1960, Sumner P. Davis, who had joined the project during the previous year, took over his responsibilities. A three-year grant from the National Science Foundation provided funds for equipment and salaries.

The red CN system, which appears prominently in the spectra of carbon stars and sunspots, was selected as the first to be studied because of its wide spectral range (from about 4370 Å to the region beyond the photographically accessible infrared). The tabulations cover the 39 bands which are sufficiently intense to be recognized in photographic plates, using a relatively high-temperature laboratory source, such as an arc. In addition to CN, the molecules selected for study during the program include $C_2$, TiO, AlH, NH, BH, MgH, SiH, HgH, SiF, BO, and ZrO.

### *Review of Materials Science*

The National Academy of Sciences—National Research Council and the Office of Naval Research have collaborated in a 771-page survey of materials science entitled *Perspectives in Materials Research*. The study came about as the result of the need felt by the National Academy and the ONR Metallurgy Branch for a comprehensive statement on the state of knowledge and the important problems in the science of materials. Funds for the study were provided through an ONR contract, and the Division of Engineering and Industrial Research, NAS–NRC, was given the responsibility of administering it. An Advisory Committee on Perspectives in Materials Research, headed by Academy president Frederick Seitz, was set up, which organized panels of scientists to prepare the series of individual-area perspectives included in the volume. The book's 12 chapters are devoted to the science of materials; cohesive properties of solids; magnetism and magnetic materials; electrical, optical, and thermal properties of solids; diffusion and mass transport in solids; phase transformations in the solid state; growth, structure, and morphology of crystals; mechanical behavior of crystalline solids; surface phenomena; structure and properties of liquids; effects of radiation on materials; and techniques and instrumentation. The volume has been published by ONR as number 10 in the series, *Surveys of Naval Science*, and is available from the Superintendent of Documents, Government Printing Office, Washington 25, D. C., for $4 a copy.

### *Bibliography on Magnetism*

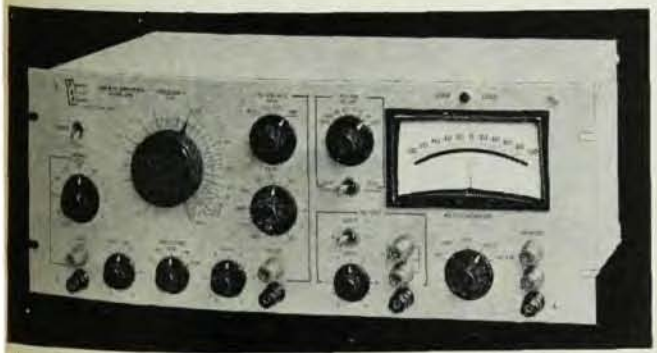
The 1962 AIP–AIEE Conference on Magnetism and Magnetic Materials has undertaken the distribution of Volume 2, and Part 1 of Volume 3, of the *Index to the Literature of Magnetism*. The *Index* is published on a semiannual basis by Bell Telephone Laboratories and originally was intended for the use of the Laboratories' staff. It includes references from the literature on ferro-, ferri-, and antiferromagnetism and superconductivity. Volumes 1 and 2 contain 1000 and 1400 references, respectively, from the 1961–1962 literature; the

# a note to the experimentalist who has signal/noise problems:

It is safe to say that the majority of current research in the physical sciences involves the measurement of small-effect phenomena where noise sets the limit to attainable precision or detectibility. When discussing noise, we include most of the extraneous effects that arise during the course of an experiment that mask the effect under investigation. We also include noise having as its origin either the fundamental thermal fluctuation of all matter not at absolute zero or the quantized nature of radiation. One does not have to be engaged in highly sophisticated research problems such as detecting the Doppler shift of 21 centimeter galactic radiation to have need for modern signal processing techniques. In fact, many less exacting experiments, be they in physics, chemistry, astronomy or even biology, would be rendered more tractable by the application of relatively simple concepts that allow the realization of signal-to-noise ratios near the theoretical optimum.

## LOCK-IN TECHNIQUE SOLVES THE PROBLEM

A particularly simple, yet elegant, way of achieving this goal has been pointed out by R. H. Dicke* who applied it to his sensitive microwave radiometer. This technique involves modulation *at the source* of the quantity being measured. The unknown signal may be a voltage, current, mechanical displacement, radiation, or any physical quantity that can be transformed into electrical energy. The signal to be detected is switched on and off at a fixed frequency, $f_0$, a frequency not too high for the transducer to follow, and not so low as to invite flicker-effect noise. The resulting small AC electrical signal, together with the multi-sourced noise that has entered the picture are now brought up to a high level in a selective amplifier tuned to $f_0$. A tuned amplifier is used to avoid dynamic range problems (overloading on noise) and to reject harmonics of $f_0$, when important. The amplified signal plus noise and a large "reference voltage" at $f_0$ are then fed into a mixer. This mixing process is called "coherent detection" and shifts the information in a given bandwidth at $f_0$ to an equal bandwidth about DC. The signal at DC is filtered by a simple resistor-capacitor low-pass network and displayed on a D'Arsonval meter or strip-chart recorder. It is easily shown that the equivalent bandwidth of the overall system is the cut-off frequency of this RC low-pass filter, which can be made as narrow as desired.

