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54] **AUTOMATIC BURST TESTER**
 10 Claims, 7 Drawing Figs.

[52] U.S. Cl. 73/102
 [51] Int. Cl. G01n 3/26
 [50] Field of Search..... 73/102,
 159, 52

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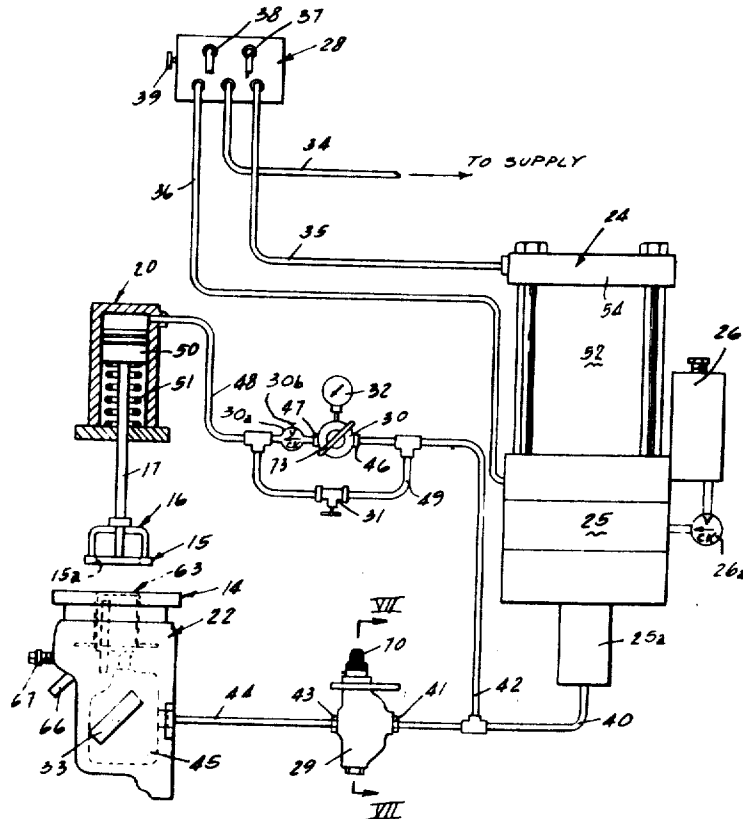
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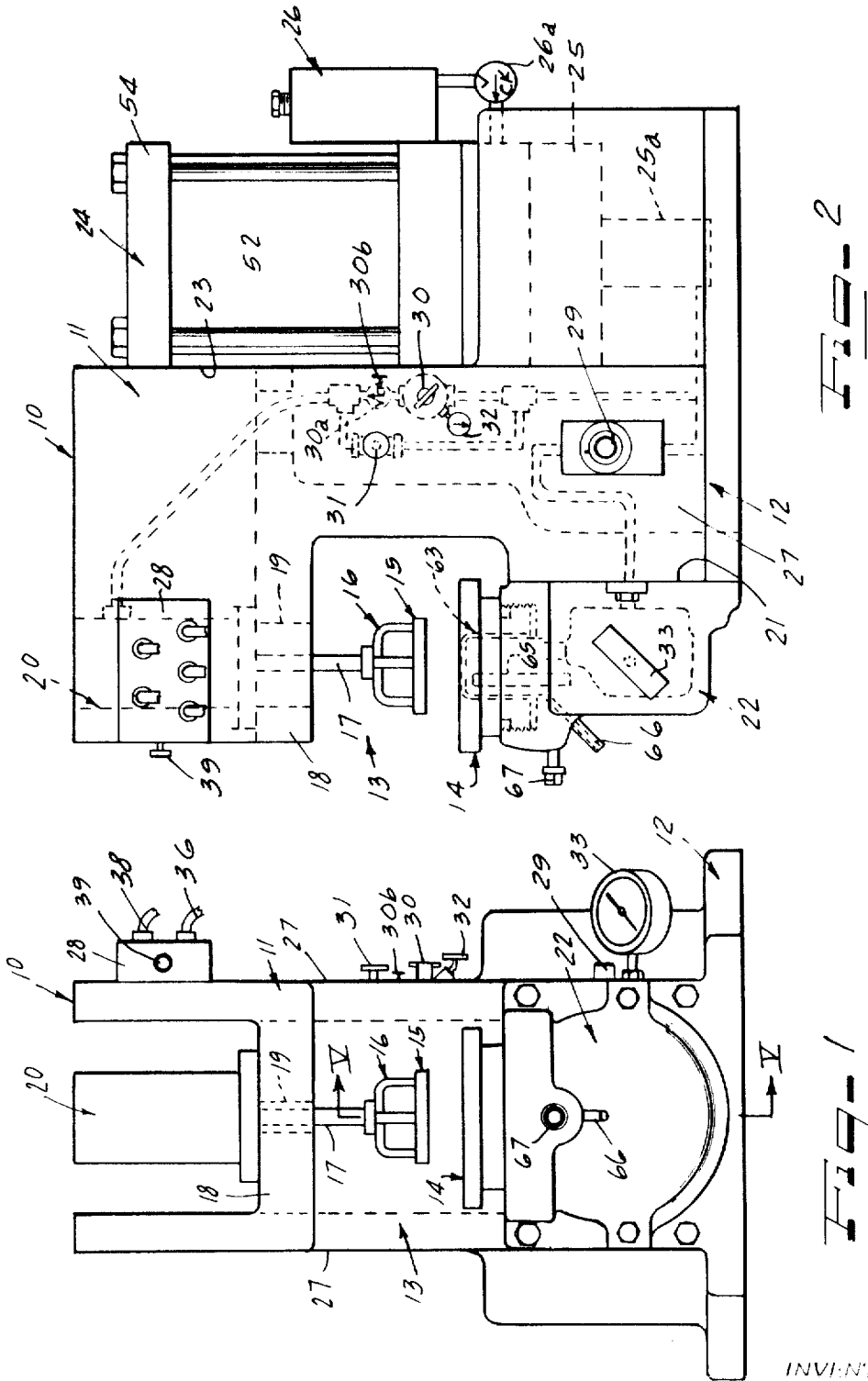
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ABSTRACT: A sheet material burst testing machine which automatically clamps the sheet to be tested between two apertured members under a controlled hydraulic load sufficient to prevent slippage without crushing the sheet, and which then automatically exerts a constantly increasing hydraulic pressure against the exposed clamped sheet area in the apertures of the members until the sheet bursts, whereupon the pressure drops. A gauge actuated by the increasing pressure stops at the maximum developed pressure and indicates the burst resistance of the sheet material. The machine has a pneumatically operated positive displacement ram servomotor or hydraulic booster which forces the flow of hydraulic liquid in a closed system to first actuate a clamping device and to then expand a rubber diaphragm against the sheet clamped by the plates until the sheet bursts. The clamping load is automatically proportionally higher than the load on the diaphragm by an amount sufficient to prevent slippage, or alternately a desired clamping load may be predetermined to prevent slipping without crushing of the sheet, and automatically reapplied on subsequent tests. The machine is especially useful in measuring, in pounds per square inch or kilograms per square centimeter, the bursting strength of paper, fiberboard, corrugated board, and shipping containers made therefrom.

