A New and Ultra-Sensitive Detector, the Sodion

By JOHN V. L. HOGAN*

CONSULTING ENGINEER; PAST PRESIDENT AND FELLOW, INSTITUTE OF RADIO ENGINEERS; MEMBER, AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

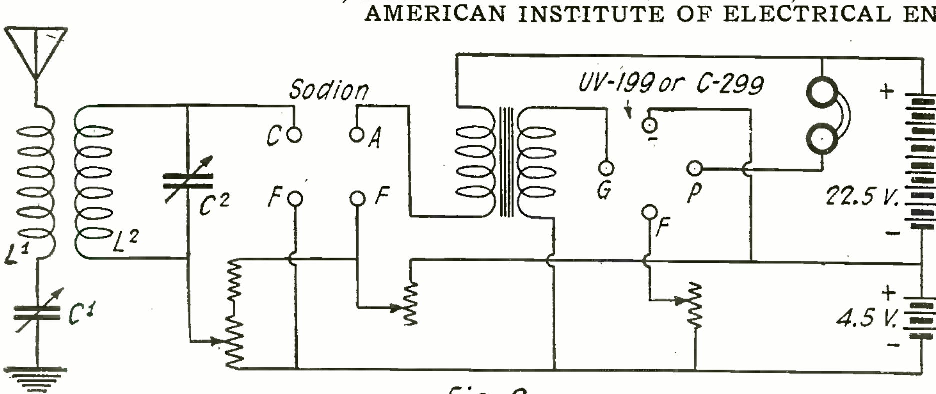


Fig. 2

Circuit of the Sodion Detector with One Stage of Audio Frequency Amplification.

THE novel detector tube that was described by its inventor, Mr. Harold P. Donle, at a recent Institute of Radio Engineers' meeting, offers almost endless possibilities of investigation and experiment. Its extreme sensitiveness, which has been measured by a number of independent laboratories and found to be about two stages better than that of the standard hard audion tubes, makes the Sodion particularly interesting to radio amateurs and broadcast listeners who are anxious to increase their ranges of long-distance reception.

Unlike the audion tubes that we have come to know so well, the Sodion contains no grid or interposed control-electrode. It gets its name because it utilizes some unusual properties of ionization of an alkali or highly electropositive metal such as sodium, the new word being derived from "sodium" and "ion." The input circuit of the Sodion detector is connected between its filament and an electrode called the *collector*, which is a bent or trough-shaped plate that partially surrounds the filament and has its open side toward the anode. The output circuit extends from this anode to the filament, and contains a "B" battery and the usual head-telephones or the primary of an audio-frequency amplifier transformer.

Fig. 1 shows the Sodion tube in diagrammatic form, with a standard circuit that gives good results. The small heater that is shown above the tube in this drawing is in the practical bulb wrapped around the glass tube and covered, for protection and heat-retention, by a second glass shell which makes the tube very easy to handle.

In setting up the circuit of Fig. 1 with the type S-13 or dry-cell Sodion, an "A" battery of three fresh dry cells *in series* should be used. These will operate the tube for a long time, since the current of the filament circuit is only 0.24 ampere or a little less than is called for by the WD-11 and WD-12 dry cell tubes. The working voltage is 3.8, however, and when the three dry cells have dropped from their "new" voltage of 4.5 to this value, they should be replaced or reinforced to maintain the desired e.m.f. A set of three standard No. 6 cells will last for three months or more, however, under average use of one hour per night. A standard filament rheostat of 3 to 6 ohms will be found adequate to take care of the excess potential of three fresh dry cells, though if it is desired to use a 6-volt storage battery a 10 or 15 ohm rheostat will be necessary to reduce the current sufficiently.

The Sodion tube is not critical as to anode potential, but best results will ordinarily be had by using a single 22½-volt "B" battery block. In the input circuit, note that a direct connection is made from the filament through the potentiometer and the tuning inductance to the collector electrode, with

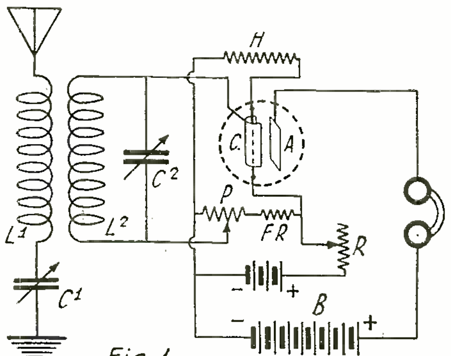


Fig. 1

Hook-up of the Sodion Detector. It is Necessary to Use a Double Circuit Tuner with Very Loose Coupling, as the Resistance of the Collector Circuit Should Be Low.

no blocking condenser or leak resistance of any kind. Care in the choice of low-loss coils and condensers for the primary and secondary circuits will be repaid in increased selectivity and signal strength.

