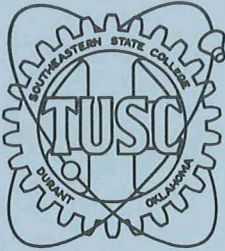


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APPLICATIONS OF HYDRAULIC COMPONENTS

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Technology Fact Bulletin

Number 1

November, 1969

TECHNOLOGY USE STUDIES CENTER

SOUTHEASTERN STATE COLLEGE
DURANT, OKLAHOMA 74701

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FOREWORD

This "Technical Fact Bulletin" is designed to explain new technology. It is intended primarily for those managers, technicians, and owners of small businesses who through desire, interest, and practical experience rather than formal training are applying technology in the development of saleable products.

This Bulletin deals with the concepts of hydraulics and with its application in the hardware that has been developed in the Aerospace Community during the last decade. The basis of this and similar Bulletins in the series are the results of research of the National Aeronautics and Space Administration and other Governmental agencies.

Research, of course, is continuing. Therefore, even more advanced developments in the application of hydraulics can be expected. The theoretical information and results of laboratory experimentation are available to inventors and small business owners/managers from the NASA-sponsored Technology Use Studies Center at Southeastern State College, Durant, Oklahoma.

INTRODUCTION

Blaise Pascal, a Frenchman, first recorded discoveries relating to fluid pressures in 1663. Though his research contained the basic theories of hydraulics, it was almost 300 years before the advantages of hydraulic power were put to practical use. One of the first major applications of hydraulics, the automobile brake, required an uphill fight of several years by auto manufacturers before it was accepted as superior to the mechanical brake. Following this, rapid advancement in aircraft building, mechanized farming, and a booming construction-equipment industry literally forced the acceptance and wide application of hydraulic power. Without hydraulic power for control, damping, and leverage, today's achievements in these fields would have been impossible.

Space research during the 1960's has caused another major increase in the application of hydraulics. Many of these recently discovered uses show promise of being useful in the everyday operations of small firms. To speed the transfer and use of new items of information on hydraulics, this Bulletin describes new hydraulic techniques and outlines possible areas of application.

Much of the recent increase in hydraulics applications has resulted from the enormous effort to put a man on the moon. In that effort by NASA, the greatest technical task ever attempted by man, hydraulics were found to have played a major role.

NASA has used hydraulics to push, pull, lift, control, press, and propel--all the functions necessary to the building of equipment to send men safely into space. Though few new principles have been discovered, many of the applications are new. Better still, many of them appear to be usable in everyday life. See page 10 for a selected list of publications dealing with NASA's uses of hydraulics in the space program.

HYDRAULIC CONTROL DEVICES

The amount of horsepower an individual has been able to employ and control has a close parallel in the economic growth and technical development of our society. The horsepower used per worker has tremendously increased since the end of World War II.

The availability of power alone will not insure its entry into everyday usage. From the engine-manufacturer's viewpoint, 100-HP farm tractors were feasible in 1940. But tractor makers concluded: Why develop a tractor with enough power to pull eight plows when man-muscle was the only control available, and a man could lift and control only two plows?

Hydraulic fluid transmission of power has made possible the rapid increase of the "power-to-man ratio." The force necessary to retract the heavy landing gear of World War II airplanes was supplied by hydraulic power transmission devices. The growth of hydraulic technology has accelerated since those airplane applications of the 1940's. The most common employment of hydraulic-power transmission is in the automobile brake. The system has been refined and improved by power-assist devices which employ the same hydraulic principles as the original hydraulic brakes. Now, a woman or child can stop a heavy car with a light pressure on the brake pedal.

Government and private research have advanced the state-of-the-art in fluid-power transmission tremendously in recent years. However, the basic laws of physics involved in fluid-power transmission are not new by any means. The Frenchman, Pascal, published his findings about fluid pressures in 1663. Pascal's law, in essence, states that pressure applied to an enclosed fluid is transmitted equally throughout the fluid.