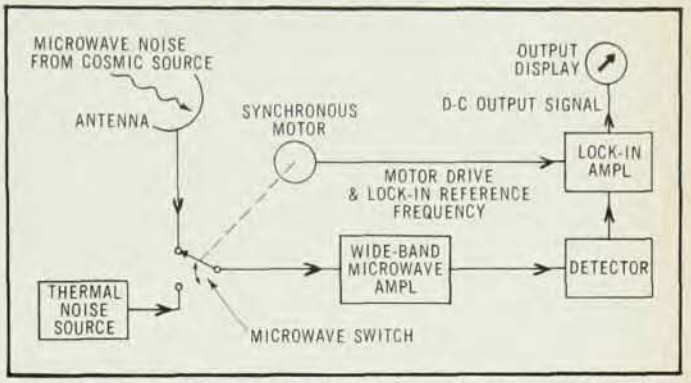


Transistorized Lock-In Amplifier — Model JB-5

*R. H. Dicke, Rev. Sci. Inst. 17, p 268, 1947

## NO FREQUENCY DRIFT PROBLEMS

Inasmuch as the signal frequency is always "locked-in" to the detector, there are no frequency drift problems, regardless of the bandwidth used. The signal/noise ratio can thus be made arbitrarily large at the expense only of observation time. A sample experimental set-up is shown in block-diagram form below.




*Lock-in amplifier used in radio telescope. Receiver noise, although much larger than noise signal from antenna, is not modulated and hence contributes little to DC output of lock-in amplifier. With this arrangement, it is possible to detect cosmic noise signals 40 db below the input noise level of the wideband microwave receiver.*

Princeton Applied Research can provide the experimenter with a lock-in detection system for implementing this technique, the use of which will allow signals deeply buried in noise to be retrieved and measured with good accuracy. This equipment is contained in a single 7" relay rack chassis and has the following specifications:

## TECHNICAL FEATURES

Transistorized Lock-In Amplifier — Model JB-5

*Frequency Range:* 1.5 cps to 150 kc continuously tunable in five ranges.

*Time Constants:* 0, 0.001, 0.01, 0.1, 1, 3, 10, EXT. Single or double section RC filtering.

*Gain:* (rms AC in to push-pull DC out) — Greater than 9,000.

*Linearity:* Better than $\pm 1\%$ of full scale.

*Zero Drift:* $\pm \frac{1}{2}\%$ of full scale per hour, maximum.

*Outputs:* (a) $\pm 5$ volts DC maximum, balanced to ground into high impedance load. (b) $\pm 1$ ma or $\pm \frac{1}{2}$ ma switch selectable into pen recorder of less than 2K internal resistance.

*Frequency Selective Amplifiers:* Selectivity characteristic of tuned amplifiers in signal and reference channels is that of parallel resonant circuit with a Q of approximately 25 (*NOT TWIN-T TYPE*).

*Operating Modes:* External, Selective External or Internal. Lock-in accepts sinusoidal or non-sinusoidal reference signal or provides sinusoidal 5V p to p reference from internal oscillator.

*Price:* $1350.00

To aquaint those interested we are offering our Bulletin 109 which describes how the PAR lock-in system may be used to advantage in experiments in many fields.

*Write for Bulletin 109 to:*

**PRINCETON APPLIED RESEARCH CORP.,** Box 565 / Princeton, N. J. / Tel. 799-1222, Code 609

first part of Volume 3 contains 1200 references from the 1962–63 literature. Volume 3, Part 2, which will appear in January, will complete the 1962–63 coverage. In addition to the bibliography, each volume contains a permuted title index, author index, and a list of corrections to papers listed earlier. Copies of Volumes 1 and 2 and of Volume 3, Part 1, can be ordered from the American Institute of Physics at $3 per copy.

### *Nuclear Science*

The Nuclear Data Project of the National Academy of Sciences—National Research Council has issued two bibliographies to papers dealing with nuclear-structure theory: *Nuclear Theory Reference Book for 1957 and 1958* and *Nuclear Theory Reference Book for 1959 and 1960*. Each volume contains entries for about 1000 published papers and unpublished reports in the following categories: nuclear structure, nuclear models, nuclear properties, nuclear reactions, electromagnetic radiation, beta decay and parity, alpha decay, and tables and computational aids. Author indexes are included. The books supersede the Nuclear Theory Index Cards which had been issued since 1958. The volumes can be ordered from the Superintendent of Documents, Washington 25, D. C., for $1 a copy ($1.25 for overseas orders).

The NAS–NRC has also issued the proceedings of the 1961 Conference on *Electromagnetic Lifetimes and Properties of Nuclear States* (Publication 974), held October 5–7 in Gatlinburg, Tenn. Edited by Paul H. Stelson of the Oak Ridge National Laboratory, the volume includes 21 invited papers, many of which are in the nature of a review of their topic, as well as several expanded abstracts and some of the discussion which followed presentation of papers. Areas covered by the proceedings are theoretical and experimental aspects of nuclear lifetime measurements, electromagnetic moments of excited nuclear states, and properties of particle unbound nuclear states. The publication can be ordered from the NAS–NRC, 2101 Constitution Ave., N.W., Washington, D. C., for $2.00 a copy.

The background and status of atomic energy development as well as its framework of law and policy are the subject of a new reference book issued by the Reinhold Publishing Corporation. Entitled *The Atomic Energy Deskbook*, the volume was prepared under a contract between Arthur D. Little, Inc. and the Atomic Energy Commission, with material compiled largely from published sources of information. Its more than 1000 entries, alphabetically arranged, deal mainly with work being done in the United States on peaceful uses of atomic energy with orientation toward subjects of industrial importance. Data are also given on military applications and on foreign atomic energy programs. The book can be obtained from the Reinhold Publishing Corporation, 430 Park Avenue, New York, N. Y., for $11.00 a copy.