The potentiometer should be of about 50 ohms resistance and should have in series with it (on the positive side) a fixed resistor of from 100 to 150 ohms. This will give ample range of adjustment on the potentiometer scale, yet will not introduce large resistance into the radio-frequency circuit to the negative end of the filament. An ordinary 30-ohm rheostat having three connections may be used for the potentiometer, but then the series resistor should not be of more than 75 or 100 ohms resistance.

Having set up the circuit as described, of course the next thing to be considered is its operation. The tuning of two-circuit receivers has been explained in print many times, and the only peculiarity notable when the Sodion tube is used is the extremely weak coupling that may be utilized without marked loss of signal strength. The detector is so sensitive that the ordinary variocouplers are unsuitable for use with it in the circuit of Fig. 1, because electrostatic coupling between primary and secondary is too great to allow good selectivity even when the magnetic coupling is reduced to zero. Some form of coupler in which the two coils are moved physically apart as the coupling is weakened should be relied upon for best results.

With the weak couplings that the Sodion's high sensitiveness makes feasible, the two circuit tuner is very selective. This makes it extremely important to adjust *both* the primary and secondary tuning condensers very carefully whenever one changes the coupling or shifts to a different wave frequency.

The detector is simplicity itself to operate. Turning on the "A" battery, bring the filament current up until the tube glows at a bright yellow color (not a brilliant white); then adjust the potentiometer to give the loudest signals. If the filament current is too high, a hiss will be heard in the telephones at all settings of the potentiometer. On the other hand, if the current is too low it will not be possible to get a hiss at any position of the potentiometer. For correct filament current a slight hiss will be heard at one or two points of the potentiometer scale; the most sensitive adjustment is usually just below such a hissing point. In general the faint hiss will be heard only when the receiver is detuned or when no waves are being received; the application of a radio frequency carrier current to the detector

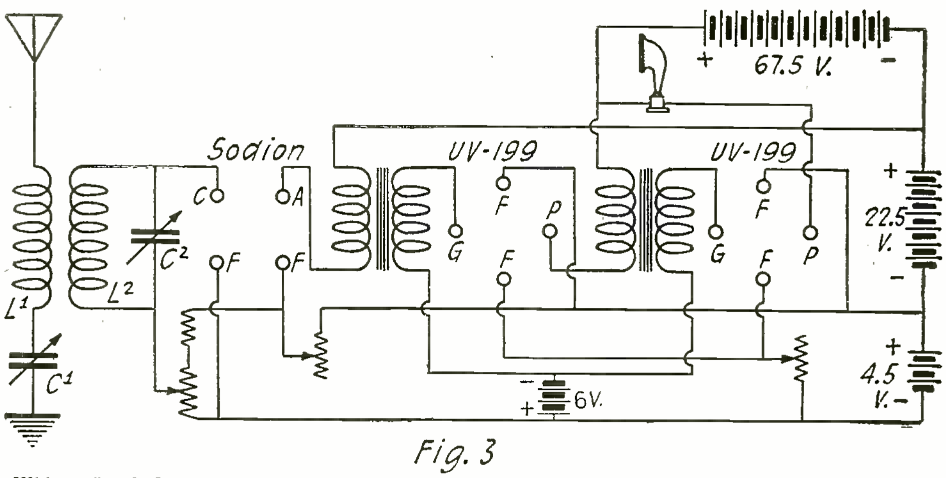


Fig. 3

With a Loud Speaker, Two Stages of Audio Frequency Amplification Should Be Used After the Sodion, as Shown in This Diagram.

*Author of "The Outline of Radio."

stops the hiss, and this action is a useful aid in "picking up" unmodulated waves.