The basic principles of fluid-power transmission have today become widely understood and employed. The knowledge of controlling and applying fluid power is, however, not as widely understood. It offers many opportunities for greater employment or application of hydraulics. Pascal's law and later developments have become a specialized division of engineering. It is called Fluidics.

Fluidics deals with the flow of fluids as a means of the control of mechanical and electronic devices. The drop of pressure of fluid flowing through an orifice (small opening) or the friction generated by the flow of fluid around an obstruction is being used to control devices as complex as computers.

NASA and other governmental agencies as well have funded extensive research in the application of hydraulics in the aerospace effort. If the results of the research are to benefit the general public, technicians need an understanding of the more common fluid-control devices that have developed. Therefore, six fluid-control devices or hydraulic components have been selected for discussion in this Bulletin. Each is readily available from hydraulic supply firms. From this publication the reader may understand how these devices function. He may then be able to find uses for them in applying and controlling power within his own products. The result would be more useful and better-built products for all mankind.

The selected hydraulic components are:

1. Hydraulic Accumulator
2. Hydraulic Force Amplifier
3. Sequence Valve
4. Hydraulic Fuse
5. Servo Valve
6. Priority Valve

Basic schematics (diagrams) of the more widely used components have been provided. The limited scope of this Bulletin will not permit a discussion of all flow-control components. Companies specializing in hydraulic devices can likely provide the components

that the reader needs for applying hydraulic power in new and different ways.

HYDRAULIC ACCUMULATOR

One of the best ways of realizing cost-savings and of increasing the utility of fluid-flow systems is through the use of a hydraulic accumulator (Figure 1). Basically, the accumulator functions as a storage battery functions in an electrical system. The accumulator stores unused pressure that is flowing through the hydraulic system. As a result, during short periods of time, a greater volume of fluid under pressure is available for use than the rated capacity of the pump in the system. For example, if a hay baler were hydraulically-powered, the return stroke of the piston could be speeded up as desired merely by tapping the reserve fluid stored in the accumulator. An accumulator might also be used to store fluid power for positioning machinery for servicing. On other occasions, it might be inconvenient to start an engine and thereby operate an entire system in order to position a single part of the system for routine maintenance or for troubleshooting. There might also be instances where a large volume of fluid pressure is needed for the completion of a machine's cycle. If there is any idle time for the pump during any part of the cycle, an accumulator can be used to spread the work throughout the cycle thus permitting the use of a smaller pump than would be needed if no accumulator were available. NASA's Report A66-31224, Fitting An Accumulator to APU Starting Requirements, tells how to select the size accumulator to use in starting an engine instead of using a conventional storage-battery system.

HYDRAULIC FORCE AMPLIFIER

The hydraulic force amplifier (Figure 2) is widely used in industry today. It raises pressure in selection portions of the system beyond the level that the pump produces. It is commonly used where additional functions are added to an existing system. For example, a punch press requiring 2,000 PSI (pounds per square