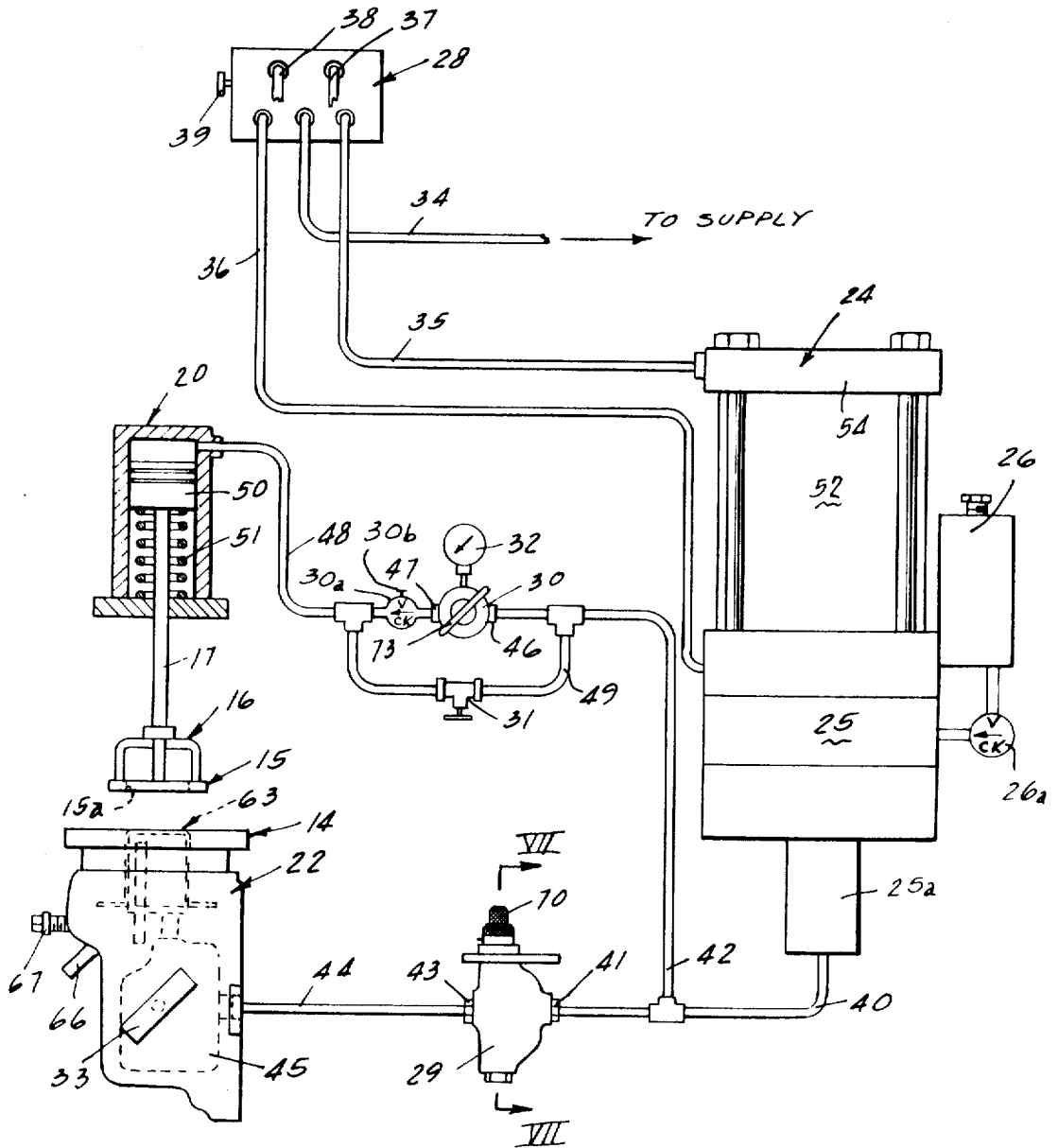




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Fig. 3



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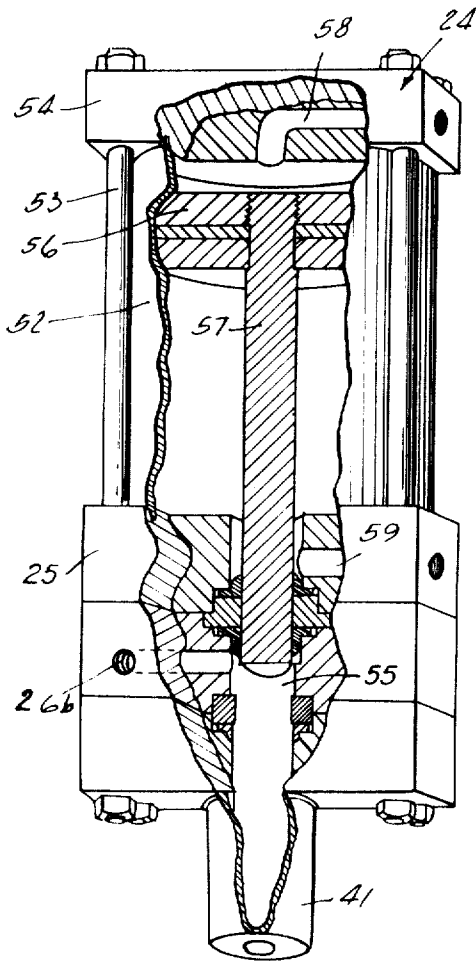


