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CONSTRUCTION

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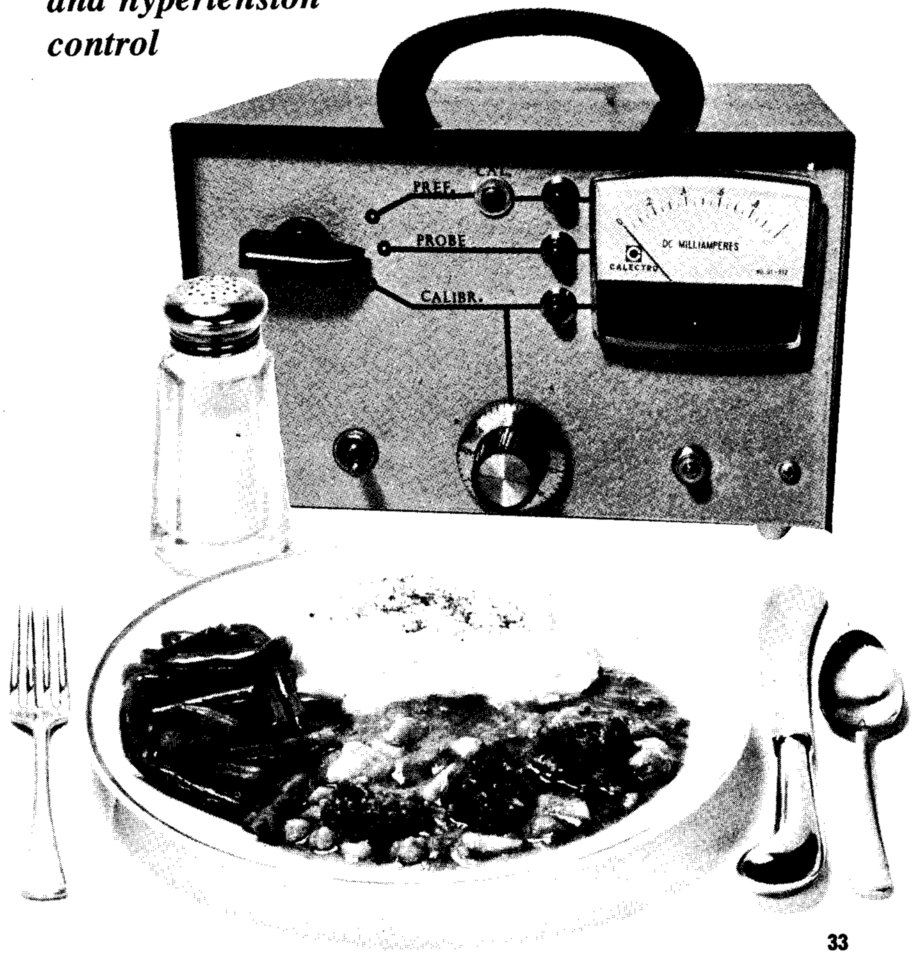
An Electronic Salt Meter For Family Health

With this low-cost device, you can check food for salt content, an important consideration for weight and hypertension control



COMMON table salt, like water, is an essential ingredient to all animal life on earth — including man. Recently, however, research has revealed that diets high in sodium, one of the elements in salt, may be a leading cause of hypertension. Also, the reduction of dietary sodium intakes has become an important treatment in the management of congestive heart disease. (For more information on the clinical and physiological roles of salt in human nutrition, see the box on the third page of this article.)

With salt being linked to medical problems, it is no wonder that many of us have become concerned with the benefits of low-salt diets. Unfortunately, progress in salt metering has long been held back by the high cost of ac-type conductance meters required for testing foods. (Dc-type ohmmeters are useless for this application.) While commercial ac salt meters cost $1000 or more, less than $30 will buy the components for you to build your own. The salt meter described in these pages will permit you to rapidly sample the salt content in baby foods, canned and raw foodstuffs, and drinking water. Simply immerse the probe tip into the food sample, and observe the meter pointer's deflection.

