APX ATARI® PROGRAM EXCHANGE

William L. Rice

HYDRAULIC PROGRAM (HYSYS)

Calculations for sizing hydraulic systems and components

Diskette: 32K (APX-20066)

User-Written Software for ATARI Home Computers

William L. Rice

HYDRAULIC PROGRAM (HYSYS)

Calculations for sizing hydraulic systems and components

Diskette: 32K (APX-20066)

HYDRAULIC PROGRAM (HYSYS)

by

William L. Rice

Distributed By

The ATARI Program Exchange
P.O. Box 3705
Santa Clara, CA 95055

Tc request an APX Product Catalog, write to the address above, or call toll-free:

800/538-1862 (outside California)
800/672-1850 (within California)

Or call our Sales number, 408/727-5603

Trademarks of Atari

The following are trademarks of Atari, Inc.

ATARI®
ATARI 400™ Home Computer
ATARI 800™ Home Computer
ATARI 410™ Program Recorder
ATARI 810™ Disk Drive
ATARI 820™ 40-Column Printer
ATARI 822™ Thermal Printer
ATARI 825™ 80-Column Printer
ATARI 830™ Acoustic Modem
ATARI 850™ Interface Module

Printed in U.S.A.

CONTENTS

APPENDICES

INTRODUCTION

OVERVIEW

The HYDRAULIC PROGRAM (HYSYS) uses the ATARI Home Computers' fast computation speed to solve problems commonly encountered in sizing fluid power components for hydraulic systems and for designing simple-to-complex hydraulic systems. The program is straightforward and easy to use. In fact, once you use HYSYS to help you calculate your system or component sizing, you'll be reluctant to go back to using a calculator. The program's tally sheets can also be an instructional aid in showing cause and effect relationships.

HYSYS comprises two major sections: the cylinder section (linear force), and the pump/motor section (rotational force). Using menu options, you can obtain either a single calculation for a particular variable or calculations for a variety of variables displayed on a tally sheet. You can change one or all values on the tally sheet and then observe the effect on the other variables. You can print the tally sheet, if you wish.

REQUIRED ACCESSORIES

32K RAM
ATARI 810 Disk Drive
ATARI BASIC Language Cartridge

OPTIONAL ACCESSORIES

ATARI printer or equivalent printer

CONTACTING THE AUTHOR

Users wishing to contact the author about HYSYS may write to him at:

4758 Calle de Lucia
San Jose, CA 95124

ABBREVIATIONS, TERMINOLOGY, AND INPUT DATA

Abbreviations

HYSYS uses the following abbreviations:

OUT=output	C.I.=cubic inches
DISP=displacement	H.P.=horsepower
HYD=hydraulic	P.S.I.=pounds per square inch
FT./LBS.=foot pounds	R.P.M.=revolutions per minute
IN./LBS.=inch pounds	G.P.M.=gallons per minute
EFF.=efficiency	C.I./PER REV.=cubic inches per revolution
SQ.IN.=square inches	IN./SEC.=inches per second
E.T.=elapsed time	GAL.=gallons

Terms

HYSYS uses common terms that newcomers to hydraulics should be able to understand. However, you should be familiar with system and component efficiencies to use HYSYS. (Note. For actual engineering applications, unless otherwise noted, answers are in theoretical.)

Input Data

A question mark near a prompt indicates that HYSYS is waiting for you to enter data. Enter any requested data as decimal equivalents; HYSYS doesn't interpret fractions. In all cases, after you enter your data, press the RETURN key. (The instructions that follow won't repeat the necessity for ending your input by pressing the RETURN key.) The program asks for very specific data, for example, inch pounds. If you carelessly enter foot pounds instead, you'll be apt to blame the program for faulty computations! If you do have a problem, one way to trace it is to print your data, do your calculations again and print them, and then compare the two printouts.

GETTING STARTED

LOADING HYSYS INTO COMPUTER MEMORY

1. Have your computer turned OFF.

2. Turn on your disk drive.

3. When the BUSY light goes out, open the disk drive door and insert the HYSYS diskette with the label in the lower right-hand corner nearest to you. (Use disk drive one if you have more than one drive.)

4. Turn on your computer and your TV set. The program will load into computer memory and start automatically.

THE FIRST DISPLAY SCREEN

The first display screen is HYSYS's main menu of numbered options, described in the next section.

USING HYSYS

INTRODUCTION

The program is divided into two sections, the Cylinder Section and the Pump/Motor Section. These instructions also follow that division. But first we'll use HYSYS to solve a hydraulics problem. (The example is rather long. If you prefer, you can skip over it and go directly to the explanations for the program sections and options.)

You'll find other useful information in the appendices. Appendix A lists the N.F.P.A. Cylinder Bores and Rod Sizes. Appendix B notes the normal minimum and maximum values for the variables used in HYSYS. Appendix C lists typical applications for hydraulic system usage. Appendix D suggests sources for obtaining more information about hydraulics.