Fig. 4

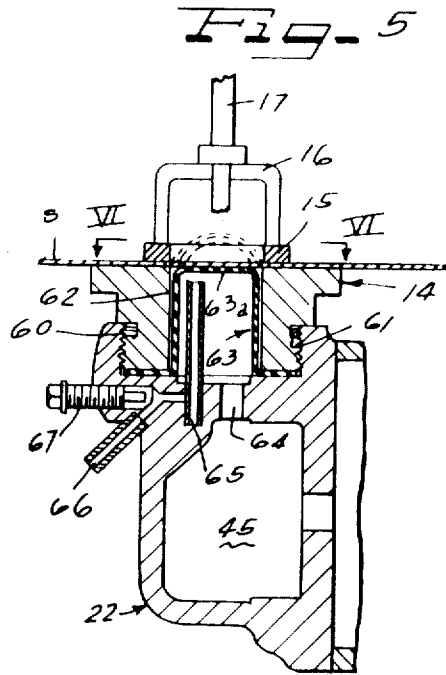


Fig. 5

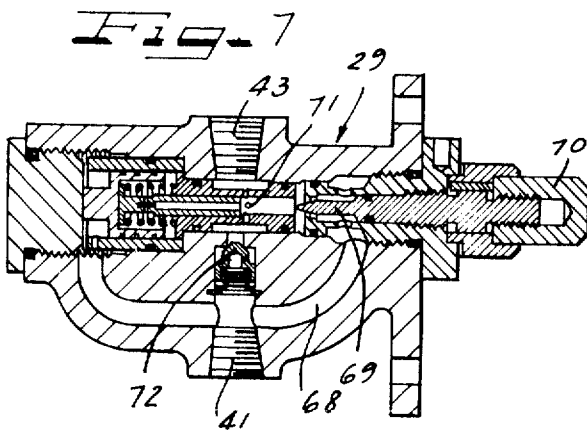


Fig. 7

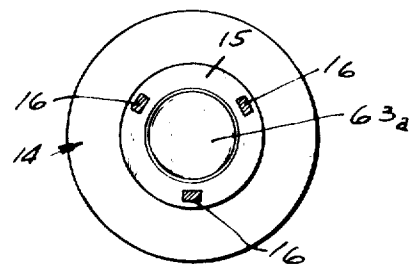


Fig. 6

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AUTOMATIC BURST TESTER

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates generally to Mullen testers for indicating the burst strength of sheet material such as paper, fiberboard and the like. Specifications for such sheet material, especially material used for shipping containers, include a burst strength determined by a Mullen tester which measures and indicates the pressure in pounds per square inch, or kilograms per square centimeter, at which bursting of the material occurs. These testers clamp the sheet material between flat circular plates or rings, with center openings having an effective area of one square inch. Fluid under pressure forces a rubber diaphragm to expand through the apertures of the plates or rings, thereby exerting a constantly increasing pressure against the unsupported area of the material. This pressure is measured by a gauge having a pointer that will stop at the maximum pressure to develop during the test. When the paper bursts, the pressure drops, leaving the gauge indicator in a stationary, easily read condition indicating, in pounds per square inch, the force required to burst the material.

2. Description of the Prior Art

Heretofore, Mullen testers have used a piston driven manually or by a motor at a constant rate to displace the diaphragm through the clamping rings for bursting the sheet, and have used manually operated screw means or manually controlled hydraulic means for actuating the clamping rings. The mechanically moved piston required expensive, cumbersome drive gear and was slow-moving. The clamping devices of these prior-known Mullen testers involved manual actuation or control, thus always involving a human element in the test. Desired clamping load was always a matter of trial and error to prevent slippage of the sheet material during the test without crushing the material. Preliminary test were thus always necessary to arrive at a proper clamping load for each material being tested. If wrinkles appeared in the burst test sample, the operator would know that the clamping load was insufficient, because these wrinkles indicated slippage during the test. If the burst test sample did not exhibit wrinkles, the operator would have to carefully examine the sample for crush damage because a clamping load sufficiently high to crush the material would weaken the periphery of the test area, as by shearing the fibers, thereby preventing an accurate indication of burst strength.

Thus the prior-known Mullen testers were cumbersome and slow, and required skilled technicians to operate them.

SUMMARY OF THE INVENTION

According to this invention there is now provided a Mullen tester which removes the human element from conducting burst tests on sheet material. The testers of this invention are fast-acting, and the operator need only press a button to cause the tester to go through its complete cycle and produce an accurate reading of the burst strength of the sheet material being tested. The testers of this invention are actuated pneumatically from the conventional air pressure source of a laboratory, can be supplied with individual compressors for developing the air pressure, or can be supplied with a hydraulic pump system for customers not having a compressed air source. The operator merely presses a button to release the air pressure to a pneumatic positive displacement ram servomotor which forces hydraulic liquid, such as glycerine, through a closed cycle to, first, actuate the clamping device for securing the clamping rings on the sheet material being tested and to, next, develop the force for expanding the diaphragm through the clamped sample.

In one embodiment of the invention the liquid pressured by the pneumatic ram motor or hydraulic booster simultaneously acts on a piston which applies the clamping load and on the diaphragm which applies the bursting force. The piston has a

larger diameter than the aperture of the clamping ring through which the diaphragm is forced so that the clamping load will always be proportionally higher than the bursting load and will increase in direct proportion therewith.

