points out that often the resectionist is not a good judge of fluid accumulation, and the amount of tissue removed does not correlate with the extent of fluid uptake.[7] As would be expected, fluid absorption is more closely correlated to the progress and extent of the operative procedure than to time *per se*. Our case points out there are exceptions to the classically taught "safe one hour" resection time advocated by Fillman *et al.*[3] Time is only a relative guide for each specific surgeon. Some surgeons reach the capsule and venous sinus plexus very early, while others never reach the capsule after 2–4 hours of resection time. Numerous reports cite one hour as a relative safe time with use of distilled water as the irrigating solution. Still and Modell[8] point out many feel a much longer time is safe when isotonic solutions are used. They were surprised that their patient developed this syndrome after only 75 min of resection time. Our case points out the need for constant vigilance during the entire procedure, as water intoxication may occur at any time.

In this case serum Na^+ fell precipitously in 15 min to 104 mEq/l, resulting in grand mal seizures. Seizures are most likely to occur when serum Na^+ drops below 120 mEq/l. However, Maluf found that the more rapid the decrease in serum Na^+, the more likely were seizures to develop; a 20–30 mEq/l reduction in serum Na^+ was an ominous sign, and indicated that large amounts of fluid had been absorbed.[6] Fluid may enter the intracellular space rapidly, and serum Na^+ may not accurately reflect the true dilution that has occurred. One cannot necessarily correlate serum Na^+ level with the total amount absorbed.[4,6,7] In our case the volume absorbed appeared to be greater than the 20 ml/min that Hagstrom suggests as an average.[1]

Often the anesthetist relies on changes in vital signs to diagnose water intoxication prior to the outset of seizures, pulmonary edema and cardiovascular collapse. In this case, there was no significant change in vital signs prior to the grand mal seizures. Had general anesthesia been used, we probably would not have determined serum electrolytes so early. Pulse and blood pressure often do not reflect the true clinical picture[9]; for this reason, conduction anesthesia is preferred for the early detection of the syndrome.

Grand mal seizures as a result of water intoxication following short transurethral resection times can occur. The classic signs of water intoxication, widened pulse pressures, slowing heart rate, and hypertension, may not occur prior to central nervous system alterations. An alert anesthetist, ever aware of the possibility of early occurrence along with conduction anesthesia, allows for early detection and treatment of this syndrome.

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Anesthesiology
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An Anesthesia Circuit Monitor

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Most new ventilators incorporate a low-pressure alarm as standard equipment. There are also available several commercial versions of high- and low-pressure alarms as separate units.[1,2] There is no question that some sort of disconnection-warning device is desirable. We describe below a multiple-function anesthesia circuit monitor. The model described adds three useful features to the basic concept of a high- and low-pressure alarm.

There is general agreement that exhaust gases should be removed.[3,5] Two problems are associated

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with a scavenging system. These are excess suction[6] and obstruction of exhaust. The first reduces tidal volume, leading to hypoventilation, whereas the second creates a continuous positive airway pressure (CPAP)‡ circuit that reduces cardiac output and leads to pulmonary rupture.[7] The unit described in this article produces an alarm signal when the pressure–time product goes above a preset low value (5–8 cm H_2O). Many alarms use a "floating baseline" to allow them to be used with a positive end-expiratory pressure (PEEP) circuit, which makes them insensitive to scavenger system obstruction. Provision for use with a PEEP circuit is allowed by switching the previously mentioned setting to a higher level (12 cm H_2O), which still insures that excessive resting pressure will not be present.

