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[11] **3,889,687**

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[54] **SHUNT SYSTEM FOR THE TRANSPORT OF CEREBROSPINAL FLUID**

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[52] **U.S. Cl.**................ **128/350 V**; 128/274; 137/38
[51] **Int. Cl.**... **A61m 27/00**
[58] **Field of Search** .... 128/350 V, 274; 137/38

[56] **References Cited**

UNITED STATES PATENTS

2,703,582	3/1955	Stepanian	137/38
3,288,142	11/1966	Harim	128/350 V
3,769,982	11/1973	Schulte	128/350 V

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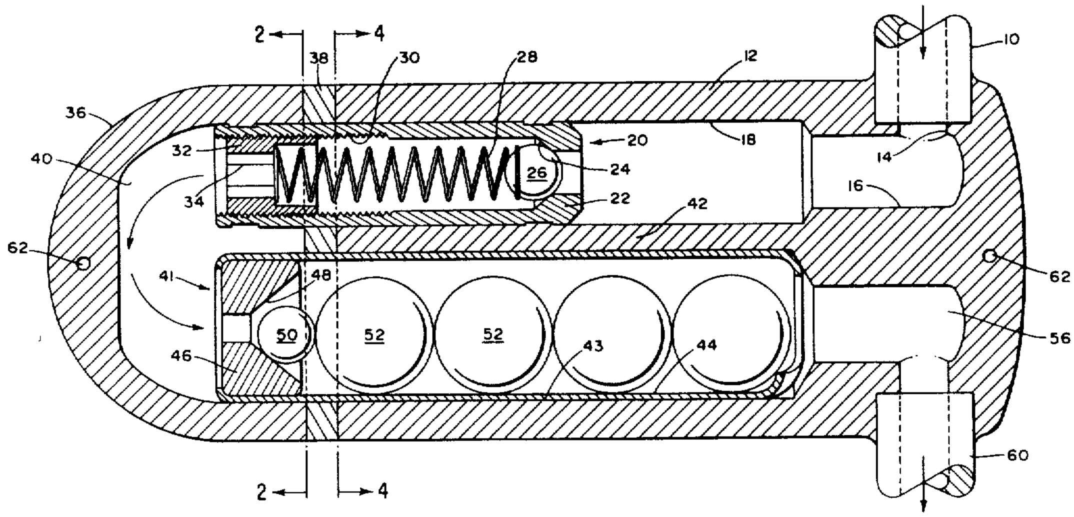
[57] **ABSTRACT**

A shunt system is disclosed for treating hydrocephalus by transporting cerebrospinal fluid from a source of such fluid to a selected site in the body of the patient, wherein the fluid is conducted through tubing in which a pressure-operated check valve is included, and connected in series with that valve is a second valve including gravity-operated means effective to urge the second valve to closed position until a higher pressure is reached when the patient is in substantially vertical position and to permit the valve to open freely when the patient is in substantially horizontal position, thus compensating for the pressure drop and consequent siphoning of fluid which would otherwise occur when the patient moves from horizontal to vertical position.