AN EXAMPLE OF USING HYSYS

Let's say your racing team decides to speed up tire changes in the pits. It currently takes about three seconds per side of the car to jack it up manually. Someone gets the bright idea that a little dc-hydraulic power unit may not only be easier but faster. The same guy happens to have a dc power unit that he'll be happy to take out of his "lowrider" car for team spirit. The unit will put out 4.5 gallons per minute (G.P.M.) at 2,500 pounds per square inch (P.S.I.). He also has a 1 1/2" diameter (BORE) cylinder. No one knows diddly about hydraulics or whether this will lift the car faster at all. The driver tells everyone to go to lunch and he'll have the answer when they get back. They guffaw as they head toward the "roachcoach." Needless to say, he doesn't tell them that he has an ATARI Home Computer with a program that will figure out all this jazz.

He loads the program into computer memory and looks at the MAIN MENU.

AHA! He sees the option:

```
2 CYLINDER CALULATIONS
```

So, he types 2 and presses the **RETURN** key and the Cylinder Section menu displays. He figures that he better check to see if the cylinder can cut the mustard forcewise. AHA! He sees the option:

```
10. BORE REQUIRED
```

So, he types 10 <RETURN> and the following display appears:

```
TO FIND THE BORE NEEDED
ENTER PUSH FORCE IN POUNDS ?
```

Well, let's see, the car weighs about 1500 pounds, but it needs to raise only one side. Better figure for the worst and use the total weight. He types 1500 <RETURN>. The program then prompts:

```
ENTER SYSTEM PRESSURE IN P.S.I. ?
```

The unit puts out 2,500 P.S.I. so he types 2500 <RETURN>. Hey! An answer:

```
MINIMUM BORE REQUIRED

0.874 INCHES
```

Hmmm, we have a 1 1/2" bore cylinder. That's larger than the minimum, so we must be O.K. What do I do now? He looks at the display:

```
HIT RETURN FOR MENU?
```

He presses the RETURN key and the Cylinder Section Menu displays. Among the options is:

```
3 CYLINDER PUSH FORCE
```

That should tell me what force I can get from this cylinder. He types 3 <RETURN> and gets:

```
PUSH FORCE

ENTER CYLINDER BORE IN INCHES?
```

He types 1.5 <RETURN> because that's the size cylinder he has. Then the prompt:

```
ENTER SYSTEM PRESSURE IN P.S.I.
```

displays. That's 2,500. He types 2500 <RETURN> (omitting the comma, of course). Finally, the answer:

```
CYLINDER FORCE IN POUNDS = 4417
```

displays. That little unit will lift almost three cars this size! Very interesting. He types YES <RETURN> in response to a prompt to continue. He returns to the Cylinder Section Menu. All right, let's see how fast that little sucker will go. He selects option 2 for CYLINDER SPEED:

```
ENTER CYLINDER BORE IN INCHES
```

He types 1.5 <RETURN> and then sees:

```
ENTER FLOW RATE IN G.P.M.
```

That was 4.5 Gallons per minute. He types 4.5 <RETURN> and gets this display:

```
CYLINDER PUSH SPEED
IN FEET PER SECOND    = 0.817
IN FEET PER MINUTE    = 49.015
IN INCHES PER SECOND  = 9.808
IN INCHES PER MINUTE  = 588.176
```

```
ENTER CYLINDER STROKE IN INCHES?
```

Let's see, that's 12 inches. He types 12 <RETURN> and gets this:

```
PUSH SPEED

        WITH A 1.5 INCH BORE AND  4.5 G.P.M.

        TO COMPLETE THE 12 INCH STROKE

        WOULD TAKE 1.224 SECONDS

ENTER ROD SIZE IN INCHES?
```

GREAT! 1.2 seconds to raise the car; that's almost two times faster than it takes to do it manually. Humm, rod size? He looks at the name tag on his cylinder and it tells him the rod size is 1/2". He types .5 <RETURN> and he gets the following display:

```
PULL SPEED

IN FEET PER SECOND    = 0.919
IN FEET PER MINUTE    = 55.138
IN INCHES PER SECOND  = 11.028
IN INCHES PER MINUTE  = 661.698

CYLINDER AND SYSTEM SPECIFICATIONS

BORE 1.5  GPM 4.5  ROD SIZE 0.5

TO COMPLETE THE 12 INCH STOKE

WILL TAKE 1.088 SECONDS

HIT RETURN FOR MENU?
```

All right! That's even faster! He presses the RETURN key and the Cylinder Section Menu displays.