HYDRAULIC ACCUMULATOR

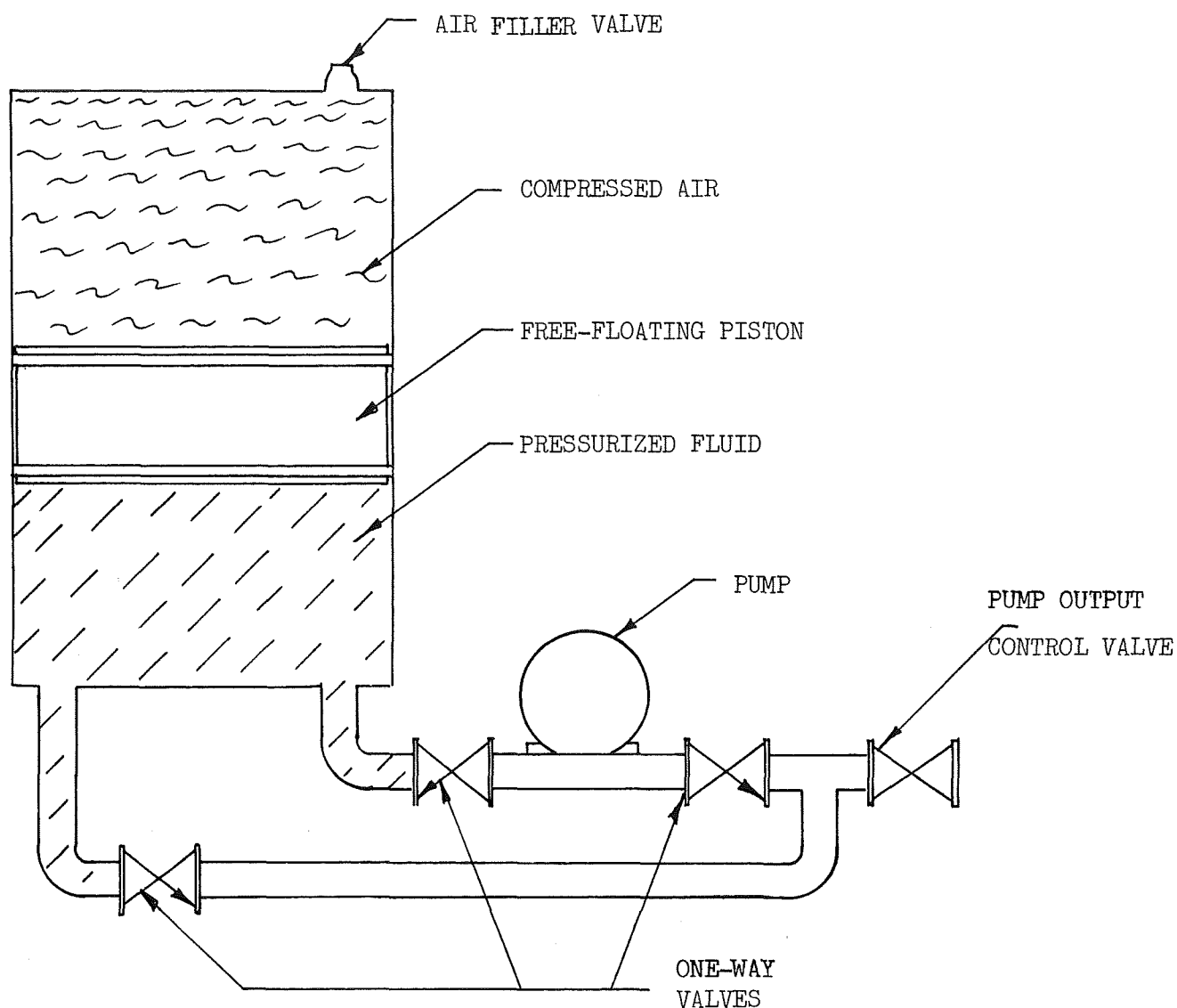