5 Claims, 1 Drawing Figure



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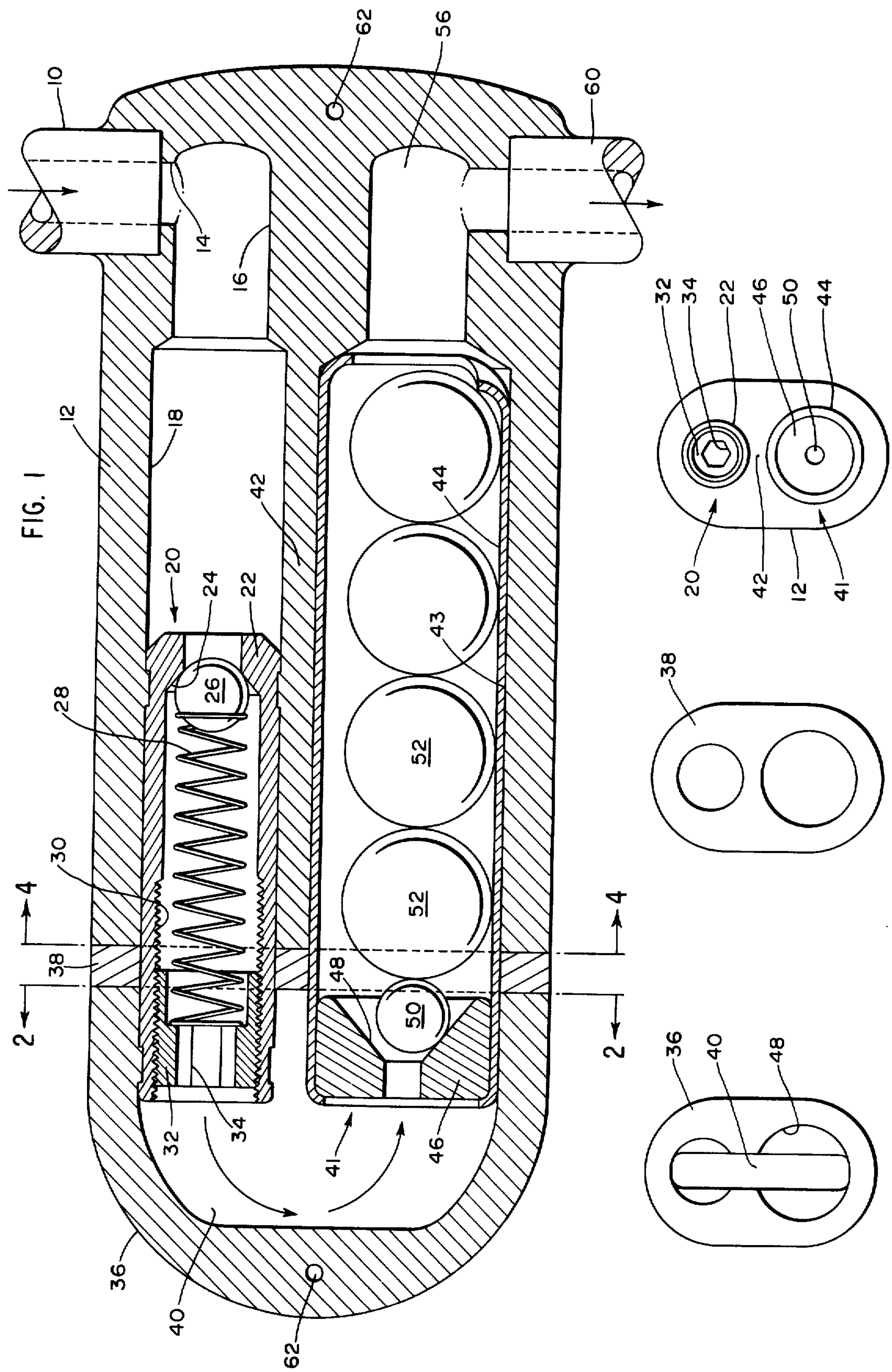

FIG. 1

FIG. 2

FIG. 3

FIG. 4

SHUNT SYSTEM FOR THE TRANSPORT OF CEREBROSPINAL FLUID

BACKGROUND OF THE INVENTION

In the treatment of hydrocephalus it has been customary to drain excess cerebrospinal fluid from one site in the body to another. For example, a catheter may be introduced into a ventricle within the brain and connected through a pressure-operated check valve to a cardiac catheter so that the fluid (CSF) is introduced into the blood stream. Alternatively, a catheter may be inserted into the body adjacent the spine and connected through a check valve to a catheter inserted in the peritoneal cavity. The latter is commonly termed a lumbar peritoneal shunt system and may be employed only upon patients afflicted with communicating hydrocephalus, in which the excess CSF is not confined to the cranium but is present in the region of the spine.

For general discussions of the nature and functions of shunt systems employed in the treatment of hydrocephalus the reader is referred to the following articles in medical journals:

"The Special Clinical Problem of Symptomatic Hydrocephalus with Normal Cerebrospinal Fluid Pressure — Observations on Cerebrospinal Fluid Hydrodynamics," S. Hakim and R. D. Adams, Journal of the Neurological Sciences (1965) Vol. 2, pp. 307–327.

"Biomechanics of Hydrocephalus," S. Hakim, Acta Neurol. Latinoamer. (1971) Suppl. 1, pp. 169–194.

"Initial Experience with the Hakim Valve for Ventriculovenous Shunt," Robert G. Ojemann, M.D., Journal of Neurosurgery (1968) Vol. XXVIII, No. 3, pp. 283–287.