The pit crew comes back from lunch and, to their surprise, he rattles off all his new found information. After they finish patting him on the back for being such a genius, he shows them his ATARI computer and HYSYS. They just look at it for a moment and then ask if they can see it run. He types 1 <RETURN> on the Cylinder Section Menu and the CYLINDER TALLY SHEET appears:

```
    CYLINDER TALLY SHEET
 1 SYSTEM PRESSURE.........P.S.I.
 2 FLOW....................G.P.M.  4.5
 3 ELECTRIC MOTOR (85% EFF.)..H.P.
 4 CYLINDER BORE...........INCHES  1.5
 5    "     PUSH PRESSURE...P.S.I.
 6    "     PUSH FORCE.....LBS.
 7    "     PULL PRESSURE...P.S.I.
 8    "     PULL FORCE.....LBS.
 9    "     ROD SIZE.......INCHES  0.5
10    "     STROKE.........INCHES  12
11    "     PUSH AREA.......SQ.IN.  1.767
12    "     PULL AREA.......SQ.IN.  1.571
13    "     PUSH FLOW.......G.P.M.
14    "     PULL FLOW.......G.P.M.
15    "     PUSH VOLUME.....C.I.
16    "     PULL VOLUME.....C.I.
17 PUSH SPEED.............IN/SEC.  9.803
18 E.T. OF PUSH STROKE.....SECONDS 1.224
19 PULL SPEED.............IN/SEC.  11.028
20 E.T. OF PULL STROKE.....SECONDS 1.088

1=MENU  2=ALTER  3=CLEAR  4=PRINTOUT
```

One of the guys says, "Hey, that's great! It'll lift it faster--but will it lift it period?"

The genius says "Yeah, here watch." He types 2 <RETURN>:

```
CHANGE WHICH LINE ?
```

Well, I know what the pressure is, so let's change line 1. He types 1 <RETURN>:

```
ENTER NEW PRESSURE IN P.S.I.?
```

He types 2500 <RETURN> and the TALLY SHEET starts spitting out answers:

```
    CYLINDER TALLY SHEET
 1 SYSTEM PRESSURE.........P.S.I. 2500
 2 FLOW....................G.P.M. 4.5
 3 ELECTRIC MOTOR (85% EFF.)..H.P. 7.72
 4 CYLINDER BORE...........INCHES   1.5
 5    "     PUSH PRESSURE...P.S.I.  2500
 6    "     PUSH FORCE.....LBS.   4417
 7    "     PULL PRESSURE...P.S.I.  2500
 8    "     PULL FORCE.....LBS.   3926
 9    "     ROD SIZE.......INCHES   0.5
10    "     STROKE.........INCHES   12
11    "     PUSH AREA.....SQ.IN.   1.767
12    "     PULL AREA.....SQ.IN.   1.571
13    "     PUSH FLOW.....G.P.M.   4.5
14    "     PULL FLOW.....G.P.M.   4.5
15    "     PUSH VOLUME.....C.I.   21.2
16    "     PULL VOLUME.....C.I.   18.8
17 PUSH SPEED.............IN/SEC.  9.803
18 E.T. OF PUSH STROKE.....SECONDS 1.224
19 PULL SPEED.............IN/SEC.  11.028
20 E.T. OF PULL STROKE.....SECONDS 1.088
```

"Well," says one awed team member, "I guess that answers that!"

HYSYS MAIN MENU

The main menu looks as follows:

```
                " HYSYS "

                 MAIN MENU
              ------------------------

              1 PROGRAM INFORMATION
              2 CYLINDER CALCULATIONS
              3 PUMP/MOTOR CALCULATIONS
              ------------------------

            ENTER LINE NUMBER & RETURN ?
```

Figure 1 Main Menu

Option 1, PROGRAM INFORMATION, briefly describes the program and contains a couple of important notes. Option 2, CYLINDER CALCULATIONS, loads the Cylinder Section into computer memory. Option 3, PUMP/MOTOR CALCULATIONS, loads the Pump/Motor Section into computer memory. To select an option, type the number corresponding to your choice and then press the RETURN key.

Following are descriptions of the calculations available for each section.

CYLINDER SECTION

The menu for the Cylinder Section looks like this:

```
                CYLINDER SECTION

          1.  CYLINDER TALLY SHEET
          2.  CYLINDER SPEED
          3.  CYLINDER PUSH FORCE
          4.  CYLINDER PULL FORCE
          5.  CYLINDER PUSH FLOW
          6.  CYLINDER PULL FLOW
          7.  CYLINDER VOLUME
          8.  CYLINDER AREA
          9.  PRESSURE FOR FORCE
         10.  BORE REQUIRED
         11.  PUMP/MOTOR SECTION
         12.  QUIT-CLEAR PROGRAM

        INPUT NUMBER AND HIT RETURN KEY ?
```

Figure 2 Cylinder Section Menu

Option 1, CYLINDER TALLY SHEET, is the multiple-answer display for the Cylinder Section of the program. The Tally Sheet summarizes the individual parameters. Therefore, before looking at the Tally Sheet, let's look at the individual calculations available in the other options.

