NBS TECHNICAL NOTE

295

DISCLOSURES ON:

A Transrotor Engine, High Temperature Platinum Resistance Thermometer, Dynamic Analog Correlation System, and Combination Metering and Safety Valve for Filling Sonde Ballons With Hydrogen

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards

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UNITED STATES DEPARTMENT OF COMMERCE • John T. Connor, Secretary
NATIONAL BUREAU OF STANDARDS • A. V. Astin, Director

TECHNICAL NOTE 295

ISSUED OCTOBER 21, 1966

DISCLOSURES ON:

A Transrotor Engine, High Temperature Platinum Resistance Thermometer, Dynamic Analog Correlation System, and Combination Metering and Safety Valve for Filling Sonde Ballons With Hydrogen

Editors: David Robbins and Alvin J. Englert

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This booklet presents descriptions and drawings of four devices, embodying interesting and unusual solutions to problems frequently encountered in their respective fields: a transrotor engine, a dynamic analog correlation system, a high temperature platinum resistance thermometer, and a combination metering and safety valve for filling sonde balloons with hydrogen.

Other disclosures on various subjects may be found in NBS Technical Notes 237, 253, 263, 282 and 287.

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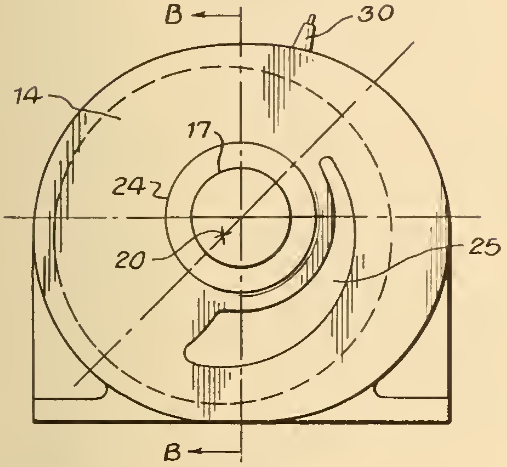
Tech. Note No. 295, October 14, 1966

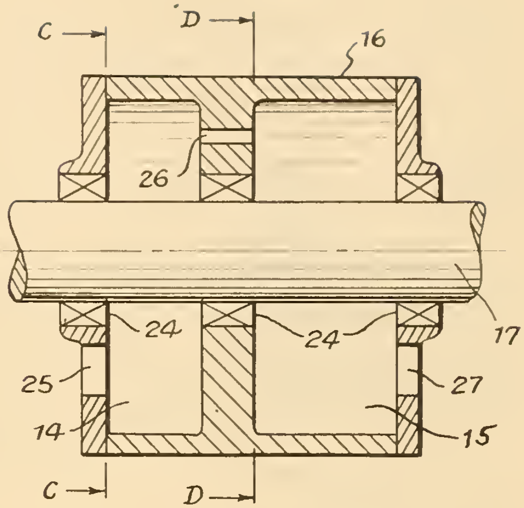
A TRANSROTOR ENGINE

Seymour Henig



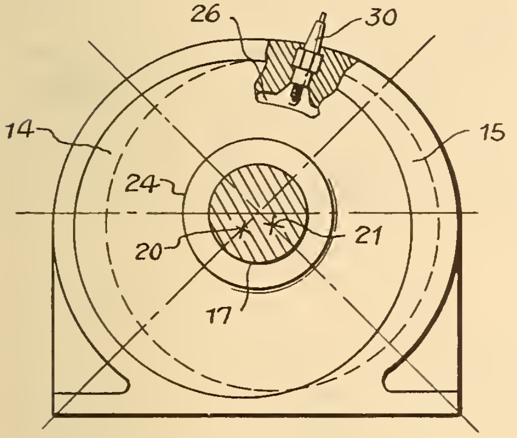
VIEW A

Fig. 2



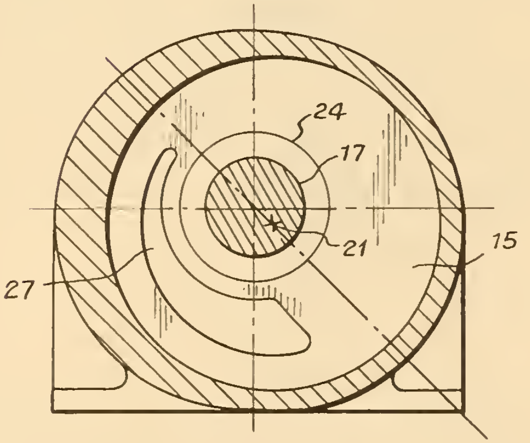
SECTION B-B

Fig. 1



SECTION C-C

Fig. 4



SECTION D-D

Fig. 3

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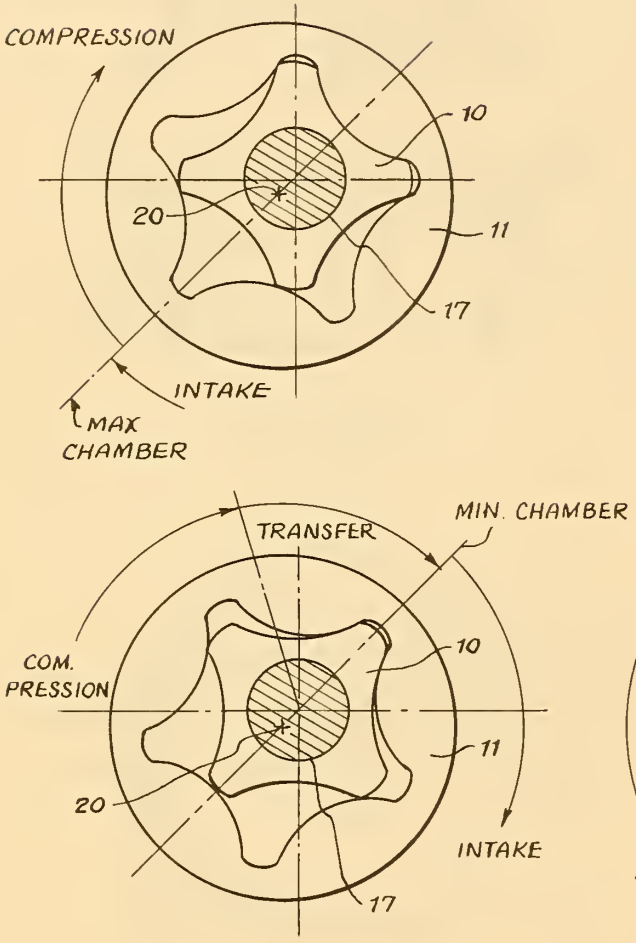
COMPRESSION
10
20
11
17
INTAKE
MAX CHAMBER
TRANSFER
MIN. CHAMBER -
COM. PRESSION
10
11
20
INTAKE
17