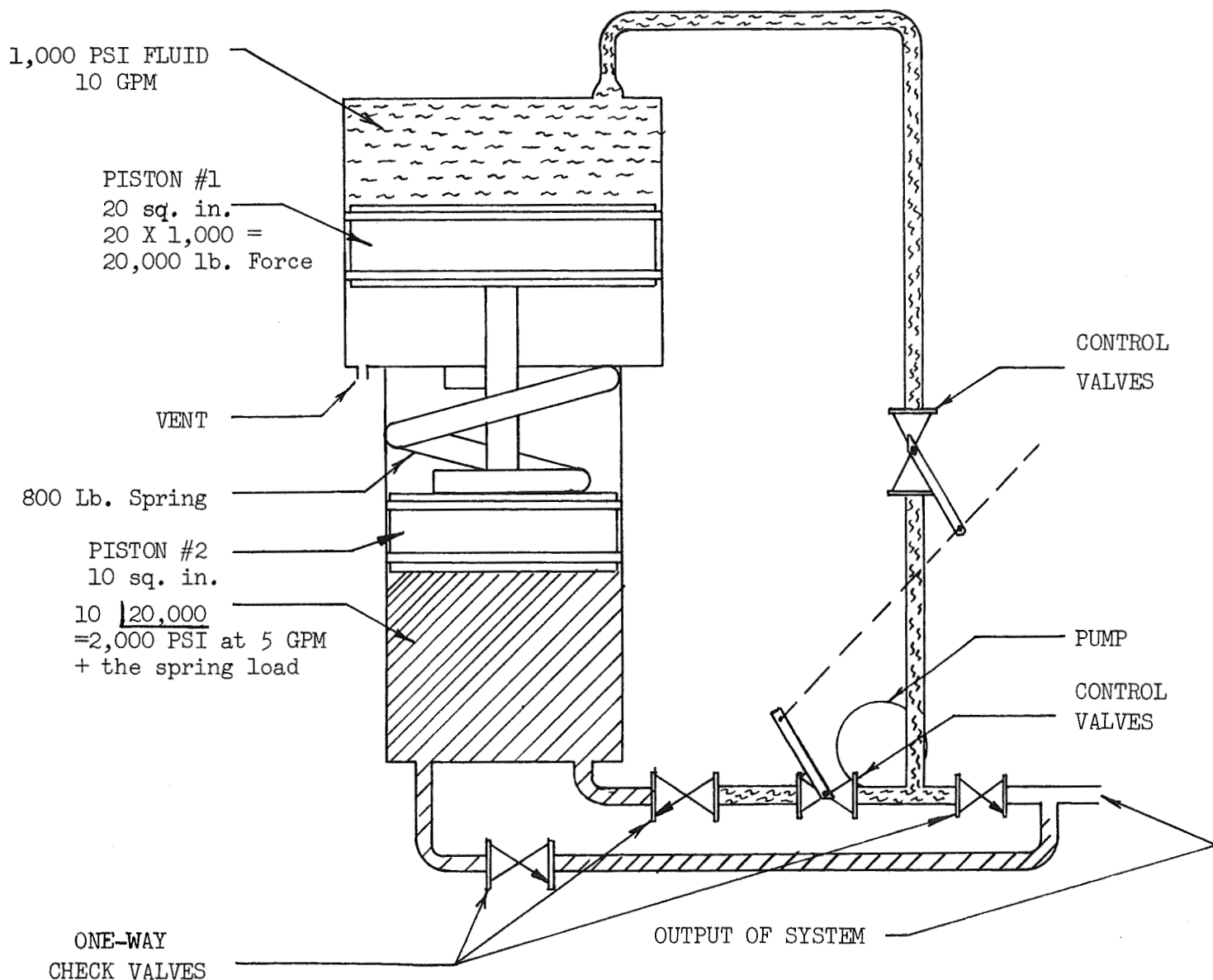