TABLE 1. Parts List

BR-1	Bridge rectifier, 1 amp, 50 PIV
C-1	2200-μfd, 35-volt electrolytic capacitor
C-2, 3	0.1-μfd, 250-volt capacitor
C-4	22-μfd, 35-volt electrolytic capacitor
C-5	10-μfd, 35-volt electrolytic capacitor
C-6	0.047-μfd, 25-volt capacitor
F-1	½-amp fuse and panel-mounted holder
IC-1	15-volt integrated circuit voltage regulator (Radio Shack 276-1772)
IC-2, 3	LM324N quad operational amplifier, each unit of the 324 integrated circuit contains 4 amplifiers per 14 pin DIP units (Radio Shack 276-1711)
LED-1 to 4	Red light-emitting diodes, 20 MA at 1.75 volts (Radio Shack 276-041)
LED-5, 6	Green or amber light-emitting diodes, 20 MA at 1.75 volts (Radio Shack 276-047)
M-1	0-50-μamp meter (Radio Shack 22-051)
Q-1, 2, 3	NPN medium-power transistor (Radio Shack 276-1640)
R-2	100-K-ohm standard variable resistor, linear taper, see text
R-6	1-M-ohm miniature PC variable resistor, see text
R-9, 13	10-K-ohm miniature PC variable resistor
R-14, 24, 25	50-K-ohm miniature PC variable resistor
R-1	180-ohm, ½-watt, 10 per cent tolerance resistor
R-3	150-K ohm
R-4	10 ohm
R-5	1-M ohm
R-7	220 K ohm
R8, 12	10-K ohm
R10, 26	3.3-K ohm
R11, 21	2.2-K ohm
R-15 to 20	680 ohm
R-22, 23	470-K ohm
R-27	2.2-M ohm
R-28, 29, 30	100-K ohm
S-1	4-pole, 4-position non-shorting rotary switch
S-2	2-pole, normally open pushbutton switch
Son.	6–28-volt DC Sonalert (Mallory)
T-1	Transformer, primary 120 volts, secondary 12.6 volts at 1.2 amp
Transducer	See text
Miscellaneous	4 × 4 × 8 case, wire, solder, tubing, 0.1 × 0.1 perforated circuit board

Note: Radio Shack, Centralab, and Mallory are registered trademarks.

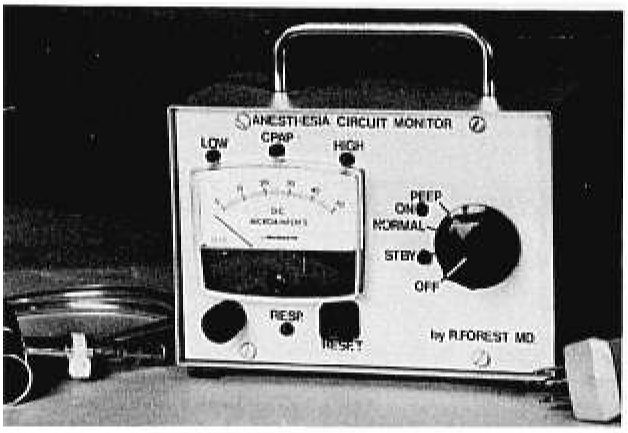

FIG. 1. Front view of the monitor.

The other two new features of this unit have to do with visual display and elimination of an additional pressure gauge. A meter incorporated into the design continuously shows pressure and also makes calibration of the circuit simple. Finally, there is a respiration pilot light that is on during the respiration phase of intermittent positive-pressure ventilation (IPPV) and confirms at a glance that there is no major system leakage.

THE MONITOR (FIG. 1) IN USE

There is only one switch, an off-mode selector. At the start of an anesthetic administration it is placed on *standby* for 2 min. The connector may be placed anywhere in the circuit. A flashing red light insures that it will not be inadvertently left in this position.

When the patient is allowed to breathe spontaneously, the switch is left on *standby*, since the CPAP feature is *on* in this position. When IPPV is used the switch is placed in *normal* position. When the monitor is being used with IPPV and PEEP, the switch is placed in the PEEP position.

Our department has two monitors in use for prolonged operations or when the connection to the endotracheal tube is not visible. They have been in constant use for six months and have not needed adjustment or repair. All components, including the transducer, are housed in a grounded steel cabinet, and have been proven to be free of interference from cautery at any setting. There has been no false alarm. The units have proven quite useful, particularly when one of our ventilators failed to cycle (*low* alarm) or stayed *on*

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‡ Any circuit in which airway pressure is always above atmospheric.

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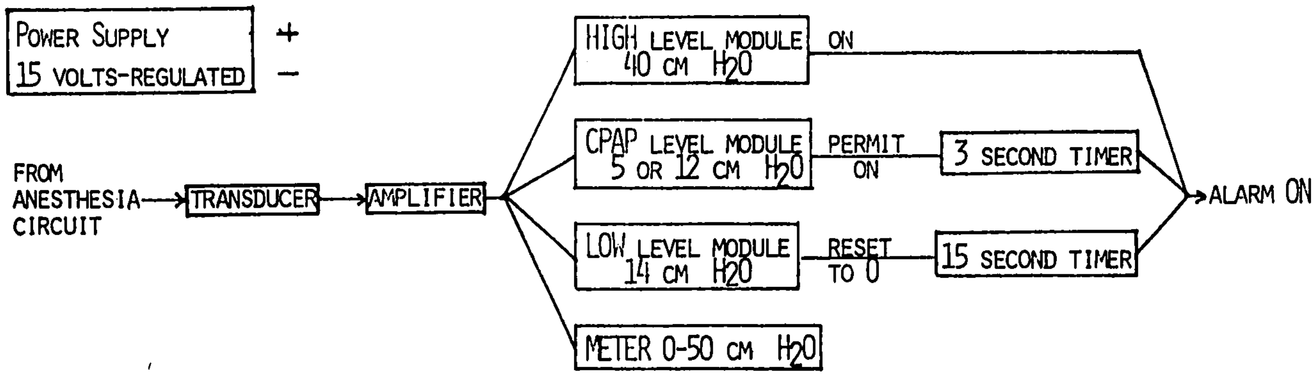

