking mechanism does not necessarily indicate its pressure drop characteristics.
5. The sliding seal type of coupling had the lowest resistance to flow and the lowest pressure drop of the units tested.
6. The sleeve and poppet type coupler had the highest pressure drop.

The sliding seal type coupler therefore is recommended for use in flow applications where minimum pressure drop is desired at a relatively high flow rate and oil loss during connection and disconnection is not critical.

The popular double poppet coupler is recommended over the sleeve and poppet type unit in high flow applications because of the high pressure drop in sleeve and poppet type couplers. Also, double poppet couplers are less expensive and more readily available from most agricultural machinery dealers. The sleeve and poppet couplers do lend themselves to an application where they may be coupled under pressure more easily than the other types.

The double rotating ball coupler, being an adaptation of the ball type double poppet unit, has similar characteristics to those of double poppet couplers, and therefore carries the same recommendation.

SUGGESTIONS FOR FURTHER STUDY

The following suggestions are provided to assist in the direction of any further studies which might relate to hydraulic quick coupler pressure drops.

1. The use of various fluids employed in agricultural applications of hydraulics with respective temperature extremes encountered should be investigated.
2. Coupler connection and disconnection under varying pressures would indicate suitability for comprehensive use.
3. A universal method of marking couplers with expected flow characteristics and application data would prove useful.
4. An economic justification of coupler type selection and application is necessary.

LIST OF REFERENCES

LIST OF REFERENCES

1. Deere and Co., Fundamentals of Service-Hydraulics, Moline, Illinois, 1967

2. Faisandier, J., Les Mechanismes Hydrauliques (French), pages 157-158, Dunod, Paris, 1957

3. Fitch, Ernest C., Fluid Power and Control Systems, McGraw-Hill, New York, 1954

4. King, Horace William, Handbook of Hydraulics, McGraw-Hill, New York, 1954

5. Marks, Lionel S., Mechanical Engineers Handbook, McGraw-Hill, New York, 1958

6. Stewart, Harry L., Hydraulic and Pneumatic Power for Production, page 5-17, Industrial Press Incorporated, New York, 1970

7. Stewart, Harry L., and John M. Storer, Fluid Power, Howard Sams and Co., New York, 1968

8. United States Plastics Co., Catalog, Lima, Ohio, 1970

9. Vickers Hydraulics Machinery Division, Industrial Hydraulics Manual 935100, Troy, Michigan, 1962

10. Yeaple, Franklin D., Hydraulic and Pneumatic Power and Control, McGraw-Hill, New York, 1966

11. Zimmerman, M., "How Much Hydraulic Horsepower?", Implement and Tractor, Volume 81, Number 11.

APPENDIX

PROCEDURE FOR LOADING MANOMETER

1. Lay the entire manometer assembly on its side with the upper ends lower than the rest of the unit.
2. Disconnect the plastic tube fittings from the manometer exposing the upper open ends of the U tube to the atmosphere (caution: any fluid in the tube will run out onto the ground.....heated mercury is potentially poisonous).
3. Blow compressed air through the U tube being careful to catch any residue which is expelled in a suitable container.
4. Attach 2 feet of 3/16 I.D. surgical tubing to the lower leg of the U tube by slipping it over the manometer tubing a distance of ¼ inch.
5. Attach 6 inches of 3/16 I.D. surgical tubing to the upper leg of the U tube by slipping it over the manometer tubing a distance of ¼ inch.
6. Attach a 50 cc. hypodermic syringe to the upper surgical tubing with the syringe fully compressed.
7. Stick the end of the lower tube into a container of mercury below the fluid level.
8. Pull a negative pressure on the system by retracting the syringe plunger....hold it in the retracted position.
9. Slowly raise the container of mercury, making sure the end of the tubing does not break the surface of the fluid, until the desired level of mercury is obtained in the U tube.
10. When the desired level is reached, quickly pinch the end of the lower tubing near the place where it joins the manometer U tube.

11. Slowly raise the manometer on its side until the tube leg is high enough to keep the mercury from running out as the surgical tube is unpinched and both surgical tubes are removed.
12. Replace the nylon tubing fittings and tighten them.
13. Raise the manometer to its normal working position and bleed any transient mercury from the pipe lead lines by opening all valves on the manometer gage assembly and opening the plumbing unions near the base of the pressure gages.
14. If any bubbles appear in the manometer tubing repeat the above procedure.