2. CYLINDER SPEED

This option calculates how fast the cylinder rod will extend or retract. The program prompts you to enter these values:

```
Cylinder bore in inches
Pump flow rate in G.P.M.
Cylinder stroke in inches
Rod size in inches
```

3. CYLINDER PUSH FORCE

This option figures force output from cylinder in pounds. The program prompts you to enter these values:

```
Cylinder bore in inches
System pressure in P.S.I.
```

4. CYLINDER PULL FORCE

This option figures the pull force of a cylinder in pounds. The program prompts you to enter these values:

```
Cylinder bore in inches
Rod size in inches
Pressure in P.S.I.
```

5. CYLINDER PUSH FLOW

This option calculates the flow, in gallons per minute, that it takes to extend a cylinder (rod) at a given speed. The program prompts you to enter these values:

```
Cylinder bore in inches
Push speed in FT. PER SEC.
```

6. CYLINDER PULL FLOW

This option calculates the flow, in gallons per minute, that it takes to retract a cylinder (rod) at a given speed. The program prompts you to enter these values:

```
Cylinder bore in inches
Rod size in inches
Pull speed in FT./SEC.
```

7. CYLINDER VOLUME

This section figures the volume of a cylinder in cubic inches. The program prompts you to enter these values:

```
Cylinder bore in inches
Cylinder stroke in inches
Rod size in inches
```

8. CYLINDER AREA

This option calculates the push and pull areas, in square inches, for any cylinder. The program prompts you to enter these values:

```
Cylinder bore in inches
Rod size in inches
```

9. PRESSURE FOR FORCE

This option figures the pressure needed to obtain a given force with the cylinder. The program prompts you to enter these values:

```
Push or pull force in pounds required
Cylinder bore in inches
Rod size in inches
```

10. BORE REQUIRED

This option calculates the minimum cylinder bore (cylinder diameter) required to obtain the desired force with a set pressure. The program prompts you to enter these values:

```
Push force in pounds
System pressure in P.S.I.
```

11. PUMP/MOTOR SECTION

This option loads in the PUMP/MOTOR SECTION of the program.

12. QUIT-CLEAR PROGRAM

This option clears computer memory and returns you to the READY prompt in ATARI BASIC. (Note. If you use this option by mistake, turn your computer off then on again. The main menu will automatically load back into computer memory.)

Now let's return to Option 1 for a look at the Cylinder Tally Sheet.

1. CYLINDER TALLY SHEET

This is the multiple-answer portion of the program. The program stores in the Tally Sheet the most recent value for each parameter you computed under the other options, up to the time you select the Tally Sheet option. Using this option, you can then change one or more variables and observe the effect on all the other variables. HYSYS retains the computed values for display on the Tally Sheet only under two conditions: (1) you don't

return to the Cylinder menu and (2) you remain in the Cylinder Section of the program. That is, once you return to the Cylinder Menu, the program clears the Tally Sheet. This aspect ensures that any displayed information relates correctly to the other information displayed with it. Also, when you switch from the Cylinder Section to the Pump/Motor Section, the program erases the computations for the Cylinder Tally Sheet.

The Cylinder Tally Sheet looks like this:

```
            CYLINDER TALLY SHEET                          VARIABLE LETTERS
                                                          (INFORMATION USE ONLY)
 1.  SYSTEM PRESSURE. . . . . . . . . P.S.I.                    P
 2.  FLOW . . . . . . . . . . . . . . G.P.M.                    G
 3.  ELECTRIC MOTOR (85% EFF.). . . . H P.                      H
 4.  CYLINDER BORE. . . . . . . . . . INCHES                    C
 5.     "   PUSH PRESSURE . . . . . P.S.I.                      ZP
 6.     "   PUSH FORCE. . . . . . . . LBS.                      F
 7.     "   PULL PRESSURE . . . . . P.S.I.                      ZO
 8.     "   PULL FORCE. . . . . . . . LBS.                      Z
 9.     "   ROD SIZE. . . . . . . . . INCHES                    R
10.     "   STROKE. . . . . . . . . . INCHES                    S
11.     "   PUSH AREA . . . . . . . . SQ.IN.                    A
12.     "   PULL AREA . . . . . . . . SQ.IN.                    ZM
13.     "   PUSH FLOW . . . . . . . . G.P.M.                    ZK
14.     "   PULL FLOW . . . . . . . . G.P.M.                    ZQ
15.     "   PUSH VOLUME . . . . . . . . C.I.                    V
16.     "   PULL VOLUME . . . . . . . . C.I.                    ZE
17.  PUSH SPEED . . . . . . . . . . IN./SEC.                   IS
18.  E.T. OF PUSH STROKE. . . . . .SECONDS                     PS
19.  PULL SPEED . . . . . . . . . . IN./SEC.                   SS
20.  E.T. OF PULL STROKE. . . . . .SECONDS                     RS

     1= MENU     2= ALTER     3= CLEAR     4= PRINTOUT ?
```

Figure 3 Cylinder Tally Sheet

(The VARIABLE LETTERS, which don't appear on the screen display, are explained below.) The bottom line prompts you for your activity. Type a 1 to return to the Cylinder Section Menu. When you return to the menu, HYSYS automatically clears the Tally Sheet memory. Therefore, if you want a printout of your calculations, use option 4 (PRINTOUT) before you return to the menu.