"Hydraulic and Mechanical Mis-matching of Valve Shunts Used in the Treatment of Hydrocephalus: the Need for a Servo-valve Shunt," Salomon Hakim, Developmental Medicine and Child Neurology, Vol. 15 (1973), pp. 646–653.

"A Critical Analysis of Valve Shunts Used in the Treatment of Hydrocephalus," S. Hakim, F. Duran de la Roche, and J. D. Burton, Developmental Medicine and Child Neurology, Vol. 15, No. 2 (Apr. 1973), pp. 230–255.

Shunt systems of this general sort are disclosed in U.S. Pat. Nos. 3,288,142 and 3,527,226 granted November 1966 and September 1970 to Salomon D. Hakim, to which the reader is referred for information concerning the valves and their functions. Shunt systems heretofore employed have not satisfactorily solved a problem brought about by the pressure drop which results when the patient shifts from substantially horizontal to substantially vertical position. The check valves normally include a spring action to keep the valves closed until the CSF pressure rises to a predetermined pressure setting of the valve. However, in the case of a patient fitted with a lumbar peritoneal shunt system the hydrostatic head, working upon the check valve, increases abruptly when he moves from horizontal to vertical position, and the pressure increase causes the valve to open. The result is excessive rate of drainage. A similar rate of drainage change is caused by the length of the drainage tubing on a ventricular atrial or ventricular peritoneal shunt system as the patient moves from horizontal to vertical.

BRIEF SUMMARY OF THE INVENTION

To overcome the problem just referred to we provide a second valve connected in series with the first valve and including means operated by gravity for urging the valve to closed position and operable at a higher pressure when the patient is substantially vertical. Consequently the CSF pressure required to produce drainage is automatically increased by an amount very close to the increase in the hydrostatic head or negative siphoning pressure when the patient rises from the horizontal.

DESCRIPTION OF THE DRAWING

These and other objects and features of the invention will more readily be understood and appreciated from the following detailed description of a preferred embodiment thereof selected for purposes of illustration and shown in the accompanying drawing, in which:

FIG. **1** is a view in longitudinal cross-section through the valve structure of a lumbar peritoneal shunt system constructed in accordance with my invention,

FIG. **2** is a view in end elevation of the cap portion of the valve casing from the locus suggested by the line **2—2** of FIG. **1**,

FIG. **3** is a view in side elevation of the color coded gasket, and

FIG. **4** is a view in end elevation of the casing and two valves from the locus suggested generally by the line **4—4** of FIG. **1**.

DETAILED DESCRIPTION OF AN EMBODIMENT OF THE INVENTION

The shunt system shown in the drawing is organized about a valve casing **12** conveniently molded from resilient plastic tissue compatible material, such as silastic rubber, in the shape of an elongated lozenge having at one end a chamber **16** communicating with an inlet port **14** adapted for the reception of a hollow plastic tissue compatible tube **10** adapted for connection to a catheter inserted in the region of the spine or other location in the body of the patient from which cerebral spinal fluid (CSF) is to be taken. Communicating with the chamber **16** is an elongated socket **18** of circular cross-section adapted to receive a check valve **20.** The valve **20** includes a hollow cylindrical casing **22,** preferably of stainless steel, snapped into the socket **18** and provided internally with a valve seat **24** dimensioned to cooperate with a saphire ball **26** urged against the valve seat by means of a compression spring **28** held in place by an externally threaded hollow plug **32** received in threads **30** on the interior of the valve casing **22** and provided at its outer end with a socket **34** for reception of an Allen wrench. Consequently the plug may be translated axially within the casing **22** to adjust the pressure of the spring against the ball **26**; this arrangement permits the manufacturer to pre-set the pressure at which the valve opens and the attending physician to change the pre-set pressure with a hypodermic needle after implant if he so desires.