The salt meter's design takes advantage of the fact that salt-enriched foods conduct electrical current. The higher the salt content, the greater the current flow. Pure salt-free water has a specific conductance (the reciprocal of resistance, or 1/R) of 0.05 μmhos, or a resistance of 20 megohms. Its low conductivity results from a deficiency of ions. Our saltmeter, on the other hand, expresses conductivity in terms of currents ranging from 0 to 1.0 mA, affording the greatest possible convenience for the average user.

About The Circuit. The salt meter (see Fig. 1) is a true ac-type conductance meter. It is based on an ac-energized bridge circuit, which consists of *R2*, *R3*, and *R5*. External test probe *PL1* is switched (via *S2B*) across *R3*. Dipping the probe into a food sample places a given parallel resistance across *R3* which, in effect, unbalances the bridge and causes current to flow through the 20,000-ohm primary winding of *T2*. This current is inductively coupled into the secondary circuit of *T2* where it is rectified and fed to meter *M1*. Note that no dc appears in the circuit.

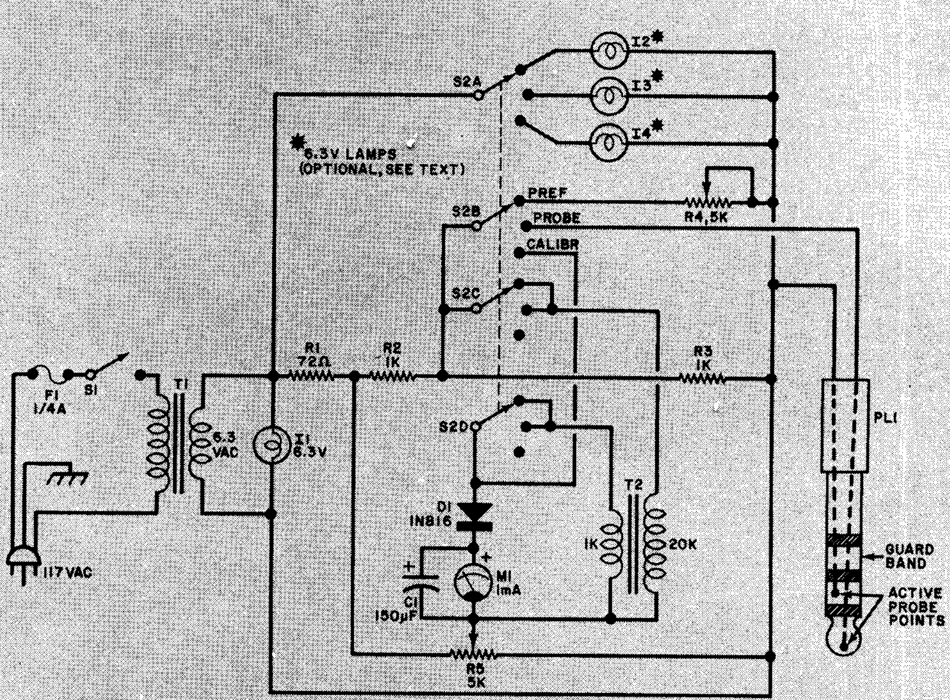


Fig. 1. The circuit of the salt meter is a true ac-type conductance arrangement. The bridge circuit is unbalanced by resistance across probe.

PARTS LIST

C1—150-μF, 50-volt electrolytic capacitor
D1—1N816 diode
F1—¼-ampere fuse
I1-I4—6.3-volt lamp (I2-I4) optional—see text)
M1—0-1-mA meter movement (Calectro No. D1-912 or similar)
PL1—Four-conductor, ¼-in. phone plug (Calectro No. F2-833 or similar)
R1—72-ohm, 1-watt resistor
R2,R3—1000-ohm, 1-watt, 5% resistor
R4—5000-ohm, linear-taper potentiometer with screwdriver-adjust shaft
R5—5000-ohm, linear-taper potentiometer
S1—Spst switch
S2—Four-circuit, 3-position rotary switch (RCA No. 56584 or similar)
T1—6.3-volt, 1-ampere filament transformer (Lafayette Radio No. 33P80946 or similar)
T2—20,000-ohm primary, 1000-ohm secondary miniature driver transformer (Calectro No. D1-719)
Misc. — Suitable chassis; control knobs (2; 3 if building reference standard); 5-percent resistors (see Fig. 2 for values) and ¼-in. phone jack (for reference standard); probe cable; three-conductor power cord; fuse holder; machine hardware; hookup wire; solder; etc.