Type a 2 to alter one of the calculation values. The prompt, "CHANGE WHICH LINE ? ", asks you for the number of the calculation you want to alter. You may change any data on any line at any time. HYSYS will ask the pertinent questions to give you the answers for every line of the Cylinder Tally Sheet. If answers or data appear next to all the lines of the Tally Sheet, then you need input only the value you asked to change. HYSYS updates any other value(s) related to your changed value. All answers displayed on the Tally Sheet relate to each other correctly at all times. You may use this option to change as many of the variables as you want. This feature is handy if you want to "work backwards or forwards" on the system. Experiment with this feature. But remember, changing one

line may have a ripple affect, so take note or print any set of calculations you want to keep.

Type 3 to clear computer memory of the Tally Sheet computations. A verification prompt displays before HYSYS does so.

Type 4 to print the Tally Sheet. Make sure your printer and interface module, if applicable, are turned on and that the printer is in ONLINE mode.

All answers on the Tally Sheet are truncated and rounded according to the normal usable range for each variable, plus a few extra places. If your answer is too long to display in the screen area provided, then a "TOO BIG" message appears in the answer space. Check the value you input. You may have used an unrealistic number, because the space provided should be enough for 99 percent of real applications. However, these large numbers do appear on printouts. If you don't have a printer, use the list of variables on the right-hand side of Figure 3. To find out what the large number is, press the BREAK key and type "PRINT X", where "X" represents the variable letter in question. Then, to restart program, type "RUN" or "GOTO 20."

The parameters on the Tally Sheet were described in earlier sections. However, additional comments about some of these items follow.

1. SYSTEM PRESSURE
2. FLOW

The pump supplies system pressure and flow. You can obtain this data from catalogs published by manufacturers of pumps, motors, cylinders, and so forth. The catalogs usually state vague curves or general performance characteristics, whereas HYSYS uses that information to figure specific values.

3. ELECTRIC MOTOR

You can't alter this line because this is just another way of stating the H.P. to run a pump at 85 percent efficiency, a typical efficiency for a pump. (The "85% EFF." in parentheses on the Tally Sheet refers to 85 percent efficiency.)

4. BORE SIZE
9. ROD SIZE

Bore always refers to cylinder diameter. Because the rod fits inside the bore of a cylinder, the rod can't be larger in diameter than the bore. If you enter a larger rod size than bore size, the program prompts you to change your rod size.

5. CYLINDER PUSH PRESSURE
6. CYLINDER PUSH FORCE
7. PULL PRESSURE
8. PULL FORCE

These variables are changed by changing variable 1, SYSTEM PRESSURE.

10. STROKE

The stroke is the length of the rod. If the cylinder is mounted horizontally or vertically with a side load, then any length more than 48 inches is a special problem that can easily be remedied by talking to a manufacturer. That, however, won't affect the output for HYSYS.

Note on PUSH and PULL

Push and pull are referred to in various calculations. A cylinder has two sides, the push side and the pull side. The rod is on the pull side. The effective area of these two sides differs owing to the displacement of the rod itself.

PUMP/MOTOR SECTION

You can load the Pump/Motor Section of HYSYS into computer memory by selecting either option 2 of the main menu or option 11 of the Cylinder Section menu. The Pump/Motor menu is as follows.

```
PUMP/MOTOR MENU

 1. MOTOR TALLY SHEET
 2. PUMP/MOTOR TORQUE
 3. HYD. MOTOR SPEED
 4. PUMP SPEED
 5. PUMP PRESSURE
 6. HYD. MOTOR H.P. OUT
 7. G.P.M. TO RUN MOTOR
 8. H.P. TO RUN PUMP
 9. CYLINDER SECTION
10. QUIT-CLEAR PROGRAM

        INPUT NUMBER AND HIT RETURN KEY ?
```

Figure 4 Pump/Motor Menu

Option 1, MOTOR TALLY SHEET, is the multiple-answer display for the Pump/Motor Section of the program. The Tally Sheet summarizes the individual parameters. Therefore, before looking at the Tally Sheet, let's look at the individual calculations available in the other options.