In another embodiment of the invention the pneumatically actuated ram motor will simultaneously displace the hydraulic liquid to the clamping piston and to the bursting diaphragm, but the hydraulic force on the clamping piston will be preset by a pressure regulator so as to develop a predetermined clamping load. The position of the clamping device is then locked against backing off of the sample under bursting loads by a lock or check valve preventing back flow of the fluid on the clamping piston until the test is completed. The predetermined load will be sufficient to hold the test sample against slippage without crushing the sample.

It is then an object of this invention to provide a burst tester which is fully automatic in operation and avoids the requirement for a skilled operator.

Another object of this invention is to provide an automatic burst tester which uses a single pneumatic positive displacement ram motor to develop a hydraulic force on a closed hydraulic system which will, in turn, develop the clamping load and the bursting force for the test.

Another object of this invention is to provide a Mullen tester which is operated automatically from a conventional laboratory air pressure source.

A still further object of this invention is to provide a burst test machine with a closed loop hydraulic system actuating a clamping device and a burst diaphragm and, in turn, actuated by a pneumatic ram motor.

A further object of this invention is to provide a Mullen tester which automatically develops a clamping load on the test sample which is proportionally higher than the bursting force applied to the sample, and increases with bursting force at this proportionally higher level.

Other objects, features and advantages of this invention will be readily apparent from the following description of certain preferred embodiments thereof, taken in conjunction with the accompanying drawings, although variations and modifications may be effected without departing from the spirit and scope of the novel concepts of the disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a front elevational view of an automatic burst tester according to this invention;

FIG. 2 is a side elevational view of the burst tester of FIG. 1;

FIG. 3 is a diagrammatic view illustrating the pneumatic and hydraulic piping to the related components;

FIG. 4 is a fragmentary perspective view with parts broken away and shown in section of the pneumatic servomotor used in the tester of this invention;

FIG. 5 is a broken vertical cross-sectional view taken along the line V—V of FIG. 1, but showing the clamping ring in its lowered position;

FIG. 6 is a cross-sectional view taken along the line VI—VI of FIG. 5;

FIG. 7 is a longitudinal cross-sectional view of the flow-proportioning valve taken along the line VII—VII of FIG. 3.

BRIEF DESCRIPTION OF THE PREFERRED EMBODIMENT

The reference numeral 10 in FIGS. 1 and 2 illustrates generally the burst tester of this invention. The unit 10 includes an upright metal frame designated at 11, with a base 12 that may rest on a laboratory bench or be secured to a stand (not shown). The frame 11 provides an open front and open side recess 13 giving free access to the horizontal plate 14, on which the sheet material to be tested is deposited.

A clamping ring 15 depends into the space 13 above the plate 14. This ring 15 is connected by a cuplike spider or cage 16 to a piston rod 17.

The frame 11 has a horizontal wall 18 defining the top of the recess 13, and having an aperture 19 therethrough freely receiving the piston rod 17. A closed top cylinder 20 is vertically mounted on this wall 18.

The frame 11 has a front pad 21 on which is mounted a cuplike casting 22 which carries the plate 14 on its top end.

The frame 11 has a rear face 23 carrying an air cylinder positive displacement ram motor 24 which, as illustrated, is vertically mounted, although it may be horizontally mounted. This motor 24 has a base 25 mounted on the base 12 of the frame, and a small tank 26 mounted adjacent the cylinder supplies hydraulic liquid to this base portion 25, as will be more fully hereinafter described.

The frame 11 has vertical sidewalls 27, on one of which is mounted an air control valve 28 for the ram motor 24, a flow-proportioning valve 29 for controlling flow of hydraulic liquid from the base portion 25 of the servomotor to the casting 22, and a pressure-regulating valve 30 for controlling liquid pressure from 25 to the cylinder 20. A releasable type check valve 30a is also provided on the discharge side of the valve 30 to prevent backflow except when desired. In addition, a bypass valve 31 is mounted on this sidewall 27 for controlling flow of fluid around the pressure-regulating valve 30 and check valve 30a. A pressure-indicating gauge 32 is mounted on the valve 30 to show the pressure of the fluid fed to the cylinder 20.

A pressure-indicating gauge 33 is mounted on the casing 22 and projects outwardly therefrom to be clearly visible when conducting a burst test. If desired, the gauge 33 can be mounted on the frame 11 in front of the cylinder 20.