Fig. 5

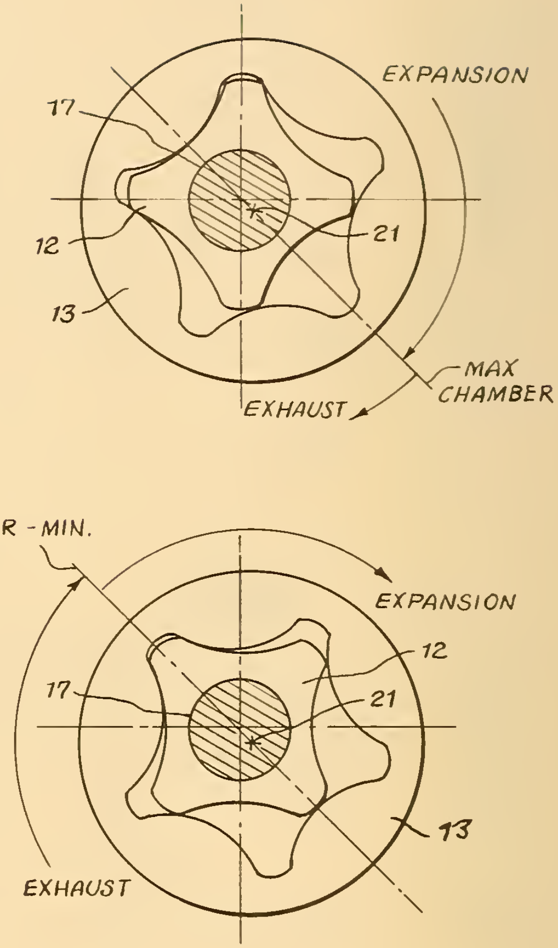
17
EXPANSION
12
21
13
MAX CHAMBER
EXHAUST
MIN.
EXPANSION
12
17
21
13
EXHAUST

Fig. 6

A TRANSROTOR ENGINE

Seymour Henig *

This note describes an engine of inherent rotational balance which retains the operating characteristics of a four-stroke cycle internal combustion reciprocating engine. Sine the kinematics of the engine's mechanism feature simple rotation, with the absence of reciprocation, it may be considered to operate on a four-phase cycle.

The engine employs two sets of gerotor components 10, 11 (Fig. 5) and 12, 13 (Fig. 6) that are positioned in circular cavities 14 and 15, respectively, in engine block 16 (Fig. 1). The inner gerotor components 10 and 12 are keyed to a common shaft 17, but to simplify the drawings the two sets of gerotor components are shown separate from their cavities. Each set is shown in two positions of rotation to show the phase-limit chamber size relationship.

Each inner rotor component 10 and 12 rotates on an axis coincident with the axis of rotation of output shaft 17. The axis of rotation of the outer gerotor components 11 and 13 are designated as 20 and 21, respectively, (Fig. 4) and are located on the center axis of their related cavities. Relative to the center of the output shaft, the axes of the outer gerotor components are displaced 90° from each other. This 90° angular displacement is illustrative and not a requirement.

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[*] All rights in the engine described in this Note have been retained by Seymour Henig, subject to a nonexclusive, irrevocable, royalty-free license to the Government with power to grant licenses for all governmental purposes.

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Spark plug 30 is mounted so that its electrodes have access to transfer passageway 26. Seal bearings 24 are shown symbolically.

A combustible mixture is fed to inlet port 25 (Fig. 2) by a conventional arrangement such as a carburetor, not shown. Rotation of shaft 17 causes the fuel-air mixture to be drawn through the port into an enlarging chamber formed by opposing tooth spaces of gerotor components 10 and 11 (Fig. 5). The chamber attains maximum volume after 180° of rotation where the inlet port and the intake phase end. Further rotation causes this chamber, in traversing the next sector, to reduce in volume. Because there is no vent in this sector of cavity 14, the combustible mixture is compressed. The compression phase ends after the chamber travels some degrees less than 360°, where, nearing its minimum volume, it reaches arcuate passageway 26 and is vented through to cavity 15. Coincidentally, a chamber formed by gerotor components 12 and 13 starts to enlarge at the passageway from which the charge is received.

The charge is fired by spark plug 30 approximately at the time of the compression chamber's minimum volume. Spark synchronization is not critical since some of each compressed charge remains in passageway 26 in a state of combustion and serves as a pilot to ignite the next charge.

Passageway 26 is positioned so as to be closed on the entry side by the trailing tooth of gerotor component 11, which has bounded the compression chamber before the latter's reaching minimum volume. As combustion proceeds, and tends to increase the charge's pressure, it is relieved on the exit side of the passageway to the opening chamber formed by gerotor components 12 and 13. This is the start of the expansion phase (Fig. 6) which continues until the chamber reaches the point of maximum enlargement after about 180° of rotation. Here the chamber starts venting at the beginning of the exhaust port 27 (Fig. 3). The exhaust phase proceeds while the chamber is reducing for approximately the 180° remainder of this rotational cycle.

In this way, a four-phase cycle for each charge is completed after two revolutions. Each phase is performed in an approximate 180° increment; intake and compression in a chamber bound by gerotor components 11 and 12, and expansion and exhaust in a cooperating chamber bound by gerotor components 12 and 13.