One of the most striking things that will be observed on first using the Sodion detector is the absence of squeals and whistles during tuning adjustment. The detector cannot be made to oscillate at receiving frequency, in the usual circuits, and consequently even in the hands of novice users cannot cause interference. A second point that immediately is noticed is the clarity of radio-telephonic reproduction. This high quality detection of speech and music is largely due to the "straight line" characteristics of the tube; its output power is directly proportional to the input power, from the weakest to the strongest signals.

As with any other detector, audio frequency amplifiers may be added to magnify signals not easily understandable or for loud-speaking. The voltage of the S-13 tube makes the UV-199 a good running mate as amplifier. One such amplifying tube used with the Sodion detector will usually make the signals as loud as is comfortable in head telephones, even with small receiving antennae. Two UV-199 tubes with good amplifier transformers will give loud-speaker intensity from any signal that is clear and fairly strong when heard in the telephones on detector alone.

The amplifier tubes may be run from the same dry cells as are used for the detector. Figs. 2 and 3 show the S-13 tube with one and with two UV-199 audio frequency amplifiers in the circuits recommended for those tubes. The amplifier rheostat in Fig. 2 should be of 30 ohms resistance and in Fig. 3 of 20 ohms. The "B" battery for head telephone reception with amplifier as in Fig. 2 need be only 22½ volts, though some improvement may be had by increasing it to 45 volts (two standard "B" blocks in series). For loud-speaking with two tubes it is worth-while to increase the amplifier plate potential to 90 volts (four "B" blocks) even though this makes advisable the insertion of a "C" battery of four small flashlight cells in series.

One of the most fascinating fields for experiment with the S-13 tube is its combination with radio frequency amplification. Here again the UV-199 tubes are useful as amplifiers. Fig. 4 shows a single radio frequency amplifier with the Sodion detector, in a very flexible circuit that is desirable for test work. The radio frequency transformer shown is not of the conventional type, but may easily be made by winding about 300 turns of No. 36 D.S.C. copper wire on a paper tube of 1¼" diameter for a primary and 175 turns on a thin tube that will just slide freely over the primary (about 1 5-16" diameter) for a secondary. The plate of the R.F. amplifier tube should be connected to

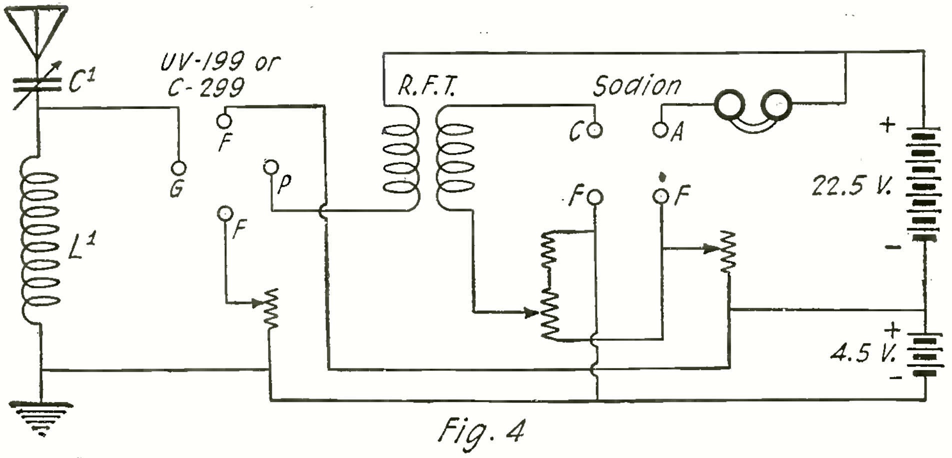


Fig. 4

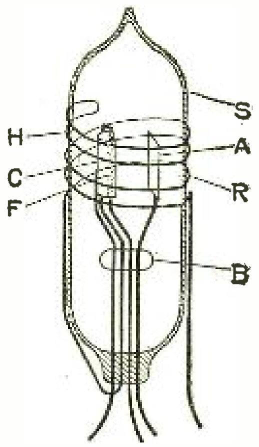
The Signal Strength May Be Enormously Increased by Using One Stage of Radio Frequency Amplification Before the Sodion.

the end of the primary that is nearest the "collector" end of the secondary.

