AMERICAN JOURNAL of PHYSICS

# A simple and sensitive tuned null detector

R. P. Baptista and J. A. Fornés

Citation: American Journal of Physics **55**, 1150 (1987); doi: 10.1119/1.15271
View online: http://dx.doi.org/10.1119/1.15271
View Table of Contents: http://scitation.aip.org/content/aapt/journal/ajp/55/12?ver=pdfcov
Published by the American Association of Physics Teachers



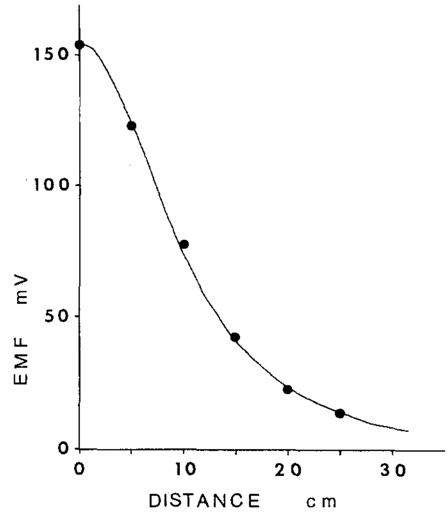



Fig. 6. Induced voltage in the search coil along the axis of the field coil for various distances from the center of the field coil. The dots are experimental, and the theoretical curve is derived from the Biot–Savart Law.

## V. CONCLUSION

We have found this to be a valuable experiment to add to our elementary physics course. It gives good quantitative data that agree well with the theory, and is not complicated by effects of self-inductance. It is a good example of a measurement in which the oscilloscope plays a crucial role and measurements have to be made directly from the oscilloscope screen. There are complications of this circuit that I have chosen to ignore by the inclusion of the two resistors. The resonance behavior of circuits with mutual inductance is certainly not dealt with in the elementary course, but in an upper level course in electricity and magnetism. The construction is simple and inexpensive. Students enjoy doing it and we have found it worth the time taken to develop it.

[1]R. M. Sutton, *Demonstration Experiments in Physics* (McGraw-Hill, New York, 1938), pp. 339–349.
[2]Fischer Scientific Co., 83–84 catalog, p. D54.

# A simple and sensitive tuned null detector

R. P. Baptista and J. A. Fornés[a)]
*Instituto de Matemática e Física, Universidade Federal de Goiás, Campus Universitário, Bloco IMF-2, 74000 Goiânia, GO, Brazil*

## I. INTRODUCTION

A lot of phenomena in physics appear in the radio-frequency range and the measurement of magnitudes that require bridges and other null balance devices for their detection is needed: such as the case in electric permittivity $\epsilon(\omega)$ and electrical conductivity $\sigma(\omega)$, when the frequency $\omega$ of the electric field is varying in the phenomenon called dielectric dispersion, and also in the measurement of double-layer electrode capacitance in electrochemistry, etc.

In determining the equilibrium point of these devices it is necessary to have a sensitive and tuned null detector to avoid electromagnetic interference.

## II. THE DETECTOR CONSTRUCTION

We describe herein how to use a radio as a simple, low-cost, and versatile tuned null detector; its frequency range will simply depend on the radio being used. In Europe receivers are common that start at a low frequency (150 kHz) and end at 20 MHz, while in other countries they normally start at 540 kHz. The advantage of using batteries as the power source of the radio is for versatility and also to avoid interference that could emerge through the ac power line. We used a Philco Transglobe model B-481-3, nine-band receiver, made in Brazil, which was placed in an aluminum case (3-mm-thick sheet) at Earth potential. A BNC connector was fixed to the case for the input signal coming from the null-balance device and this connector was linked with the antenna wire tap.

The output dc signal coming from the radio was taken after the detector diode linked to the last coil of the intermediate frequency, this signal being conducted to the 20-$\mu$A meter after passing through a voltage divider (10-k$\Omega$ knob potentiometer) to graduate the gain when the null-balance device reaches the equilibrium.

The radio has to be tuned exactly to the device's source frequency, and in doing this we have two options: one is the extension of the tuning and band axis to give external access, the other is to open the shielding case each time we want to change the frequency. We have adopted this second option through an upper door made in the case.

As the receiver will compare signals it is not necessary to cancel the automatic gain control, also, the disconnection of the audio amplifier is left to your own criterion, the advantage of not disconnecting it being that you can continue listening to the radio when you are not using it as a detector. Nevertheless, if it is disconnected you will economize in batteries.

In Fig. 1 we give three types of connections of the $\mu$A meter to the radio, namely: (a) direct, (b) transistorized, and (c) through an operational amplifier. In connection (c) we reached a full-scale meter sensitivity of 0.1 $\mu$V or better over most of the frequency range. Note that in this