HIGH TEMPERATURE PLATINUM RESISTANCE THERMOMETER

Leslie A. Guildner
Richard L. Anderson

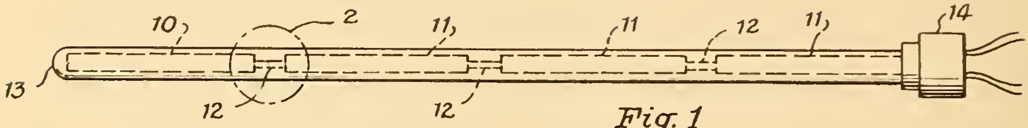


Fig. 1

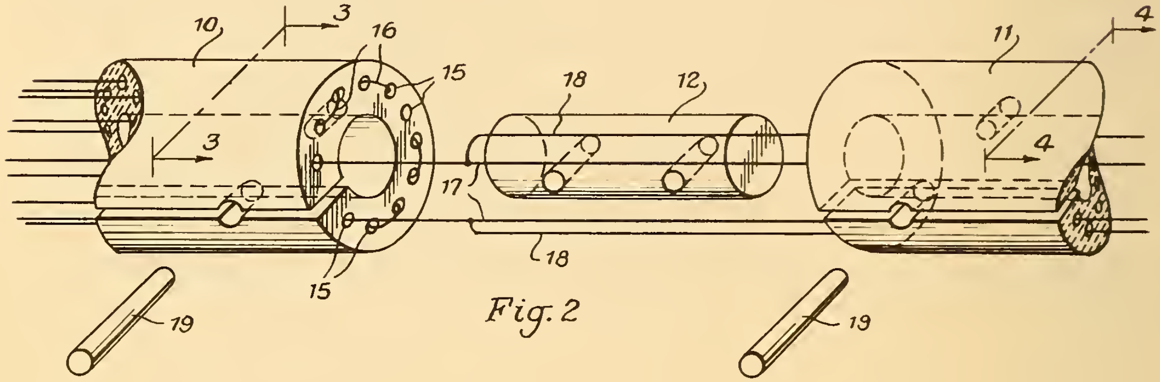
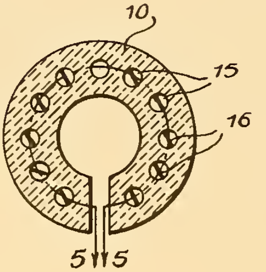


Fig. 2

Fig. 3



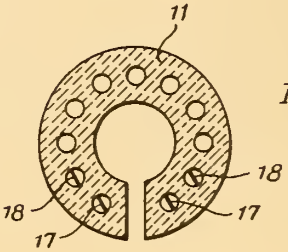
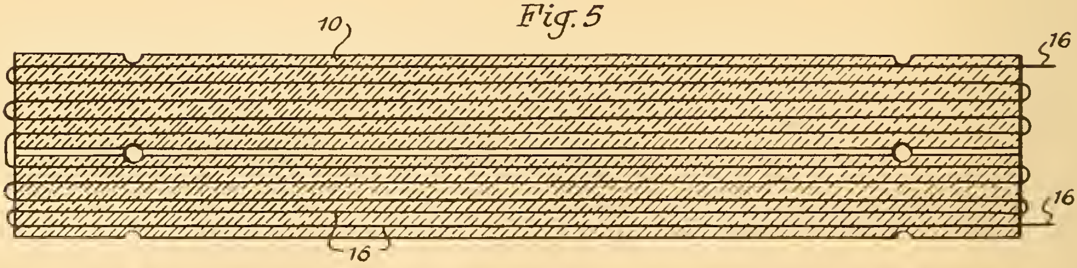


Fig. 4

Fig. 5



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HIGH TEMPERATURE PLATINUM RESISTANCE THERMOMETER

Leslie A. Guildner
Richard L. Anderson

This is a high precision platinum resistance thermometer capable of operating above the upper temperature limit (approximately 630°C) of conventional platinum resistance thermometers.

As shown in Fig. 1, the thermometer comprises a coil form 10, a plurality of insulators 11 and links 12, a sheath 13, and header 14.

The coil form 10, shown in detail in Figs. 2, 3, and 5, is a tubular ceramic member of "C"-shaped cross section. A plurality of longitudinally-extending holes 15 are provided in the form 10, and a platinum wire 16 is loosely threaded through the holes 15 from one end of the "C" to the other end thereof. By this design, the platinum wire 16 is supported in a strain-free manner within a small space, and the ends of the wire 16, where the largest voltage drop occurs, are well-insulated from each other by the gap or break in the "C"-shaped form 10.

The ceramic material employed for the form 10 should have the following characteristics at elevated temperatures (above 630°C). The resistivity of the ceramic should be high to provide good electrical insulation between adjacent parallel portions of the wire 16, and between the wire 16 and sheath 13; the dimensional stability of the ceramic should be high to avoid stretching the wire 16; the thermal conductivity and thermal diffusivity of the ceramic should be high to minimize temperature gradients along the wire 16 and to minimize the time required to attain a steady state with respect to the surroundings; and, the material should not contaminate the platinum wire 16, nor require the presence of oxygen to prevent contamination thereof. This combination of characteristics is approached in sintered high-purity beryllium oxide, which is the preferred material for constructing the form 10.

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Referring again to Fig. 2, it will be seen that the ends of the platinum wire 16 are each connected to two leads 17, 18 (the current and potential leads) in the conventional manner. These leads 17, 18 are carried by the insulator 11, which advantageously is identical to the coil form 10. As shown in Fig. 4, the leads 17 and 18 are disposed in pairs of holes on opposite sides of the air gap in the insulator, to obtain the maximum electrical insulation between the two pairs of leads.

The coil form 10 and insulator 11 are connected by a link 12, Fig. 2, comprising a rod of a low thermal conductivity ceramic material, such as sintered high-purity aluminum oxide. The use of such a material for the link 12 minimizes the conduction of heat along the axis of the thermometer, Fig. 1. To attach the link 12 to the members 10 and 11, there are provided two ceramic pins 19 which extend through matching transverse holes in the members 10, 11 and the link 12.