Figure 1. This basic accumulator has many variations. The compressed air may be replaced with a compression steel spring or a combination spring and air. The air side may have a pressure booster so that the system can produce greater pressure at a smaller volume than the pump produces. The traditional use of an accumulator, of course, is to "accumulate" the output of the pump at slack times for use when the system demands more volume than the pump can furnish.

HYDRAULIC FORCE AMPLIFIER



GPM - Gallons Per Minute
PSI - Pounds per Square Inch

Figure 2. This schematic illustrates a system that multiplies the pressure a pump can generate. It is commonly used for starting loads which have high break-out forces. The 800-pound spring can be replaced with a spring having a valve necessary to allow the lower chamber to function as an accumulator.

inch) fluid might be added to an existing 1,000 PSI system by utilizing a force amplifier.

Grease-rack automobile lifts found in garages and in service stations are usually powered by force amplifiers. Many types of presses used in machine shops have variations of amplifiers. The speed of travel of the high pressure piston is governed by its size in relation to the lower pressure pistons in the system. The grease-rack lifts are powered in many installations by $\frac{1}{4}$ -HP motors. A $\frac{1}{4}$ -HP motor, unassisted, would not be expected to raise a 4,000-lb. automobile at a high rate of speed. Amplifiers may use air, oil, or a combination of the two instead of the basic spring-system as shown in Figure 2.

SEQUENCE VALVE

Sequence valves (Figure 3) were probably the first units developed for automated hydraulic systems. Their development was promoted by the need for sequencing landing-gear doors and landing gear with the advent of large streamlined aircraft. Hydraulic sequencing functions quite satisfactorily whenever a series of mechanical actions is needed. For example: when a pilot moves a gear handle to UP position, the gear doors open first; as soon as the doors are open, all landing gear comes up; and finally, when the gear is in UP position, the doors then close to the flight position. All of these actions occur automatically whenever sequence valves are used.

A livestock feed-mixing operation might use a sequence-valve arrangement to mix and proportion livestock feed automatically. A hopper could be rigged to actuate a sequence valve if enough weight were added to the hopper to cam a sequence valve for the next step in the feed-mixing operation. NASA's Report N66-34292, Hydraulic Automation Systems, explains the details of the application of sequence valves and many other units which are used in automated hydraulic systems.