As shown in FIG. 3, compressed air from a conventional laboratory source or a compressor furnished with the tester is supplied to the valve 28 through a tube 34. A tube 35 connects one port of the valve with top of the ram motor 24, while a tube 36 connects another port of the valve with the bottom of the ram motor. Exhaust ports 37 and 38 respectively vent the tubes 35 and 36 to the atmosphere through the valve 28. A pushbutton 39 actuates the valve. The porting of the valve is such that air from supply tube 34 will be fed to tube 35, and air from tube 36 will be vented to port 38 when the button 39 is depressed. Conversely, when the button 39 is released, air from the supply tube 34 will be fed to the tube 36, and the tube 35 will be vented to the port 37. As will be more fully explained, this actuates the piston in the ram motor downwardly when the button 39 is depressed, and upwardly when the button is released.

Hydraulic fluid from the portion 25 of the ram motor operates in a closed system, including a tube 40 extending from a cylinder 25a that depends from the bottom of the portion 25 of the ram motor. This tube 40 is connected to the inlet port 41 of the flow-control valve 29, and to a branch tube 42 ahead of the valve 29. The valve 29 has a discharge port 43 feeding a tube 44 which communicates with a chamber 45 in the member 22.

The branch tube 42 is connected to the inlet port 46 of the pressure-regulating valve 30, and the outlet port 47 of this valve is connected to a check valve 30a and then through a tube 48 to the top of the cylinder 20. The check valve 30a has a release button 30b which will open the valve when depressed. A bypass tube 49, controlled by the valve 31, connects the tubes 42 and 48 around the pressure-regulating valve 30 when the valve 31 is opened and the valve 30 is closed.

The cylinder 20 has a piston 50 slidably mounted therein and urged by a spring 51 to the top of the cylinder. The piston rod 17 depends from the piston 50 and extends through the bottom of the cylinder to carry the cup-shaped cage 16 for the clamping ring 15, as described above.

The hydraulic circuit thus flows hydraulic liquid such as glycerine, from the ram motor through the metering or flow control valve 29 to the chamber 45, and at the same time either through or around the pressure-regulating valve 30 to the top of the cylinder 20.

As shown in FIG. 4, the ram motor 24 includes a cylinder 52 clamped by draw bolts 53 between a head 54 and the base 25.

A piston 56 is slidably mounted in the cylinder 52, and has a rod or ram 57 depending therefrom into a liquid chamber 55, provided in the base 25. Hydraulic liquid is fed to the chamber 55 under the rod 57 from the supply tank 26 through a port 26b and a check valve 26a (FIG. 3) prevents backflow out of this port 26b. The head 54 has a port 58 which receives the air supply tube 35, while the base 25 has a port 59 which receives air from the supply tube 36.

Hydraulic liquid is sealed in the chamber 55, and when the piston rod or ram 57 is forced into this chamber by air pressure applied on top of the piston 56 from the port 58, liquid is displaced from the chamber 55 to the tube 40. Conversely, when air is supplied to the port 59 under the piston 56, the piston rod or ram 57 is lifted toward the top of the chamber 55, and the fluid is drawn back into this chamber.

In installations where air pressure is not convenient to operate the pneumatic hydraulic ram motor 24, this motor could be replaced with an electric motor driven hydraulic pump and the valve 28 could be replaced with an electric switch. Such an arrangement is also included in the term "servomotor."

As shown in FIG. 5, the casting 22 has an internally threaded well 60 in the top thereof receiving an externally threaded boss 61 depending from the plate 14. The boss and plate 14 have a central cylindrical aperture 62 therethrough. A heavy rubber diaphragm 63 has a cup-shaped central portion molded to snugly fit in this aperture 62, and a flat peripheral flange portion clamped between the boss 61 and the member 22 in the bottom of the recess. The cup-shaped portion of the diaphragm has a wall 63a which is flat in its free state and lies flush with the top face of the plate 14 to span the top of the aperture 62.

A port 64 joins the chamber 45 with the interior of the cup-shaped portion of the diaphragm 63 so that fluid will act on the end wall 63a of the diaphragm to expand it through the aperture 62.

A purge tube 65 is threaded at its bottom end in the top of the member 22 and communicates with the top of the diaphragm in spaced relation under the wall 63a thereof. A drain outlet 66 joins the bottom of the tube 65 with the atmosphere and a valve 67 controls flow from the tube to the drain. This purge arrangement is provided to relieve air from the closed fluid system.

As shown in FIG. 5, the clamping ring 15 has been lowered to clamp a sheet of paper S on the plate 14. The aperture of the ring 15 is the same as the cylindrical aperture 62, and registers therewith. As shown in dotted line, when fluid is forced against the diaphragm portion 63a, the diaphragm will stretch and bow upwardly into the aperture of the clamping ring 15, drawing the clamped paper S therewith to form a fragmental dome or bubble which will burst the paper.