From the foregoing it will be seen that this thermometer is easily assembled using units of only three ceramic parts, namely, the "C"-shaped members (10 or 11), the links 12 and pins 19. These elements are linked together to form an assembly of any desired length, with the assembly having sufficiently flexibility to avoid fracturing of the ceramics upon slight bending of the sheath 13, Fig. 1. The selected ceramic materials and shapes thereof are such that the thermometer has favorable electrical and thermal behaviors.

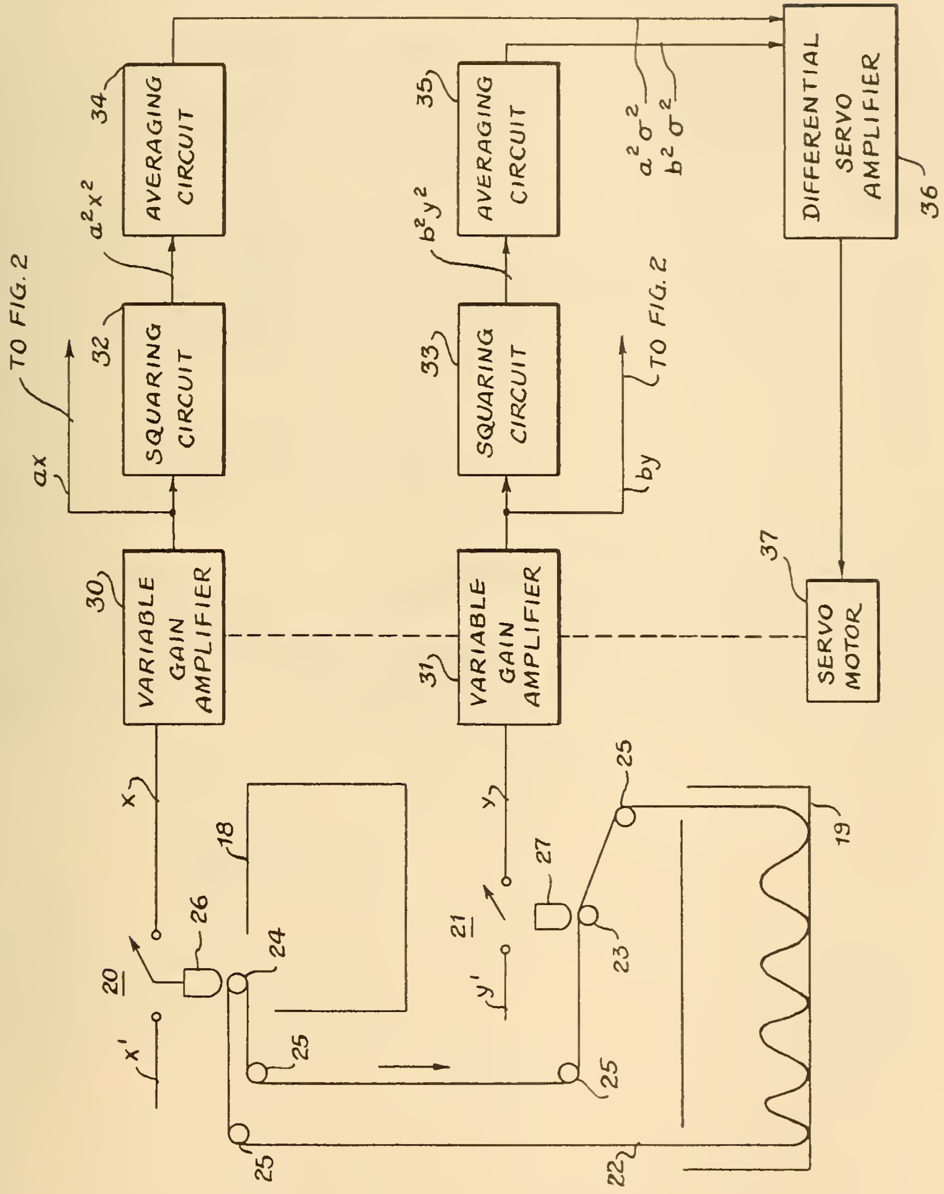
TO FIG. 2
ax
SQUARING CIRCUIT
32
a²x²
AVERAGING CIRCUIT
34
VARIABLE GAIN AMPLIFIER
30
x
x'
20
26
24
18
25
25
25
y'
21
y
27
23
25
22
19
VARIABLE GAIN AMPLIFIER
31
by
TO FIG. 2
SQUARING CIRCUIT
33
b²y²
AVERAGING CIRCUIT
35
a²σ²
b²σ²
DIFFERENTIAL SERVO AMPLIFIER
36
SERVO MOTOR
37