This circuit has only two adjustments, namely the tuning of the antenna circuit and the coupling of the radio frequency transformer. Care must be taken not to allow the R.F. amplifier tube to oscillate, for if it does one will be likely to produce interference with nearby receivers. If the selectivity should be found insufficient to take care of particularly bad local conditions it may be improved by using an inductively coupled antenna circuit as in Figs. 1 and 5.

Another interesting possibility is the reflexing of the Fig. 4 circuit. One way of doing this is shown in Fig. 5. Here an inductively coupled antenna is indicated, for maximum selectivity. Some caution is necessary in all reflex circuits to prevent them from producing internal radio or audio frequency oscillations, and it is a good plan to set up the apparatus first with the direct antenna coupling of Fig. 4. The Sodion tube will be found in itself to provide a helpful stabilizing factor in such circuits, however, and with a little care no difficulties should be encountered.

Inside Construction of the New Detector Tube: C, Control Electrode; F, Filament; A, Anode; H, Non-inductive Heater; S, Glass Bulb; R, Resistance Wire Composing the Heater.



The above suggestions by no means exhaust the applications of the Sodion tube. For the scientific investigator its perhaps most interesting aspect lies in the possibility it offers of measuring weak signal intensities. A microammeter in the collector circuit will show a steady current flow of from 150 to 250 microamperes when no signals are being received. The application of a radio signal, even though comparatively weak, will cause a marked reduction of this collector-circuit current. The difference in current can easily be read on the meter, and is proportional to the audibility of the received signal. Since a signal having an audibility of only 20 or 30 produces several microamperes change in current, such an arrangement of the Sodion detector may be seen to be exceedingly useful.

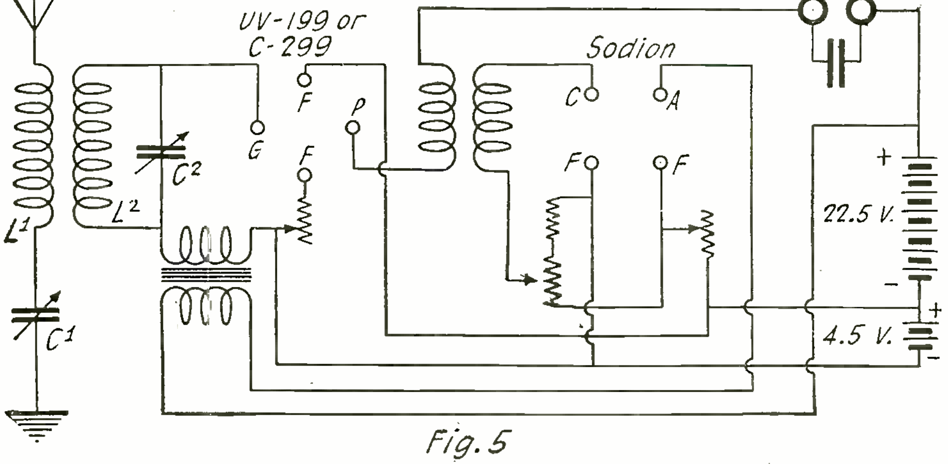


Fig. 5

A Reflex Circuit Suitable for Use with a Sodion Detector. Note That No Potentiometer Nor Bypass Condenser is Necessary for the First Tube if a UV-199 or C-299 is Used.

BROADCASTING JAZZ FROM AN AEROPLANE

Paul Specht, New York orchestra leader, and the members of his orchestra, while abroad recently, took part in an event that is unique in the annals of radio history. Specht, in order to fill an engagement, found it necessary to travel from London to Paris in a short time. He chartered a Handley-Page bombing plane at London and embarked for Paris, with his entire band of eleven pieces on the same ship. The plane was equipped with an up-to-date Marconi broadcasting outfit, the microphone being placed directly in back of the pilot's seat inside the compartment occupied by the orchestra.

While in flight the orchestra broadcast several syncopated musical selections which were picked up by receiving sets in several of the principal English and European cities. Letters from many of those who listened in stated that the Specht concert came through with remarkable clarity, due, in a measure, to the height from which the music was broadcast, over 3,500 feet.

It was at first feared that the intense vibration of the two big motors driving the plane would interfere with the broadcasting, or that the noise would be heard above or through the music. This was found not to be the case. The traveling compartment was practically air-tight and sound-proof and acted as efficiently as the best specially constructed rooms in radio broadcasting stations.