The valve casing **22** extends outwardly beyond the end of the casing **12,** and a gasket **38** fits over a portion of the exposed casing **22.** The gasket **38** may be colored according to a preselected code in order to indicate the pressure at which one or both of the valves in the casing **12** will be opened. A resilient plastic cap **36** mates with the gasket **38** to complete the valve casing, and the casing **12,** the gasket **38,** and the cap **36** may be held together by any suitable adhesive. The cap **36** is provided with a chamber **40** communicating with the passage in the plug **32** and also with a second valve **41** received in a socket **43** formed in the valve casing **12** and parallel to the socket **18**. In effect the sockets **18** and **43** are separated by an interior wall **42**. The valve **41** includes a casing **44** fitting snugly within the socket **43** and housing a hollow plug **46** having a tapered recess **48** forming a valve seat for a saphire ball **50**. Also contained within the casing **44** is a plurality of balls **52** somewhat larger than the ball **50** and serving as weights. The outlet end of the casing **44** is crimped inwardly to retain the balls in position. The arrangement is such that when the valve is horizontal, as shown in FIG. **1** the balls **52** are free to roll away from the valve seat **48**, thus permitting the ball **50** to unseat itself and open for passage of CSF. However, when the valve is substantially vertical, the balls **52** operate by gravity to press the ball **50** into engagement with its valve seat **48**. In the vertical position, therefore, more pressure is required to cause flow of CSF through the valve system. We contemplate the provision of valves incorporating different numbers of the balls **52** so that the operating pressure for opening the valve can be selected for the particular circumstances of a given patient. The color coding of the gasket **38** provides a simple means of indicating the operating pressure of a given system, and the adjustment of the plug **32** provides for fine adjustment of the operating pressure.

The casing **12** is also provided with an outlet chamber **56** communicating with a length of hollow tubing **60** which may be connected to a suitable drainage site within the patient.

The shunt system of my invention can conveniently be utilized as a lumbar peritoneal shunt where CSF is to be transported from a region adjacent the spine to the peritoneal cavity. However, the same system can also be used as ventricular shunt for implantation under the scalp and employed in connection with catheters inserted into a ventricle and into any convenient drainage site. The casing **12** and the cap **36** are provided with apertures **62** so that the valve structure can be anchored by sutures in such a position that it is horizontal when the patient is horizontal and vertical when the patient is also vertical.

It will now be seen that the valve **20** is always operating in response to the pre-selected operating pressure, while the valve **41** operates at a higher pressure when the patient is vertical and is open when the patient assumes a substantially horizontal position. In the case of the lumbar peritoneal shunt system there is an abrupt increase in pressure on the valves due to the added hydrostatic head exhibited when the patient moves from horizontal to vertical position. When the shunt system is implanted beneath the scalp, the rise from horizontal

to vertical position results in an abrupt pressure drop on the outlet side of the valves, but in either case the balls **52** function to compensate for the changes.

We claim:

1. A shunt system for transporting cerebrospinal fluid from a source of such fluid within the body to a selected site within the body, comprising tubing for connection to the source of fluid, a pressure-operated check valve connected to said tubing, a second valve connected in series to the check valve, separate means connected with said second valve and responsive to the force of gravity for causing said second valve to open at a higher pressure when the valve is substantially vertical and permitting the valve to open freely when the valve is substantially horizontal, and tubing connected in series with said second valve for connection to a site in the body to which the fluid is to be transported.

2. A shunt system for draining excess cerebrospinal fluid, comprising tubing for connection to a source of cerebrospinal fluid, a valve casing, a first pressure-operated check valve disposed in said casing, and a second valve disposed in said casing and connected in series with said first valve; said second valve including a valve seat, a first ball in said casing dimensioned to rest either on said seat or displaced from said seat, at least one other ball disposed in said casing in position to bear upon said first ball when the valve casing is in vertical position and free to roll in said casing when the valve casing is in horizontal position; and tubing connected in series with said second valve for connection to a site within the body to which the fluid is to be transported, whereby the valve casing may be so mounted in the body that only the first valve operates in response to an increase in pressure when the patient is in horizontal position but both valves open under an increase in pressure when the patient is in vertical position.

3. A shunt system for draining excess cerebrospinal fluid from a source of such fluid within the body to a selected site within the body, comprising tubing for connection to the source of fluid, a casing, a check valve disposed within said casing and connected to said tubing; a second valve disposed within said casing and including a valve seat, a ball cooperating with said valve seat, and at least one weight disposed adjacent said ball in position to bear upon the ball when the valve is in substantially vertical position and free to move away from the ball when the valve is in substantially horizontal position, said valves being connected in series, and tubing connected to the discharge side of said second valve.

4. The shunt system defined in claim **1** wherein said means comprises at least one ball.

5. The shunt system defined in claim **3** wherein the weight is a ball.

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