As shown in FIG. 7, the valve 29 has the inlet port 41 connected through a passage 68 controlled by a needle 69 which is positioned from a manually set knob 70, and regulates flow to ports 71 communicating with the outlet 43. A setting of the needle 69 will, therefore, control the rate of flow of the hydraulic fluid from the chamber 55 to the chamber 45.

The valve 29 has a built-in check valve 72 which permits free backflow from the outlet port 43 through the ports 71 to the inlet port 41, thereby bypassing the needle valve 69.

The pressure-regulating valve 30 is controlled by a handle 73 which can be set so as to deliver from the inlet 46 to the outlet 47 any pressure indicated by the gauge 32 less than the inlet pressure. In this manner the piston 50 can be subjected to fluid pressure which is preset by the valve 30. When the clamping ring 15 is loaded on the sample under the preset pressure its clamping position is locked against backoff by bursting pressure loads by means of the check valve 30a that traps the fluid on the piston 50, after the test backflow is permitted by opening the check valve with the release button 30b.

On the other hand, if the valve 30 is closed and the valve 31 is opened, the piston 50 will be subjected to the same pressure at a diaphragm 63. In this embodiment it is desired to have the

piston 50 of larger diameter than the aperture 15a of the ring 15 so that the clamping load will be higher than the bursting force. When fluid pressure on the piston 50 is released as by retracting the ram from the chamber 55, the spring 51 will raise the piston to the top of the cylinder 20, discharging the fluid ahead of the piston.

OPERATION

To conduct a burst test on the machine 10 of this invention, the sample to be tested is placed on the plate 14. The button 39 is then depressed to actuate the valve 28 for feeding air under pressure from the supply tube 34 through the tube 35 to the top of the ram motor 24, for forcing the piston 56 downwardly. At the same time air under the piston 56 in the ram motor is bled to the atmosphere through the tube 36 and port 38, which is preferably supplied with a speed control muffler (not shown). As the piston descends in the ram motor the ram or piston rod 57 forces fluid from the chamber 55 of the motor simultaneously into the chamber 45 of the member 22 and into the cylinder 20 of the clamping device. The valve 29 will meter the rate of flow into the chamber 45 so that no surge pressure will be exerted on the diaphragm 63. A slow flow rate of about 95 milliliters per minute is desired. If it is desired to clamp the sample on the plate 14 with a load that is proportional to the bursting load, the valve 30 is closed, the valve 31 is opened, and the fluid from the ram motor is forced on top of the piston 50 to lower the clamping ring 15 into thrust engagement with the plate 14, thereby clamping the sample therebetween. Then as the fluid continues to be displaced from the ram motor, the diaphragm will be forced through the clamping ring 15 under the ever-increasing pressure until the paper is distended sufficiently to burst, whereupon the button 39 will be released, the pressure will immediately drop, and the movement of the ram motor will be reversed and the pressure on the diaphragm and on the clamping piston will be relieved. The gauge 30 will show the maximum pressure reached by the fluid acting on the diaphragm, thereby giving a reading in pounds per square inch or kilograms per square inch of the burst strength of the paper.

In the event it is desired to operate the test with a preset clamping load, the valve 31 is closed and the valve 30 is set so that the piston 50 will receive only a maximum pressure, as controlled by the valve 30. In this alternative arrangement the desired clamping load can be determined in advance and the valve 30 set accordingly.

The spring 51 will automatically lift the piston 50 to raise the clamping ring 15 off of the sample at the conclusion of each test.

From the above descriptions it should, therefore, be understood that this invention provides a fully automatic burst testing device which eliminates chance for human error and does not require the services of a skilled technician.

I claim:

1. A device for measuring the bursting strength of sheet material which comprises a closed liquid circuit, liquid pressure-actuated means in said circuit for clamping sheet material around an exposed area thereof, means in said circuit for developing liquid pressure against said clamped exposed area sufficient to burst said sheet material, metering means in said circuit to control the rate of hydraulic flow to said last mentioned means and to prevent pressure surge against said exposed area, a positive displacement ram motor, actuated from an outside source, acting on liquid in said circuit to actuate the means for clamping and the means for developing liquid pressure against the clamped exposed area, and an indicator actuated by pressure of liquid in said circuit showing the pressure developed at the bursting point of the sheet material.