SEQUENCE VALVE

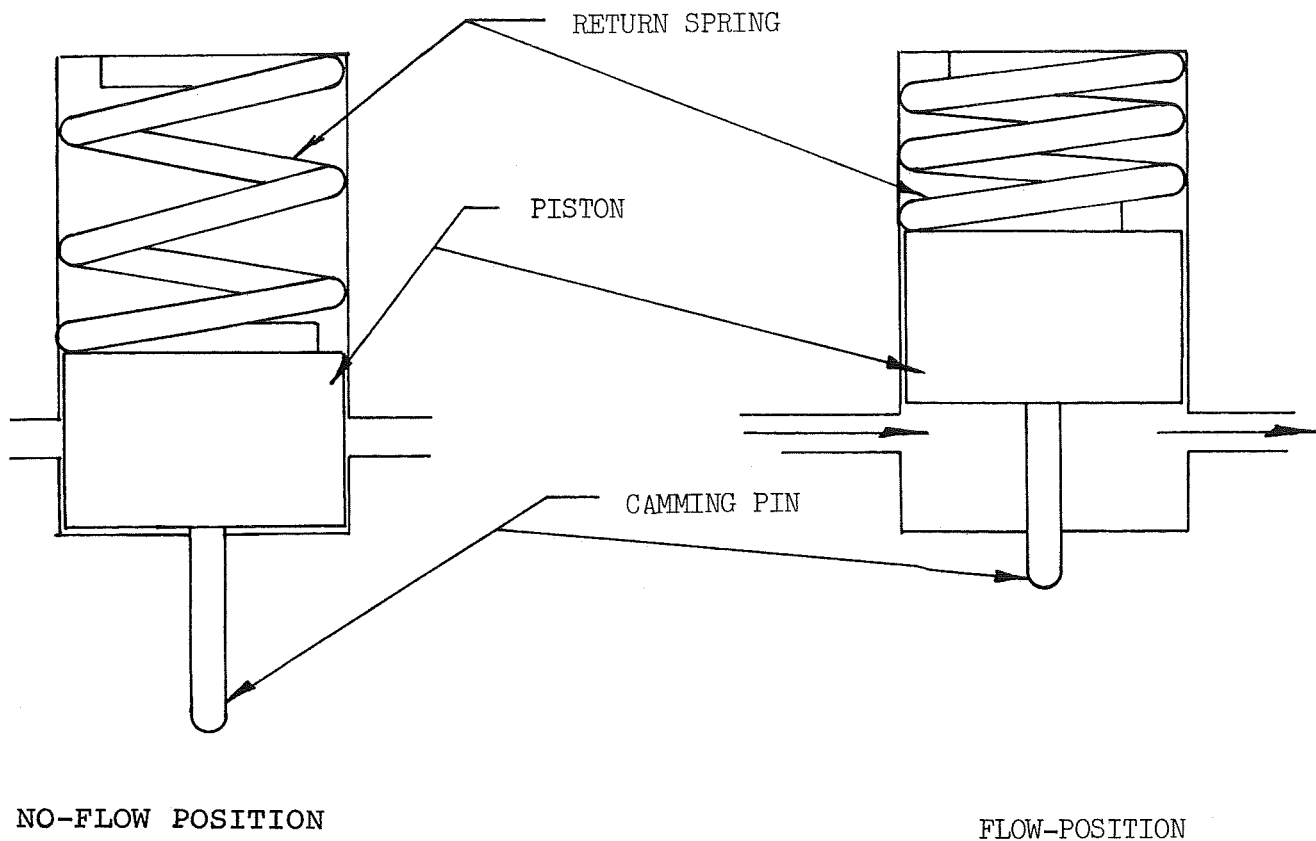


Figure 3. When enough force is applied to the camming pin to compress the return spring, the "no-flow" position of the piston will be changed to the "flow" position. Sequence valves may be operated by cam action, electrical solenoid, or by many other means. This basic schematic depicts only one hydraulic circuit, although a sequence valve may control any number of circuits.

HYDRAULIC FUSE

Whenever an electrical circuit is overloaded, either the circuit breaker is tripped or a fuse burns out. Each is a safety device that has been developed to prevent overloading the circuit, thereby possibly preventing fires.

The same conditions exist in hydraulics whenever a line breaks, and the pressurized flammable fluid is sprayed out. Hydraulic fuses have been developed to prevent fires in the hydraulic system. A hydraulic fuse can be calibrated (carefully adjusted) and placed in a line to function whenever the fluid-flow exceeds a desired volume. When the tolerance has been exceeded, the fuse trips and closes the line. Fuses, therefore, are used wherever a ruptured line would present a hazard to its surroundings or to the hydraulic system itself.

SERVO VALVE

A servo valve is a valve that senses a feedback from the work being performed and uses the feedback to control the machine doing the work. For example, if the hydraulic steering system on an automobile or tractor did not have a feedback system, the driver would be required to devote a constant effort to steer in the direction he had selected. Without the "servo valve" a steering system would never have a neutral position.

Figure 4 pictures a basic hydraulic servo valve. It is the basis for hydraulic automation. Servo valves can be operated electrically, electronically, or mechanically to cycle machinery; to control the depth of a plow; to bend metal; or to do many other controlling functions better and faster than they can be performed manually.

PRIORITY VALVE

A priority valve is a device which assures that the major working units in a hydraulic system receive the main flow of a pump's output. These valves can be placed throughout a system