FIG. 2. Block diagram. The pressure in the anesthesia circuit is transmitted through tubing to the transducer; it is then converted from pressure to voltage and subsequently amplified. This signal is applied simultaneously to the meter and the three level modules. The result when applied pressure reaches the set level of each module is shown. Note that the *low* timer is normally on *during expiration* (low pressure), and that the CPAP timer is on only *during inspiration*. The *high*-level module or the timers turn on the alarm through individual pilot lights. The output of the *low* level module controls the *respiration* pilot light.

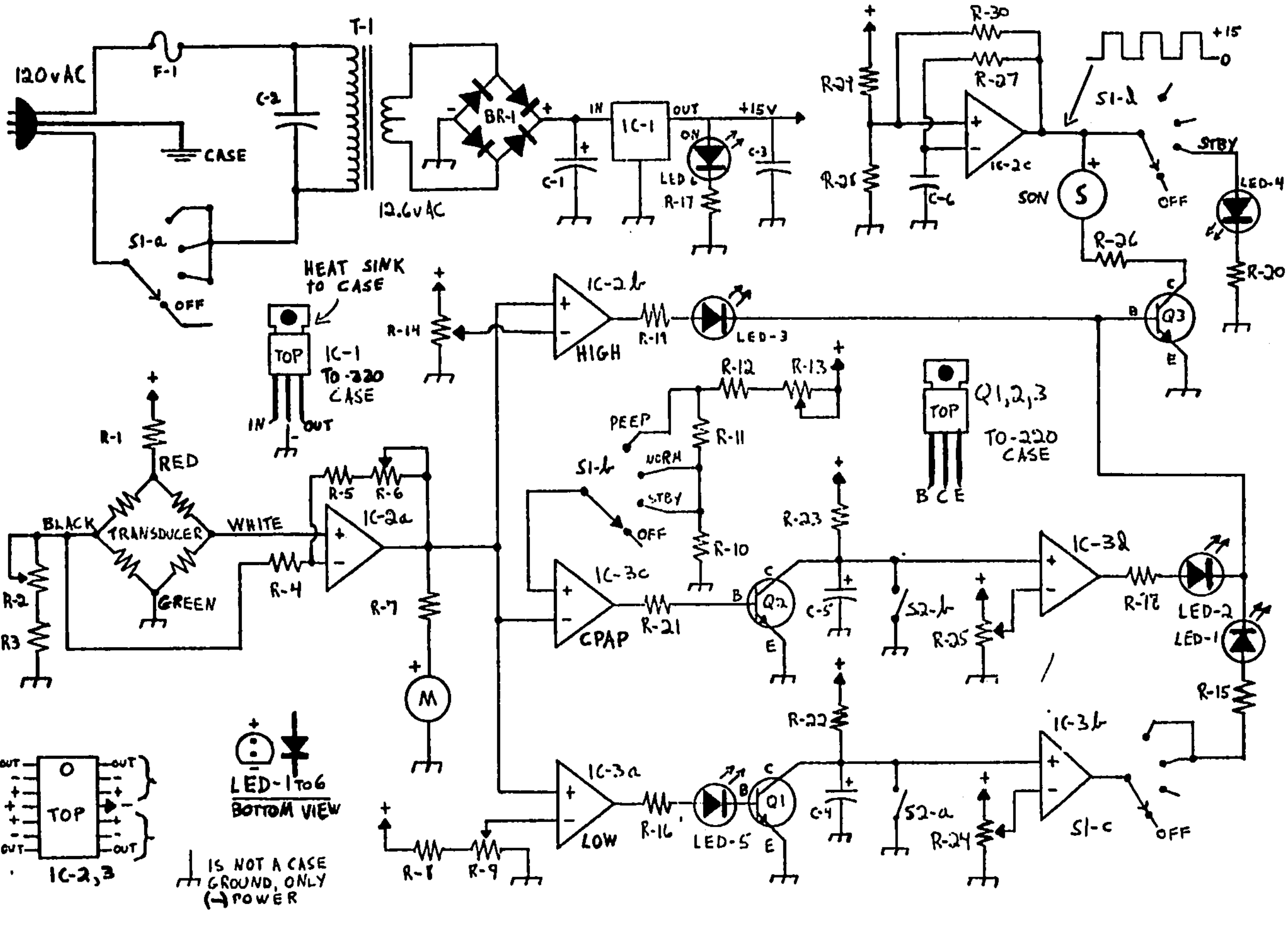

FIG. 3. Schematic. All parts are identified in the parts list (table 1). Note especially the polarity of the diodes and capacitors. Also be sure to connect the output of the amplifier (IC-2a) to the inverting (−) input of IC-3c, as described in the text.

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(CPAP alarm). The appendix lists the settings we have used for the various functions.

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APPENDIX

Block Diagram and Circuit Description: (Figs. 2 and 3)

a) Power Supply

120-volt line power was chosen to prevent battery failure during long-term use. The unit is supplied with 15-volt regulated DC voltage through T1, BR-1, C1 and IC-1. C2 and C3 filter cautery interference. The pilot is always on during use. The case of the unit is grounded.

b) Transducer and Amplifier

Any general-purpose transducer can be used. Simple strain gauges have too much drift for use in a circuit that is DC-coupled.

The transducer used is a Statham P23Db. R1 reduces input lead voltage to less than 10 volts (manufacturer's specification). R2 and R3 allow the transducer to be set to zero. The inputs are to a 324 integrated circuit (IC-2a) operational amplifier. The gain of the IC is determined by Rf/Ri which are the feedback resistors (R5 + R6) and the input resistor (R4), respectively. The gain is approximately 150,000×. Since this is a differential amplifier (*i.e.*, it amplifies the difference in voltage between the inputs), a large output sends back a small signal to the inverting (−) input, thereby reducing gain.

c) Meter