Switch *S2* has three positions: PREF, PROBE, and CALIBR (meter null). Each position is equipped with an indicator lamp (*I2* to *I4*) that identifies the position to which the switch is set. These lamps are optional. Omitting them will not affect the instrument's performance and will allow you to use a simpler switch for *S2*.

In the PREF position of *S2*, taste-preference potentiometer *R4* is adjusted to a low-salt value of, say, 0.73 as indicated on the meter. However, before *R4* is adjusted, *S2* must first be put into the CALIBR position and *R5* set for a meter reading of 0.1 mA.

In the PROBE position, external test probe *PL1* is in the circuit. (Note that this probe is a standard ¼-in., four-conductor phone plug. Only the tip and second conductor are active.) Inserting the probe into a food sample causes a current to flow, its magnitude dependent upon the salinity of the food, and resistance drop across *R3*. This resistance drop, resulting from the flow of current, causes the meter's pointer to swing up-scale to give a measure of saltiness. (For typical readout values, see the table on the opposite page.)

In the CALIBR (meter null) position, the ac bridge can be balanced by adjusting calibration control *R5*. Balancing is achieved by adjusting *R5* until the meter's pointer rests at the zero index of the scale. To ready the instrument for taste preference calibration and probe readings, adjust *R5* for a 0.1-mA meter reading. Now, if the test probe's active contacts are shorted to each other, the meter will read precisely 1.0 mA.

The saltmeter is also capable of indicating probe contamination. If *PL1* is not wiped perfectly clean after each sample test, an error will be indicated by the meter pointer's up-scale swing. To investigate probe contamination or internal leakage due to extensive use,

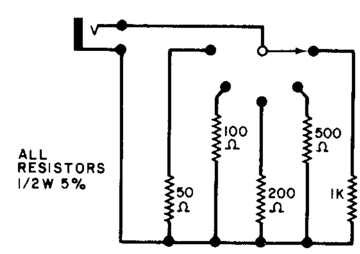


Fig. 2. The salt meter's calibration should be checked periodically by using known resistances.

set $S2$ to CALIBR and $R5$ for a meter pointer null indication. Then switch to the PROBE position. If the meter's pointer remains at the zero index, no contamination or leakage exists.

The salt meter should be periodically checked against a calibration reference of known resistance. Such a reference can be made from a rotary switch, 5-percent tolerance resistors, and a phone jack that properly mates with the four-conductor phone plug used for *PL1* as shown in Fig. 2. The jack and potentiometer can be housed in an external box, or room can be made for mounting them on the front panel of the instrument case where the reference will be always handy.

Now, by plugging the salt meter's test probe into the reference circuit's jack, you can obtain an error-free analog meter reading. Consult the table for reference values.

FOOD SAMPLE READINGS

Food Sample	Meter Reading (mA)	DC Resistance (ohms)	Test Resistance (ohms)
Fresh tap water*	0.17	5000-13,000	1000
Fruit dessert with tapioca	0.64	3400	220
Plums	0.64	3400	220
Coffee with cream*	0.68	4000-8500	185
Bananas	0.73	3200	155
Custard Pudding	0.77	7500	132
Vegetables with ham	0.80	6500	110
Vegetables with lamb	0.81	4000	105
Beef stew	0.88	6100	67

*All food samples, except those indicated by an asterisk, are baby foods in glass jars. Readings obtained with 0.1-mA calibration setting and test probe inserted in food above guard band; dc resistance taken with standard dc-type ohmmeter connected only to probe.

Construction. The salt meter's simple circuit lends itself nicely to

CLINICAL AND PHYSIOLOGICAL ROLES OF SALT IN HUMAN NUTRITION

It is important for all of us to understand both the clinical and physiological roles salt plays in human nutrition. Major importance resides in the quantities of sodium that can be consumed without harm.