Fig. 1

DYNAMIC ANALOG CORRELATION SYSTEM

Robert W. Hubbard

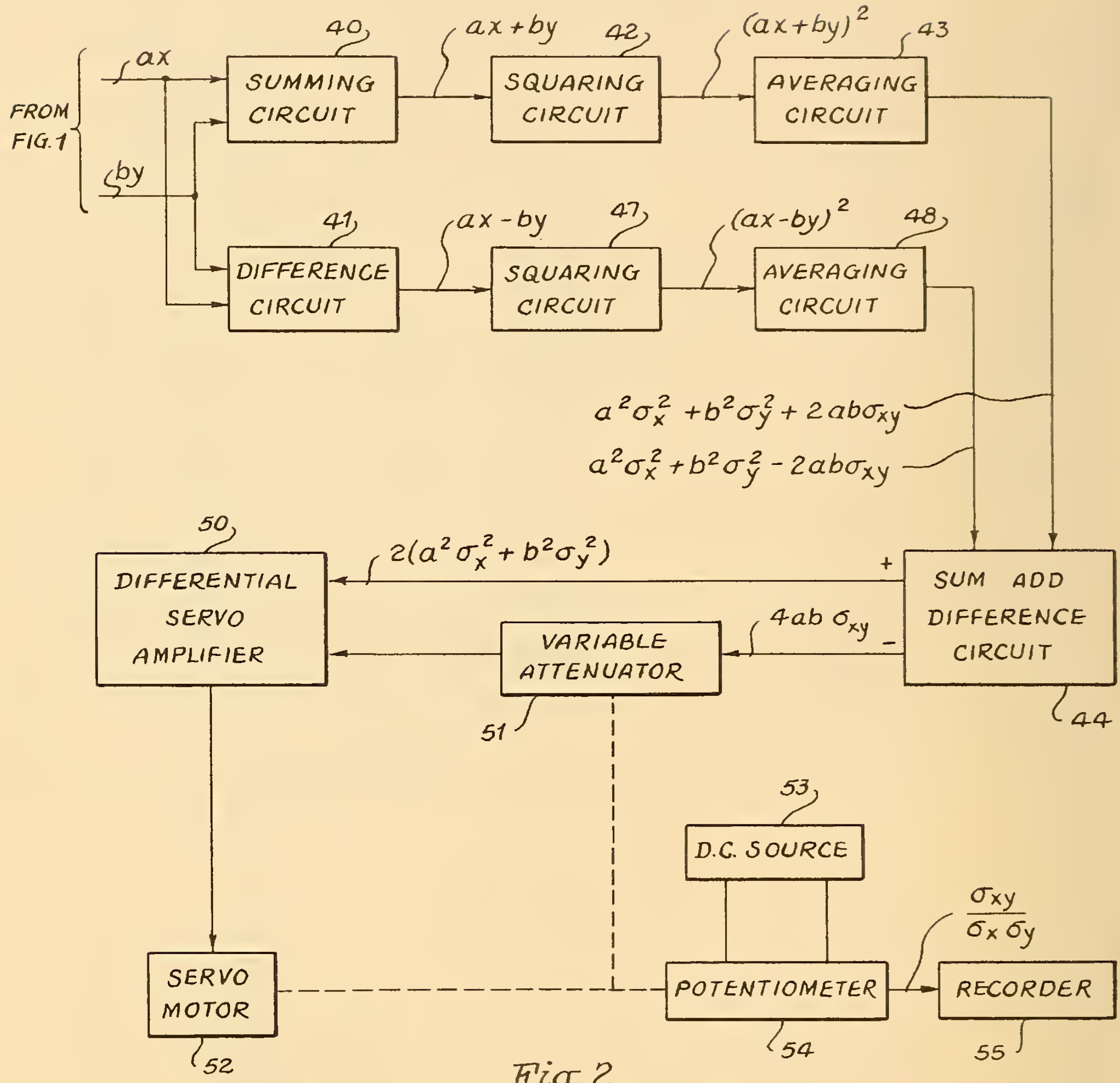

Fig. 2

DYNAMIC ANALOG CORRELATION SYSTEM

Robert W. Hubbard

This system may be used to obtain the correlation between two time-varying signals. This relationship is found continuously and is normalized automatically.

Consider two random or periodic signals, both functions of time, x(t) and y(t) and both mean zero signals Let σ_x^2 and σ_y^2 represent the variances of x and y, respectively, and σ_x and σ_y the standard deviations. Then, the variance of the difference of x and y and the variance of their sum are as follows:

$$\sigma_{x-y}^2 = \sigma_x^2 + \sigma_y^2 - 2\rho\,\sigma_x\sigma_y \qquad (1)$$

$$\sigma_{x+y}^2 = \sigma_x^2 + \sigma_y^2 + 2\rho\,\sigma_x\sigma_y \qquad (2)$$

where

$$\rho \equiv \frac{\sigma_{xy}}{\sigma_x\sigma_y}\ ; \text{ correlation coefficient.}$$

The sum and difference of the variances in equations (1) and (2) are:

$$(\sigma_x^2 + y) + (\sigma^2\ x-y) = 2(\sigma_x^2 + \sigma_y^2) \qquad (3)$$

$$(\sigma_{x+y}^2) - (\sigma_{x-y}^2) = 4\rho\sigma_x\sigma_y = 4\sigma_{xy}\,. \qquad (4)$$

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If the two signals x(t) and y(t) have the property $\sigma_x^2 = \sigma_y^2$ over the averaging period of interest, then (3) becomes

$$2(\sigma_x^2 + \sigma_y^2) = 4\sigma_x\sigma_y \qquad (5)$$

and the ratio of equations (4) and (5) yield the desired correlation coefficient

$$\frac{4\sigma_{xy}}{4\sigma_x\sigma_y} = \rho \, . \qquad (6)$$

In the present system, the variances of x and y are computed and a servo loop is used to hold the variances equal over a selected averaging period. Signals ax and by, where a and b are amplification factors, are derived from the latter loop and are used to obtain the relationships expressed in equations (3) and (4). A self-balancing servo loop is then employed to compute the ratio of equations (4) and (5). Thus, a signal that represents the correlation coefficient (ρ) is obtained, and is recorded in analog form.

The function (ρ) may thus be computed and recorded as a function of time (t) with fixed time lag (τ), or as a continuous function of (τ) for fixed data sample lengths. A dynamic time lag is translated to the computer through the use of a special magnetic tape transport mechanism.

With reference to Fig. 1, the time lag storage bin and the main storage bin are indicated by 18 and 19, respectively. During recording the arms of switches 20 and 21 are thrown to the left in Fig. 1, and magnetic tape 22 is driven by capstan 23 and is guided by capstan 24 and rollers 25 past read-record heads 26 and 27. The signals to be correlated, signals x' and y', are then recorded simultaneously on separate channels of tape 22. During play-back the arms of switches 20 and 21 are thrown to the right, the magnetic tape is driven by capstans 23 and 24, and heads 26 and 27 generate signals x and y, respectively. This arrangement is used to introduce a dynamic time lag of signal y with respect to signal x. When the magnetic tape is taut the time lag is zero, and when capstan 23 is driven at a slower speed than capstan 24 the tape piles up in container 18 and the time lag increases linearly with time.