The output is coupled to R7 and M-1, the readout meter. The meter is adjusted (power off) so that the needle is off-scale, below zero. This insures that the setting of the electrical zero will place it on the linear gain slope of the amplifier (0–50 cm H_2O = 1–11 volts = 0–50 μamp). Gain is adjusted (R6) by comparison with an ordinary, good-quality, mechanical pressure gauge, 0–50 cm H_2O.

d) Level Modules and Timers

The output is also coupled to the three level modules. The ICs are operated as voltage comparators. The *low* level module has its reference voltage (−) set by R8, R9. When the pressure is adequate (nominally 14 cm H_2O) and the (+) input of IC-3a goes above the (−) input reference voltage, IC-3a turns on. This turns on Q1 through LED-5 (*respiration* pilot) and current-limiting resistor R16. Q1 discharges C4. When pressure drops, IC-3a, LED-5 and Q1 turn off and allow C4 to charge through R22.

In the event the voltage on C4 reaches the selected voltage (by R24), IC-3b turns LED-1 (*low* pilot) and Q3 *on*; This activates the alarm when S1-c is in either the *normal* or the *PEEP* position. Either an adequate pressure reading (turning on IC-3a and Q1) or closing S2-a (*Reset*) will discharge C4, turning off IC-3b and the alarm. Respiration will normally reset C4 every 5 sec or so, and IC-3b will not turn on. We use a 15-sec delay.

The CPAP module, however, is on during exhalation, keeping Q2 on and C5 discharged. During respiration the inverting input (−) will go above (+), turning IC-3c and Q2 off, allowing C5 to charge. The sequence is then similar to that of the *low* timer. C5 is smaller than C4 and the delay can be set for 3 sec. When pressure drops to below threshold, IC-3c and Q2 turn on, Q2 discharges C5, and IC-3d turns off. S1-b selects the (−) reference voltage and thus the CPAP level tolerated, either 5 or 12 cm H_2O in *PEEP* position. The timer is normally on for only 2 sec or less, and IC-3d does not go on. When inspiration is prolonged or there is PEEP above threshold, the timer turns Q3 and the alarm on.

The *high* module directly turns on Q3 through LED-3 and R19, with no delay: it goes off when pressure drops to below threshold (set by R14), nominally adjusted at 45 cm H_2O.

e) Flasher, Sonalert Alarm

The flasher uses IC-2c to provide pulsating (+) voltage either for LED-4 (*standby* flasher) or to the (+) terminal of the Sonalert; R26 reduces the volume. Q3, when on, completes Sonalert circuit to the (−) supply.