2. A burst tester for sheet material comprising an apertured plate for receiving the sample to be tested over the aperture thereof, a clamping ring having an aperture aligned with the plate aperture, a resilient diaphragm under said plate and having a portion adapted to be expanded through the plate aper-

ture, a closed hydraulic circuit, a hydraulic device in said circuit for loading said clamping ring against said plate to clamp the sample around the apertures of the ring and plate, a valve in said circuit for metering hydraulic fluid in said circuit under pressure against said diaphragm at a controlled rate to expand the diaphragm through said apertures against the clamped sample and to prevent surge pressure against said diaphragm, a pneumatic actuated positive displacement ram motor forcing fluid in said circuit to said valve and to said hydraulic device to first actuate the clamping ring against the sample on the plate and to then expand the diaphragm sufficiently through the apertures of the plate and clamping ring to burst the sample, and a gauge showing the fluid pressure on the diaphragm at the bursting point of the sample.

3. An automatic burst tester for fibrous sheet material and the like which comprises a closed hydraulic circuit, hydraulically actuated means in said circuit for clamping the sample to be tested around a circular area thereof of predetermined diameter, a diaphragm in said circuit acting against said circular area, means for metering hydraulic fluid in said circuit at a controlled flow rate against said diaphragm to expand the diaphragm for bursting the sample at said circular area thereof and to prevent surge pressure against the diaphragm, a double-acting piston and cylinder air motor having a plunger acting on hydraulic fluid in said circuit to load said hydraulically actuated clamping device and said diaphragm sufficiently for preventing slippage of the sample during expansion of the diaphragm against the sample until the sample bursts, and a device for indicating the pressure of the fluid at the bursting point of the sample.

4. An automatic burst tester for conducting Mullen tests on paper and the like which comprises an apertured rigid plate for receiving the sample to be tested thereon over the aperture thereof, a hydraulic cylinder fixedly mounted above said plate, a piston slidable in said cylinder having a rod depending therefrom, a cup-shaped spider secured on said rod, a clamping ring depending from said spider having an aperture aligned with the aperture of said plate, a spring in said hydraulic cylinder acting on said piston to raise the clamping ring away from said plate, an inlet for hydraulic fluid in said cylinder above said piston for forcing the piston downwardly against said spring to lower the clamping ring in thrusting relation with said plate for clamping the sample to be tested therebetween, means providing a chamber for hydraulic fluid beneath said plate, a diaphragm in said chamber clamped around the periphery thereof and having an inverted cup-shaped portion adapted to be expanded through the apertures of said plate and clamping ring, means for purging air from said chamber, an adjustable metering valve for controlling the rate of hydraulic flow into said chamber under said diaphragm and to prevent surge pressure against said diaphragm, a source of hydraulic fluid, a closed hydraulic circuit connecting said source to said hydraulic cylinder and to said chamber a double-acting piston and cylinder air motor having a ram displacing hydraulic fluid from said source through said valve into said chamber and into said hydraulic cylinder for first loading the clamping ring against the sample being tested and for next expanding the diaphragm through the apertures of the plate and clamping ring for bursting the sample, a gauge indicating the pressure of the hydraulic fluid in said chamber to register the bursting point of the sample, an air control valve selectively feeding air under pressure to one side of the piston of the air motor while venting air from the opposite side to control displacement and return of hydraulic fluid from and to said source, a bypass valve through said metering valve accommodating free return of fluid from the chamber to the source, said spring in said hydraulic cylinder acting on the piston to return the fluid from the cylinder to the source upon release of pressure from the fluid, and said fluid acting in a closed circuit between said source, said chamber and said hydraulic cylinder.

5. The device of claim 1, including an adjustable pressure-regulating valve controlling the maximum fluid pressure in

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said fluid pressure-actuated means for clamping the sheet material.

6. A device according to claim 1, in which the fluid pressure-actuated means for clamping the sheet material includes a piston of larger diameter than the exposed area of the clamped sheet material so that the clamping load will be greater than the fluid pressure force developed for bursting the sheet material.

7. The burst tester of claim 2, wherein the valve for metering hydraulic fluid includes a free flow return valve.

8. The burst tester of claim 2, wherein the hydraulic device for loading the clamping ring includes a piston of larger diameter than the diameter of the plate aperture for develop-

ing a greater load on the clamping ring than is developed on the portion of the diaphragm adapted to be expanded through the plate aperture.

9. The burst tester of claim 2, including a pressure-regulating valve controlling maximum fluid pressure in the hydraulic loading device, and means for adjusting said valve to provide a clamping force of a predetermined magnitude.

10. The burst tester of claim 3, including a quick flow return valve around said metering means for return of the fluid from the diaphragm area to the source, a pressure-regulating valve between the source and the hydraulic clamping device, and a bypass valve around said pressure-regulating valve.

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