Signals x and y are applied to the variable gain operational amplifiers 30 and 31 whose outputs are fed to squaring circuits 32 and 33 to obtain signals a^2x^2 and b^2y^2. The latter signals are transmitted through averaging circuits 34 and 35, developing signals $a^2\sigma_x^2$ and $b^2\sigma_x^2$, which are applied to differential servo amplifier 36. The output of this amplifier controls servo motor 37 which in turn controls the gain of amplifiers 30 and 31 in such a manner that $a^2\sigma_x^2$ is maintained equal to $b^2\sigma_y^2$ over the averaging period selected for circuits 34 and 35. It should be noted that $a^2\sigma_x^2$ and $b^2\sigma_y^2$ are equal to the variances of signals ax and by, respectively.

Signals ax and by, developed by amplifiers 30 and 31, are applied to summing circuit 40 and difference circuit 41 in Fig. 2. Signal $ax + by$, the output of circuit 40, is sent through squaring circuit 42 to generate signal $(ax + by)^2$, which is applied to averaging circuit 43. The output of the latter circuit is signal $a^2\sigma_x^2 + b^2\sigma_y^2 + 2ab\sigma_{xy}$ and is applied to the sum and difference circuit 44. Likewise, signal $(ax - by)$ appears in the output of difference circuit 41 and is transmitted through squaring circuit 47 to develop signal $(ax - by)^2$, which is applied to averaging circuit 48. The latter circuit develops signals $a^2\sigma_x^2 + b^2\sigma_y^2 - 2ab\sigma_{xy}$, which is sent to circuit 44.

The sum and difference circuit 44 provides a sum signal $2(a^2\sigma_x^2 + b^2\sigma_y^2)$, that is fed to differential servo amplifier 50 and a difference signal $4ab\sigma_{xy}$, that is fed to variable attenuator 51. The gain of the attenuator is $1/K$. The output of amplifier 50 is applied to servo motor 52 which controls the shaft of attenuator 51 in such a way that the sum and difference output signals of circuit 44 are maintained equal. Hence

$$1/K\,(4ab\sigma_{xy}) = 2(a^2\sigma_x^2 + b^2\sigma_y^2).$$

Since

$$a^2\sigma_x^2 = b^2\sigma_y^2$$

$$1/K(4ab\sigma_{xy}) = 2(2\,a^2\sigma_x^2) = 4(a\sigma_x \cdot a\sigma_x) = 4\,ab\sigma_x\sigma_y$$

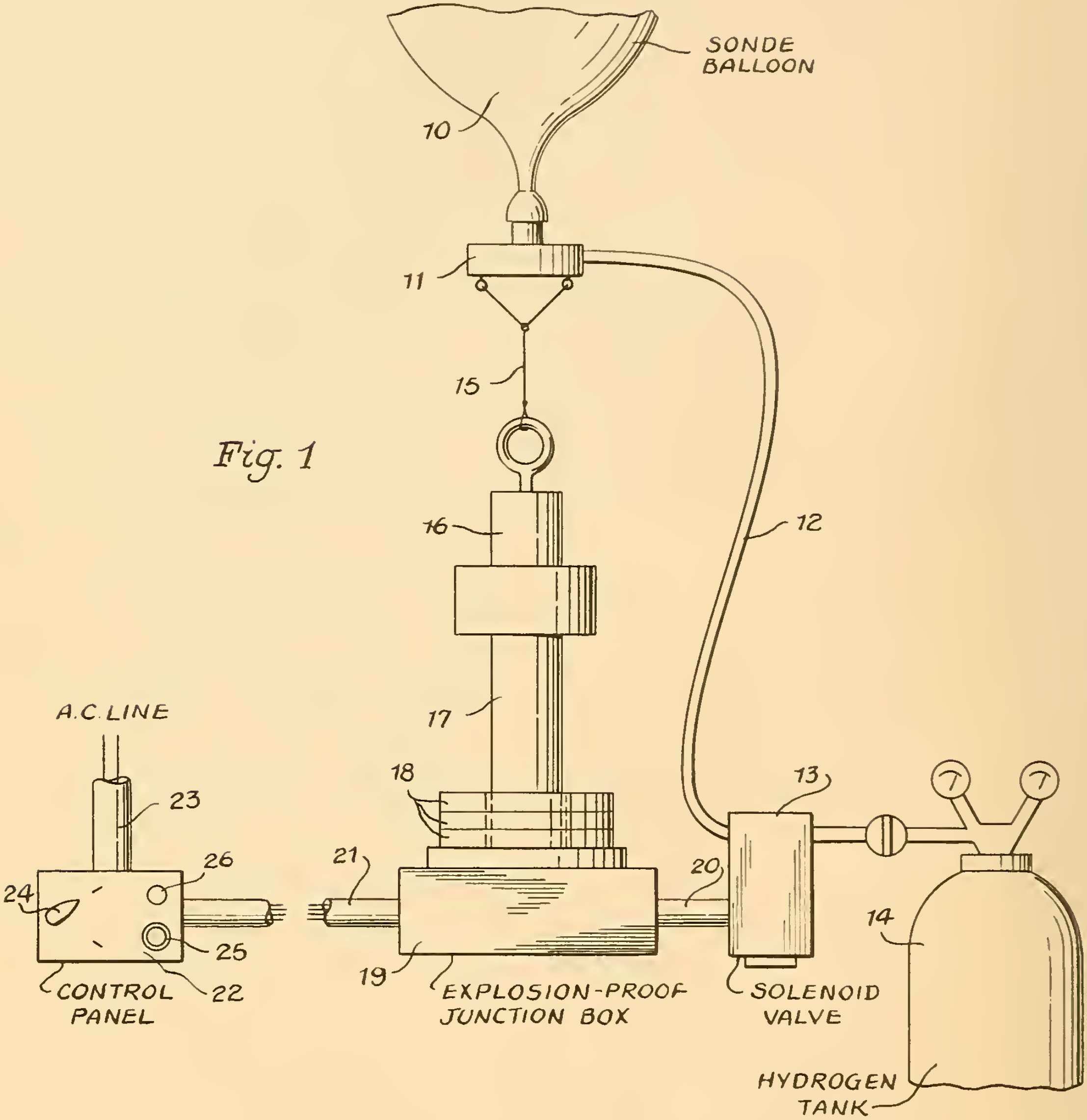
$$K = \frac{\sigma_{xy}}{\sigma_x\sigma_y} = \rho.$$

D. C. source 53 is connected across center-tapped potentiometer 54. Servo motor 52 controls the arm of the potentiometer to generate a signal across the arm to ground that has a magnitude dependent upon the value of K. The latter signal, representing the correlation coefficient, is recorded as a function of time by means of recorder 55.