2. PUMP/MOTOR TORQUE

You may choose from three methods for finding pump or motor torque, depending on the factors you supply. The program asks you to enter one of these factors (the prompts for the data you must supply are listed under each factor):

```
1. DISPLACEMENT PER REV. AND P.S.I.
     System pressure in P.S.I.
     Motor disp. in C.I./PER REV

2. R.P.M. AND OUTPUT H.P.
     HYD. motor output H.P.
     Hydraulic motor RPM

3. G.P.M., R.P.M. AND PRESSURE (P.S.I.)
     System flow in G.P.M.
     RPM's of hydraulic motor
     System pressure in P.S.I.
```

3. HYD. MOTOR SPEED

This option figures the speed required to run the hydraulic motor. The program prompts you to enter these values:

```
Motor output horsepower
Torque in foot pounds
```

4. PUMP SPEED

This option calculates the speed required to run the pump. Normally the speed of a pump is fixed by the electric motor driving it. The program prompts you to enter these values:

```
Pump flow in G.P.M.
Pump disp. in C.I./PER REV
```

5. PUMP PRESSURE

This option calculates the output pressure from the pump at a given horsepower and flow, with both theoretical and actual pump efficiency. The program prompts you to enter these values:

```
Pump efficiency in percent
Input H.P. to run pump if pump were 100% efficient
Pump flow in G.P.M.
```

6. HYD. MOTOR H.P. OUT

The abbreviations stand for "hydraulic motor horsepower output". This option figures the output horsepower of the hydraulic motor at a given torque and speed. The program prompts you to enter these values:

```
Torque in FT./LBS.
HYD. Motor speed in RPM's
```

7. G.P.M. TO RUN MOTOR

This option calcualtes the flow needed to run the hydraulic motor. The program prompts you to enter these values:

```
HYD. motor speed in R.P.M.
Motor disp. in C.I./PER REV
```

8. H.P. TO RUN PUMP

This option calculates the horsepower required to drive the pump, both theoretical (100% efficiency) and actual (85% efficiency). The program prompts you to enter these values:

```
G.P.M. of the system
System pressure in P.S.I.
```

Now let's return to option 1, MOTOR TALLY SHEET.

1. MOTOR TALLY SHEET

This tally sheet combines the calculations for motor and pump parameters. This is the multiple-answer portion of the Pump/Motor Section The program stores in the Tally Sheet the most recent value for each parameter you computed under the other options, up to the time you select the Tally Sheet option. Using this option, you can then change one or more variables and observe the effect on all the other variables. HYSYS retains the computed values for display on the Tally Sheet only under two conditions: (1) you don't return to the Pump/Motor menu and (2) you remain in the Pump/Motor Section of the program. That is, once you return to the Pump/Motor Menu, the program clears the Tally Sheet. This aspect ensures that any displayed information relates correctly to the other information displayed with it. Also, when you switch from the Pump/Motor Section to the Cylinder Section, the program erases the computations for the Pump/Motor Tally Sheet. By changing one value, you can observe its effect on the other variables. The screen display looks like this:

```
PUMP/MOTOR TALLY SHEET

HYDRAULIC MOTOR SECTION                 VARIABLE LETTERS
                                      (INFORMATION USE ONLY)
 1 HYD. MOTOR TORQUE..FT./LBS.                    T
 2 HYD. MOTOR TORQUE..IN./LBS.                    TT
 3 MOTOR DISPLACEMENT.....C.I.                    B
 4 HYD. MOTOR OUTPUT......H.P.                    HH
 5 SYSTEM FLOW..........G.P.M.                    MG
 6 MOTOR SPEED..........R.P.M.                    M
 7 SYSTEM PRESSURE......P.S.I.                    P

PUMP SECTION

 8 PUMP PRESSURE........P.S.I.                    PP
 9 PUMP FLOW............G.P.M.                    G
10 PUMP SPEED...........R.P.M.                    ZW
11 PUMP DISPLACEMENT......C.I.                    ZV
12 H.P. TO RUN PUMP(85)...H.P.                    H
13 H.P. TO RUN PUMP(100)..H.P.                    I

1=MENU  2=ALTER  3=CLEAR  4=PRINTOUT
```

Figure 5 Pump/Motor Tally Sheet

(Note. The VARIABLE LETTERS, which don't appear on the screen display for the Tally Sheet, are explained below.) These tally sheets function just like the Cylinder Tally Sheet except that the pump and motor sections are independant of each other. Therefore, information displayed in either section relates only to that section. You'll find this tally sheet most effective if you first find the size of the motor you require and then find the pump needed to drive the motor you've sized.

Answers are truncated and rounded on the Tally Sheet according to the normal usable range for each variable (plus a few extra places). Here again, if your answers are too large to print on the screen, the message "TOO BIG" displays in the answer area, but the message won't appear on a printout. If you don't have a printer, then press the BREAK key and type "PRINT X", where "X" represents the variable letter in question. (The variable letters are on the right-hand side of the Figure 5.) To restart the program, type "RUN" or "GOTO 20."