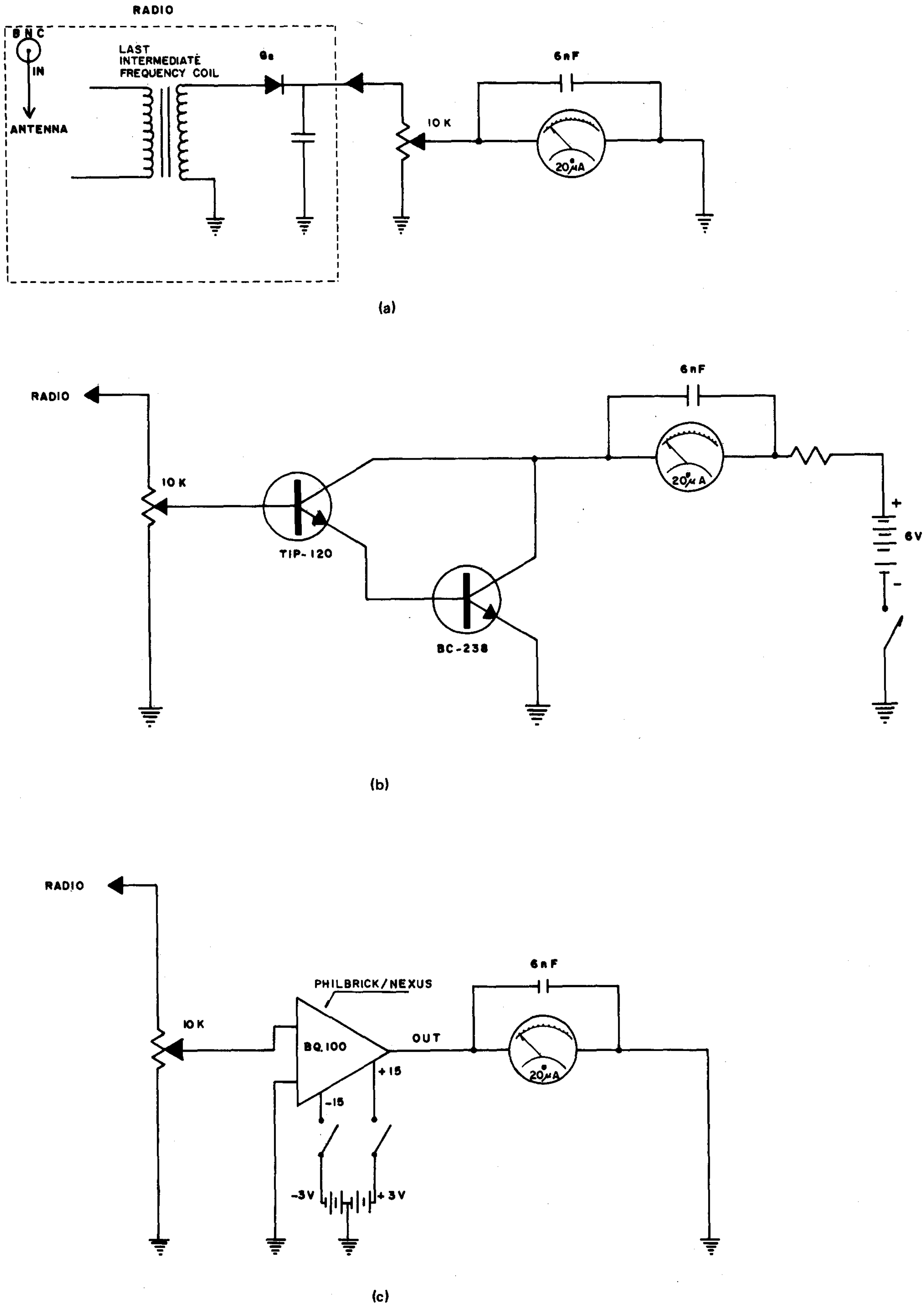



Fig. 1. Microampmeter connections to the radio. (a) Direct, (b) transistorized, and (c) operational amplifier.

connection it is not necessary to use a battery of $\pm$ 15 V for the operational amplifier, $\pm$ 3 V being sufficient.

The microampmeter is installed in a window made on the upper right-hand side of the front of the case, circuit and batteries are placed inside the case. We used this detection system with our bridge[1] to obtain the best results in the measurement of conductivities of electrolite solutions.


## ACKNOWLEDGMENTS

This work was partially supported by the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq-Brazil).

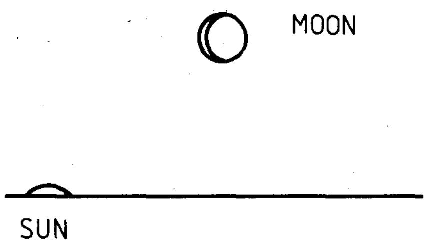

[a] Author to whom correspondence should be addressed.


[1] R. P. Baptista and J. A. Fornés, J. Phys. E **18**, 166 (1985).

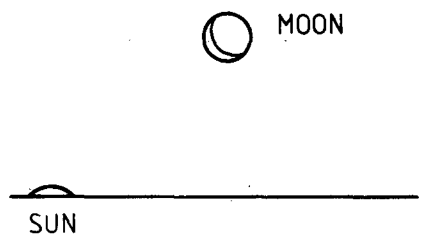

# SOLUTION TO THE PROBLEM ON P. 1095

This problem is interesting since it appears to have occupied the famous Swedish dramatist August Strindberg for a long time. Like many authors at the turn of the century, he had a strong amateurish interest in the sciences. Also, like most people I have tested, he failed to solve the problem correctly. However, the conclusion he draws from this is astounding!

"Whether it is certain that the moon gets its light from the sun, might be questioned... [!!]. During the 18 years I have studied the strange orbit of the moon I have often been surprised that in the day the moon does not show such a crescent as it should. In the morning of this day, 29 December 1907, the moon rose at 8:49. The moon was then about 35° above the horizon, in this way:




This is not correct since the moon illuminated from below should look like this:"




Strindberg obviously forgot to take into account that the Sun is also very far *behind* the moon which leads to Fig. 1 as observed. However, most people seem to make the same mistake. Have a test in your classroom!


Lars Falk
*SGAB, P.O. Box 1424*
*751 44 Uppsala, Sweden*