COMBINATION METERING AND SAFETY VALVE FOR FILLING SONDE BALLOONS WITH HYDROGEN

William W. Richardson

Fig. 1



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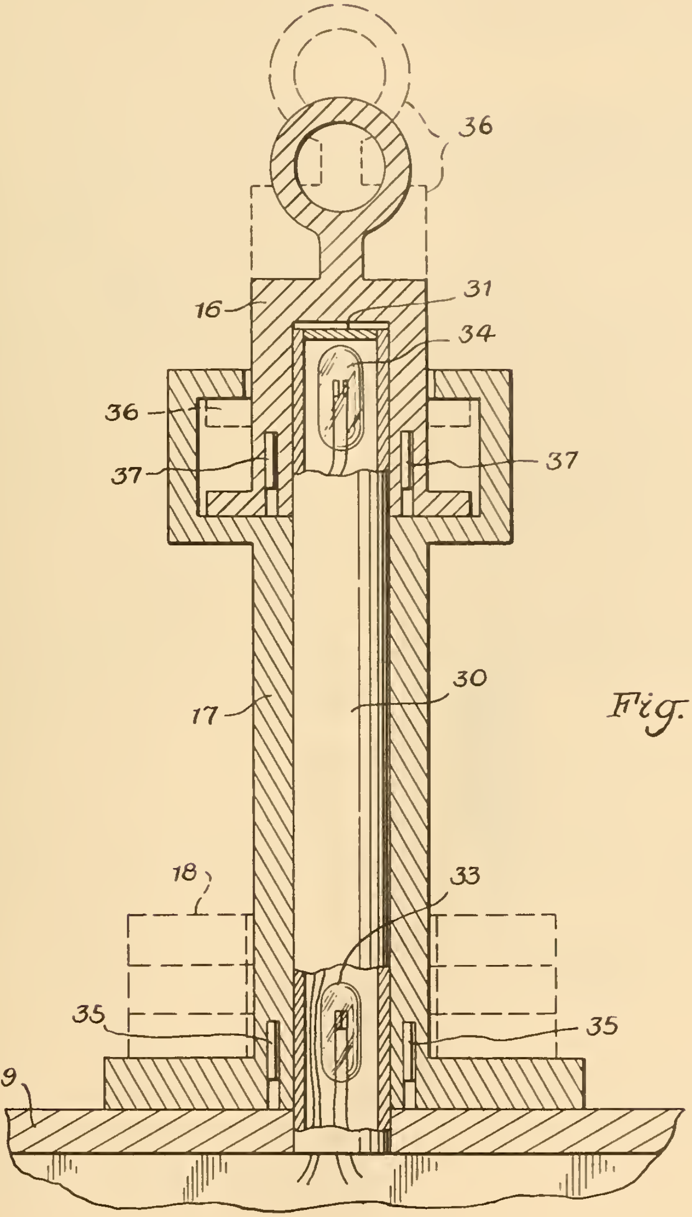