SERVO VALVE

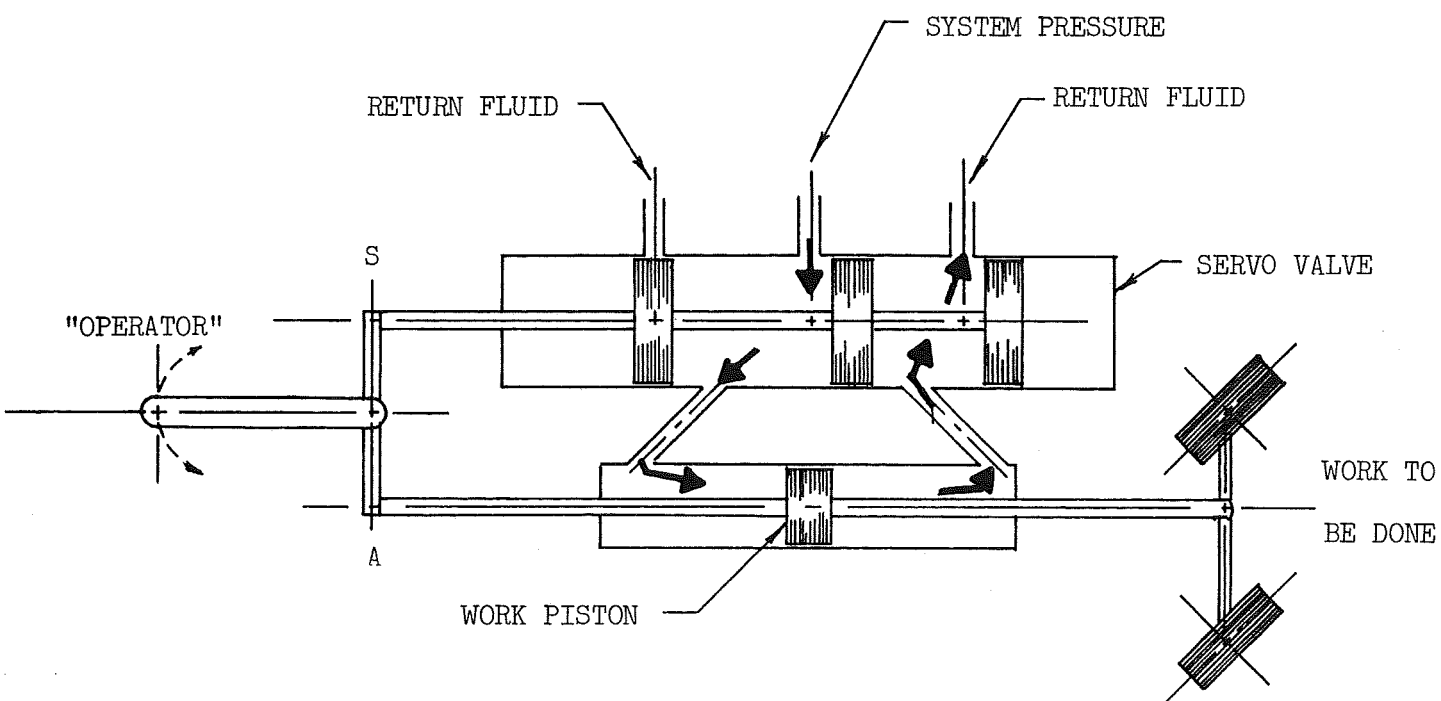


Figure 4. The "operator" may be a person or a mechanical hookup. First movement is point "S" about point "A". Pressure is ported to work cylinder to move point "A" to the right. When point "A" has moved to the right to a position even with "S" the system will shut off. "Operator" is controlled by a mechanical linkage to the work to be done.

in order that the most important units within the system will receive almost full pump capacity while the less important ones receive only the remaining pressure. For example, if the brakes and power-steering unit of an automobile were powered by the same hydraulic system, a priority valve would be used to furnish maximum power for the operation of the brakes when both the brakes and the power steering were in use.

NASA USES OF HYDRAULICS

1. Control of Parallel Hydraulic Motors--Used for Tracking Antennas.

TB 67-10418, Hydraulic System Provides Smooth Control of Large Tracking and Antenna Drive Systems at Very Low Tracking Rates, November 1967.

TB 65-10351, Hydraulic Drive System Prevents Backlash, November 1965.

2. Platform Leveling Suspension Unit--Saturn Transporter.

TB 66-10402, Rotary Valve Controls Multiple Hydraulic Leveling Cylinders, September 1966.

3. Clamps and Hold-Down Devices.

AD 447-995, Aerospace Fluid Component Designers' Handbook.

4. Shock Absorbers and Hydraulic Damper.

TB 68-10120, Pressure Variable Orifice for Hydraulic Control Valve, April 1968.