Therapeutically, low-salt diets were employed as early as 1901 for patients with edematous heart disease. Later, this form of treatment was extended to people suffering from congestive heart failure, renal diseases, hypertension, cirrhosis of the liver, toxemias of pregnancy, and Meniere's disease. In tests, when eating salt-restricted foods, one-fourth to one-third of hypertensive patients responded with a reduction in blood pressure.

There is good evidence that an adult's daily ingestion of 250 to 375 mg of sodium-chloride salt causes no harm. This is all the human body requires to maintain good health. Even so, the daily intake ranges from 10 g for Americans to 27 g for many people in certain areas of Japan. Diabetic children have been observed to have an intense craving for salt — as much as 60 to 90 g/day — which triggers a powerful hypertensive effect.

High salt intake can become a critical issue where infants are concerned. Unable to speak, the infant is totally subordinated to the food preferences of the mother, who salts things "just right" for her own tastes — not baby's true health needs. A special problem begins when the infant is between one and three months old, the age most American infants are fed supplementary commercial foods (baby food) comprised of strained vegetables, meats, and fruits. Even to many fruits, salt is added prior to canning.

The sodium concentration in strained fruits is fairly low, typically 0.6 to 2 mg/100 g of food substance. However, in the case of strained meats, sodium contents may range from 293 mg to 510 mg/100 g of food weight. Vegetable samples have an average sodium content of about 358 mg/100 g of food weight.

The seriousness of the above numbers becomes clear when we examine a 5-month-old infant weighing 6 to 8 kg and who consumes at least 100 g of commercial baby food per day. In addition to an average of 305 mg of sodium ingested, the infant will drink about 1.1 liter of cow's milk, which can have as much as 2.14 g of sodium per liter. The only statement likely to be printed on a carton is that the contents are pasteurized and that vitamin D has been added.

Adding all his food sources together, baby is bound to consume about 2.3 g of sodium chloride daily. This is equivalent to 23 g/day for a 68-kg (150-lb.) adult. It is certainly dangerously high for a small child. Here, researchers are concerned about the possibility that such abnormally high intake of sodium chloride in infancy might play an important part in hypertension in adulthood.

In research work conducted under the auspices of the Atomic Energy Commission, the lifetimes of laboratory rats were drastically shortened when the rats were fed nothing but baby foods. Three out of seven of the rats developed hypertension and died.

Clerarly, some form of salt metering is of vital importance to any family interested in good dietary control.

straightforward point-to-point wiring in a suitably large chassis case. Most of the work is involved in machining the front panel to accept the meter movement, controls, and lamps. (Do not forget to allow room for the calibration standard's switch and jack if you intend to mount them on the front panel.) In the prototype, *PL1*'s cable exited the salt meter through a grommet-lined hole in the rear panel; if you wish, the cable can exit a grommet-lined hole in the front panel.

Mounted on the rear panel should be the holder for *F1*, and the three-conductor line cord should exit through a grommet-lined hole or be held in place with a plastic strain relief. The two transformers mount to the floor of the chassis. Then all resistors, the diode, and the capacitor install directly between the appropriate lugs of the controls, meter, etc., as shown in Fig. 1.

In Use. One of the ac salt meter's outstanding features is its ability to speedily sample baby foods. Conduct all tests at room temperature.

In practice, a taste preference reading is set prior to actual food tests. Assume this reading to correspond to a very mildly salted food item, such as bananas, or 0.73 on the meter scale. Now, with the salt meter switched to PROBE, a similarly mildly salted food item should yield an equally low reading. The taste-preference calibration allows an electronically unskilled person to recognize safety levels without having to figure out complex electrical relationships.

Some food items will surprise you. One sample jar of beef-stew baby food yielded a reading of 0.92 — much too salty for an infant. Fresh water, supposedly pure, turned out to be highly conductive, indicating high ion activity due to pollution.

The approximate percentage of sodium chloride (salt) in foods can be determined by weight. For a test, prepare mashed potatoes from fresh potatoes. Add 500 mg of salt to 99.5 g of mashed potatoes and measure the conductivity of the mixture. Then add another 500 mg of salt and again measure the conductivity; note how far up-scale the meter's pointer deflects beyond your first test reading.

Most prepared foods contain such conductive substances as acids and food coloring in addition to salt. However, salt tends to be the dominant conductive agent. ◈