Fig. 2

COMBINATION METERING AND SAFETY VALVE FOR FILLING SONDE BALLOONS WITH HYDROGEN

William M. Richardson

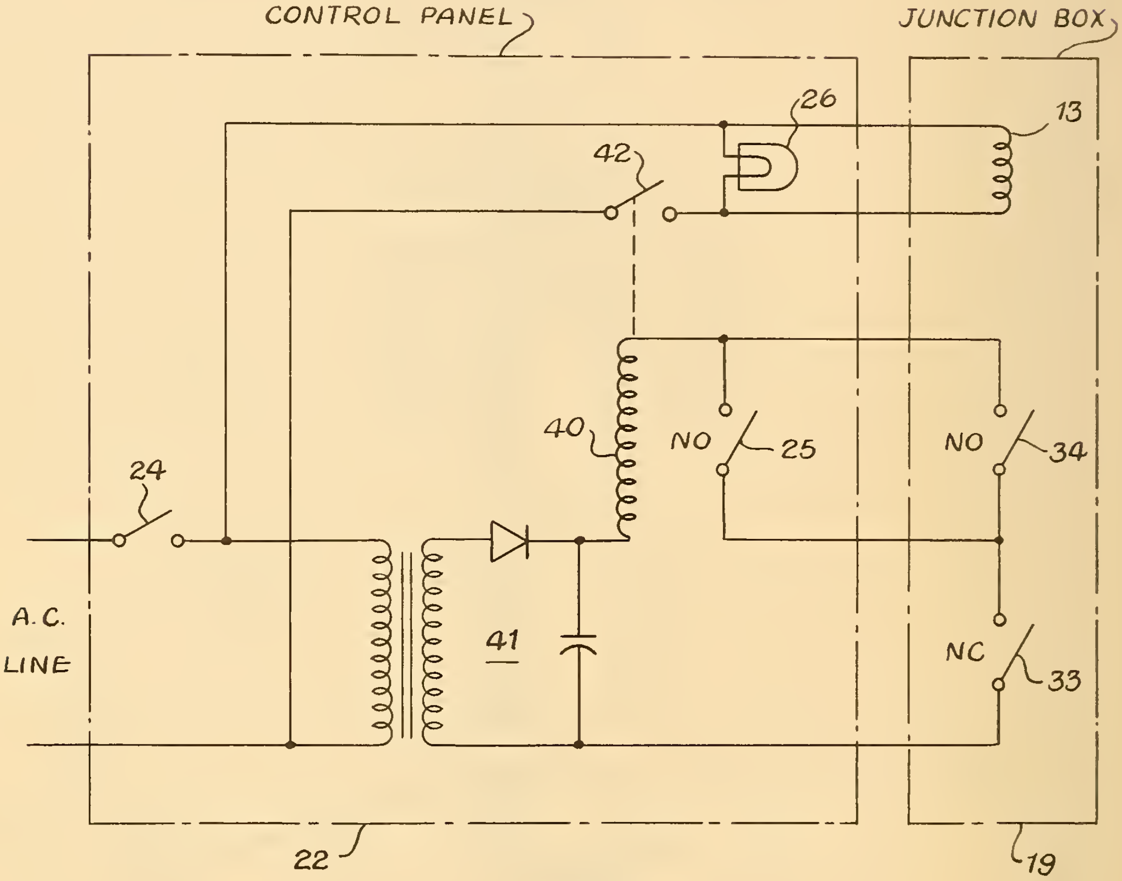

Fig. 3

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COMBINATION METERING AND SAFETY VALVE FOR FILLING SONDE BALLOONS WITH HYDROGEN

William M. Richardson

This valve automatically meters a predetermined amount of hydrogen gas to a sonde balloon, and interrupts the flow in the event that the balloon bursts before filling.

In Fig. 1, the sonde balloon 10 to be filled with hydrogen is attached to a filling nozzle 11 which is connected by a flexible tube 12 and solenoid-operated, explosion-proof valve 13 to a tank 14 of hydrogen gas. The nozzle 11 is physically restrained by a cord 15 that is tied to a short column 16. This short column 16 telescopically slides within a longer column 17 carrying a selected number of weights 18. As will be described below, the movement of the columns 16 and 17 operates electrical switches which are brought out to an explosion-proof junction box 19. The junction box 19 is connected by explosion-proof conduits 20 and 21 to the solenoid valve 13, and to a control panel 22 located in a remote bunker. The control panel 22 is connected to an ac power line by a conduit 23, and has an on-off switch 24, a push-button switch 25 and indicator light 26.

As shown in Fig. 2, the columns 16 and 17 are each coaxially disposed on a tube 30 that projects from the junction box 19. The tube 30 is sealed at its upper end 31, and contains two magnetically-operated reed switches 33 and 34. The contacts of the lower reed switch 33 are normally held closed by a pair of permanent magnets 35 that are fitted into holes drilled into the long column 17. The contacts of the upper reed switch 34 are normally open, and are closed when the short column 16 is lifted, as indicated by the dashed lines 36, causing a pair of permanent magnets 37 disposed in the column 16 to assume positions adjacent the reed switch 34.

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Referring to Fig. 3, it will be seen that the switches 33 and 34 are connected in series with a relay coil 40 and a low voltage dc source 41. The contacts 42 of the relay 40 serve to close the solenoid coil 13 across the ac input line, and thereby open the solenoid valve and allow hydrogen from tank 14 (Fig. 1) to flow to the sonde balloon 10.

In the operation of the present valve, the balloon 10 is attached to the filling nozzle 11, and a number of weights 18 corresponding to the desired lift of the balloon are placed on the column 17 (the weights of the columns 16 and 17 are included in the total weight). The main switch 24 is then closed, and the push-button switch 25 is depressed. As shown in Fig. 3, this switch 25 is in parallel with the normally-open upper reed switch 34. Hence the manually-closed switch 25 and the normally-closed lower reed switch 33 complete the circuit for relay 40, causing the solenoid valve 13 to open and permit the hydrogen to flow into the balloon 10. The opening of the solenoid valve 13 is indicated by the lighting of the lamp 26, see Figs. 1 and 3.

With push-button 25 held depressed, the balloon partially fills and exerts sufficient buoyancy to lift the short upper column 16. The column 16 is relatively light, and easily lifted to the raised position indicated by dashed lines 36 of Fig. 2. In this raised position, the magnets 37 close the contacts of the reed switch 34, so that the relay 40, Fig. 3, is then energized through switches 33 and 34. The push-button switch 25 thus may be released by the operator, and the balloon will continue to be filled with hydrogen.

When the balloon 10 has received sufficient hydrogen to lift the columns 16, 17 and weights 18, the column 17 will move upward along the tube 30 a very small amount. This upward movement will lift the magnets 35 from adjacent the closed lower reed switch 33, causing the switch to open. As can be seen from Fig. 3, opening of switch 33 opens the circuit of relay 40, and thus opens the circuit of solenoid valve 13. In this manner, the flow of hydrogen gas is automatically terminated when the balloon receives the predetermined amount of gas. The valve thus provides an automatically-metered filling.

In addition, the valve provides an automatic termination of the hydrogen flow in the event that the balloon bursts during the filling process. As will be recalled, the operator manually depresses the switch 25 until the balloon raises the upper column 16, after which the switch 25 is released. It will readily be apparent that bursting of the balloon would cause the column 16 to drop, which in turn would cause the magnets 37 to drop from adjacent the reed switch 34, and thereby open the switch 34. From Fig. 3, it will be seen that the opening of switch 34 (switch 25 being open) would release relay 40 and therefore cause the solenoid valve 13 to close. The hydrogen gas would thus be closed at the solenoid 13, rather than continue to flow to the nozzle 11 and balloon.

In Fig. 2, the columns 16 and 17 are illustrated as being in sliding contact with the tube 30 containing the reed switches 33, 34. To minimize the friction, the columns may each be provided linear ball-bearing bushings.

There is an alternative method for initiating the flow of hydrogen to the balloon until the balloon can raise column 16. In this alternative method, the column 16 is provided with any suitable mechanical latching mechanism (not shown) for holding the column 16 in the raised position 36, Fig. 2. The operation is then as follows: The switch 24 is turned on, and the operator approaches the balloon and latches the column 16 in the "up" position. This closes switch 34, which actuates the relay 40 and solenoid 13, permitting the gas to flow into the balloon. When the operator observes that the balloon has received sufficient gas to hold the column 16 up, he unlatches the column 16, so that the column is free to drop in the event of a balloon burst. When the balloon fills, it tends to lift column 17 and open switch 33 and therefore solenoid 13, as described previously.

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