APPENDIX A

NATIONAL FLUID POWER ASSOCIATION (N.F.P.A.)
CYLINDER BORES AND ROD SIZES
(Not including specials)

BORE	ROD SIZES		
1 1/2"	5/8"	1"	
2"	1"	1 3/8"	
2 1/2"	1"	1 3/8"	1 3/4"
3 1/4"	1 3/8"	1 3/4"	2"
4"	1 3/4"	2"	2 1/2"
5"	2"	2 1/2"	3 1/2"
6"	2 1/2"	3"	4"
7"	3"	3 1/2	5"
8"	3 1/2"	4"	5 1/2"
10"	4 1/2"	5 1/2"	7"
12"	5 1/2"	7"	8 1/2"

APPENDIX B

This is a minimum/maximum range sheet for students. These limits may be exceeded in special applications, but 95 percent of all hydraulic systems fall within these limits.

VARIABLE	MIN.	MAX.	COMMENTS
SYSTEM PRESSURE (P.S.I.)	.1	10,000	Most are 1,000 to 5,000
PUMP PRESSURE (Creates system pressure so it is same as above)			
SYSTEM FLOW (G.P.M.)	.1	150	Most are under 50
ELECTRIC MOTOR (H.P.)	1	175	Most are under 75
CYLINDER BORE (inches)	.25	20"	Most are under 8
PUSH FORCE (pounds)	-	350,000	Most are under 85,000
PULL FORCE (pounds)	-	300,000	Most are under 70,000
ROD SIZE (inches)	-	-	Always less than bore size
STROKE (inches)	.25	110	Most are under 48
HYD. MOTOR (torque)	1	700,000	Most are under 100,000
MOTOR DISP.(C.I./per rev.)	1	70	
FLOW FOR MOTOR (G.P.M.)	1	50	
PUMP SPEED (R.P.M.)	1250	3600	Fixed by electric motor
MOTOR SPEED (R.P.M.)	.25	3600	

APPENDIX C

Some typical examples of hydraulic system uses are as follows:

- AMUSEMENT RIDES
- AUTOMATED ASSEMBLY LINE EQUIP.
- ROBOTS, ROBOTIC ARMS
- CARWASHES
- CONVEYOR SYSTEMS
- FARM MACHINERY
- AIRLINE SERVICE EQUIPMENT
- TORQUE WRENCHES
- CANNING MACHINERY
- PRESSES
- TANKS TO CATAPULTS (MILITARY)
- INJECTION MOLDING
- CRANES
- GARBAGE TRUCKS
- JACKS
- HOISTS
- DRILLING EQUIPMENT
- AIRCRAFT CONTROLS
- FORESTRY EQUIPMENT (LOGGING)
- OIL RIG EQUIPMENT
- TIMBER PROCESSING
- PAPER MILLS
- EARTH MOVING EQUIPMENT
- LIFTGATES
- FORKLIFTS
- METAL CUTTING, FORMING OR PUNCH MACHINERY

APPENDIX D

You can obtain related data from HYDRAULICS & PNEUMATICS MAGAZINE or the FLUID POWER DIRECTORY published by the same editors at the following address:

HYDRAULICS & PNEUMATICS
614 SUPERIOR AVENUE, WEST
CLEVELAND, OHIO 44113

Or you can purchase compact reference manuals for a couple of dollars from:

HASKEL INC.
911 GRANDVIEW DR.
SOUTH SAN FRANCISCO, CA 94080

or

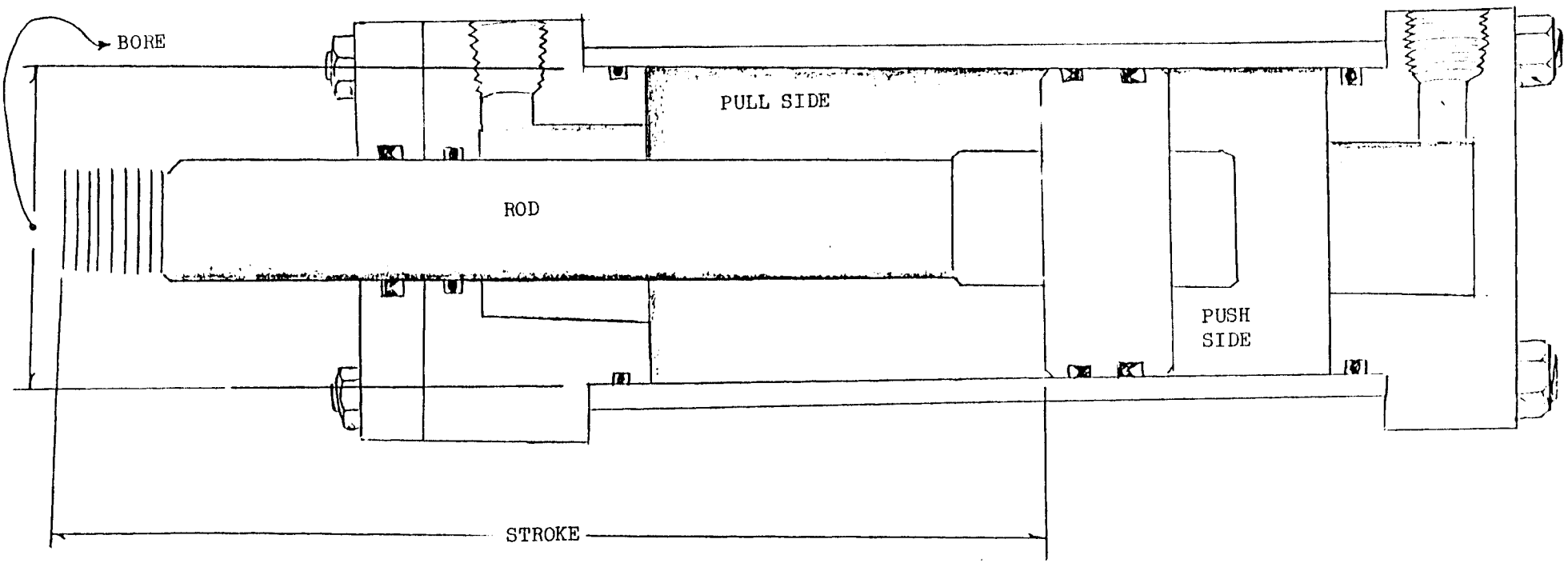
PAUL-MUNROE HYDRAULICS
8345 EAST SLAUSON AVE.
PICO RIVERA, CA 90660

If you want to learn more about hydraulics, a good set of instruction books is availble from:

WOMACK MACHINE SUPPLY COMPANY
2010 SHEA ROAD
DALLAS, TX 75235
(214) 357-3871

If you have a problem with the calculation aspect of the program or would like to ask me questions, I'd be happy to correspond.

CYLINDER CROSS-SECTION



CYLINDER CROSS-SECTION

Limited Warranty on Media and Hardware Accessories. We, Atari, Inc., guarantee to you, the original retail purchaser, that the medium on which the APX program is recorded and any hardware accessories sold by APX are free from defects for thirty days from the date of purchase. Any applicable implied warranties, including warranties of merchantability and fitness for a particular purpose, are also limited to thirty days from the date of purchase. Some states don't allow limitations on a warranty's period, so this limitation might not apply to you. If you discover such a defect within the thirty-day period, call APX for a Return Authorization Number, and then return the product along with proof of purchase date to APX. We will repair or replace the product at our option.

You void this warranty if the APX product: (1) has been misused or shows signs of excessive wear; (2) has been damaged by use with non-ATARI Home Computer products; or (3) has been serviced or modified by anyone other than an Authorized ATARI Computer Service Center. Incidental and consequential damages are not covered by this warranty or by any implied warranty. Some states don't allow exclusion of incidental or consequential damages, so this exclusion might not apply to you.

Disclaimer of Warranty and Liability on Computer Programs. Most APX programs have been written by people not employed by Atari, Inc. The programs we select for APX offer something of value that we want to make available to ATARI Home Computer owners. To offer these programs to the widest number of people economically, we don't put APX products through rigorous testing. Therefore, APX products are sold "as is," and we do not guarantee them in any way. In particular, we make no warranty, express or implied, including warranties of merchantability and fitness for a particular purpose. We are not liable for any losses or damages of any kind that result from use of an APX product.

For the complete list of current APX programs, ask your ATARI retailer for the APX Product Catalog

APX ATARI® PROGRAM EXCHANGE
P.O. Box 3705
Santa Clara, CA 95055

Review Form

We're interested in your experiences with APX programs and documentation, both favorable and unfavorable. Many of our authors are eager to improve their programs if they know what you want. And, of course, we want to know about any bugs that slipped by us, so that the author can fix them. We also want to know whether our instructions are meeting your needs. You are our best source for suggesting improvements! Please help us by taking a moment to fill in this review sheet. Fold the sheet in thirds and seal it so that the address on the bottom of the back becomes the envelope front. Thank you for helping us!

1. Name and APX number of program.

2. If you have problems using the program, please describe them here.

3. What do you especially like about this program?

4. What do you think the program's weaknesses are?

5. How can the catalog description be more accurate or comprehensive?

6. On a scale of 1 to 10, 1 being "poor" and 10 being "excellent", please rate the following aspects of this program:

_____ Easy to use
_____ User-oriented (e.g., menus, prompts, clear language)
_____ Enjoyable
_____ Self-instructive
_____ Useful (non-game programs)
_____ Imaginative graphics and sound

7. Describe any technical errors you found in the user instructions (please give page numbers).

8. What did you especially like about the user instructions?

9. What revisions or additions would improve these instructions?

10. On a scale of 1 to 10, 1 representing "poor" and 10 representing "excellent", how would you rate the user instructions and why?

11. Other comments about the program or user instructions:

From

STAMP

ATARI Program Exchange
P.O. Box 3705
Santa Clara, CA 95055

(seal here)